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CSCL 2015

Exploring the Material Conditions of Learning

The Computer Supported Collaborative Learning (CSCL) Conference 2015

Conference Proceedings

Volume 2

Edited by

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Pierre Tchounikine
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International Society of the Learning Sciences

UNIVERSITY OF GOTHENBURG

Exploring the Material Conditions of Learning:

Computer Supported Collaborative Learning
(CSCL) Conference 2015

Volume 2

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Computer Supported Collaborative Learning

June 7-11, 2015, Gothenburg, Sweden
The University of Gothenburg

Editors:
Oskar Lindwall, Päivi Häkkinen, Timothy Koschmann, Pierre
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Preface

The University of Gothenburg is hosting the 11th International Conference on Computer Supported Collaborative Learning from June 7 to June 11, 2015. The conference is part of the International Society of the Learning Sciences (ISLS). ISLS is a professional society dedicated to the interdisciplinary empirical investigation of learning as it exists in real-world settings and to how learning may be facilitated both with and without technology. The CSCL conference has an explicit focus on how and why computer support can enhance learning processes and outcomes. The CSCL field brings together researchers from cognitive science, educational research, psychology, computer science, artificial intelligence, information sciences, anthropology, sociology, neurosciences, and other fields to study learning in a wide variety of formal and informal contexts (for more information see www.isls.org). It emerged in the late 1980s and early 1990s. Before the establishment of the biannual conferences, there was a NATO-sponsored workshop in Maratea, Italy in 1989 and another workshop sponsored by Xerox PARC in 1991 at Southern Illinois University. The first international conference was held in 1995 at Indiana University, followed on a more or less biannual schedule by conferences in Toronto, ON, Canada (1997); Maastricht, Netherlands (2001); Boulder, CO, USA, (2002); Bergen, Norway (2003), Taipei, Taiwan (2005); New Brunswick, NJ, USA (2007); Rhodes, Greece (2009); Hong Kong, China (2009); Madison, WI, USA (2013). There is also a scholarly journal, the International Journal of Computer-Supported Collaborative Learning, and a book series published by Springer.

Acceptance rates for each category of submission to this year's conference:

36 % for full and short papers
46 % for symposiums and panels
45 % for posters

The program reflects a broad geographic representation from 31 countries and 6 continents. Reviews were solicited from 373 reviewers producing 848 reviews. A senior reviewer was assigned to each paper, symposium, and panel proposal and they prepared meta-reviews for each submission.

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Exploring the Material Conditions of Learning: An Introduction to the Computer Supported Collaborative Learning (CSCL) Conference 2015

Within the learning sciences, the field of Computer Supported Collaborative Learning (CSCL) has continually raised the importance of the material conditions of learning. Reinvigorating this focus in a time of rapidly expanding forms of social, cognitive, and technical mediation is particularly important. The proliferation of digitized information, the affordances of digital technology, and the current changes in media ecology affect society at all levels. Not only do these material conditions influence the way we learn or what is considered relevant knowledge in the many social contexts of our lives, they also set the premises for how knowledge is formed and how it is organized, made use of, and communicated. Changing patterns of collaboration, authority, and legitimacy of knowledge in society and its institutions have important implications for learning and cognitive processes and outcomes, and these changes are consequential for education, production, social administration, and the public.

The material conditions of learning have been explored in numerous ways, including, but not limited to: basic research of collaboration, learning processes, knowledge formation, and media ecology; applied research and design studies of how specific tools, applications, and activities are used and modified for the benefit of relevant fields of practice; and theoretical approaches to the development of the interdisciplinary fields of CSCL and the learning sciences and their manifestations in society. It is clear that the field of CSCL includes different approaches and methodologies. This variety is of course nothing new, but it is important to recognize and appreciate. High quality contributions are important for the field and are not dependent on which perspective or approach upon which they build. The multifacetedness of the field is in this sense a characteristic as well as strength.

When working with the submissions and the creation of the program, some trends have emerged. Collaborative knowledge building continues to be an important area of scholarship within the CSCL community. Many research groups and scholars around the world take the seminal work of Bereiter and Scardamalia as a starting point. The idea of collaborative knowledge building is not only applied to new contexts but also extended in different directions. Some specify the knowledge building of individuals while others look at how collaboration emerges over time. Argumentation as a specific form of collaboration has also become an important theme in the field – either as part of collaborative knowledge building or as a perspective on its own.

How scaffolds for learning are built and organized are classic issues in the field. More recently, concepts like scripting and orchestration have also become important. Designs built on scripting and orchestration give us new insight into how groups and whole classes interact and work to undertake specific tasks and solve problems. In this work, collaboration is sometimes conceptualized as multiple paths of joint work in which both individual students and the larger community benefits. Within the papers of this volume, the notion of communities of practice is used both as a metaphor and as the foundation of a perspective. As digital environments become increasingly important to our everyday lives, it is clear that the context of learning plays a central role. The importance of context, however, does not direct the focus away from the issue of collaboration. To be able to constitute a community of practice, smaller units like dyads and groups clearly need to work in productive ways.

Over time the topic of embodiment has grown to be an increasingly important consideration in cognitive studies, philosophy of language and in education generally. It was perhaps inevitable that it would become an explicit theme for research in CSCL as well and we see evidence of that in this year's program. When it comes to new technologies, it is noticeable that tangibles and tablet-based collaboration have become central scaffolds and contexts that support and enhance learning. Tangible interfaces have also enabled embodied interaction with computational objects in our physical world.

Another research strand that now has a clear presence in the CSCL community is the study of games and epistemic games. Epistemic games are designed specifically for learning and often share some design features with simulations. With regard to the recent attention of games, it is important that researchers in the field raise questions that go beyond the hype and critically investigate what people/students learn when they play games.

Similar arguments can be made about social media. It is interesting to see how social media platforms and community services can include designs that support different types and forms of collaboration.

Participation and dialogue have also gained increasing attention in massive open online courses (MOOCs), and hence, collaborative learning in MOOCs has also become a focus of research in the CSCL community.

A rather new theme for the CSCL community is learning analytics. As platforms, design, and technological features have become more advanced and data produced automatically, analytics has emerged as an important resource and topic. A key question in the field of learning analytics is the nature of the data that can help us to describe, understand, and explain learning processes and outcomes in more sophisticated ways. It is here clear that the combination of analysis of behavioral features with processes of meaning making and learning outcomes needs to be explored by multiple approaches.

In these volumes, you find a wide variety of papers that cover these themes and more. We very much look forward to continue the conversations about these issues at the conference. We would also like to express our deepest gratitude to the many people who made the conference possible: the organizing committee, the advisors, the senior reviewers and the reviewers, the local organizing committee, the sponsors, volunteers, the staff, and all the presenters and participants. Your contributions make the CSCL field a thriving field that change learning opportunities that can enhance people's participation and engagement in new and emerging activities in the society.

Finally, we would like to offer a special thanks to Laura D'Amico for the care and thoroughness that she brought to the task of putting the proceedings to order over the past several months. The construction of a conference proceedings tends to be a thankless job, but we would feel remiss, if we left it so. These completed volumes are a testament to her hard work and we are deeply grateful.

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Short Papers

Playing with Gameful Activities and Assessments: Avatars and Experience Points in a Graduate Course

Beaumie Kim, University of Calgary, beaumie.kim@ucalgary.ca

Abstract: The community of learning scientists is increasingly valuing games and game-based learning environments to engage players and learners in their pursuits. In higher education, instructors, especially those who teach game-related topics, attempt to incorporate game principles into the course activities and assessments, and found their efforts motivational for students. I argue that participating in gameful assessments and activities are important for teachers, not only to explore new ways of designing learning experiences, but also to better understand the gaming context of young people they work with. This paper introduces the design of a course that engaged graduate students in the concepts and practices of game-based learning. Specifically, I discuss the design of using avatars and gaining experience points as part of their course activities and assessments mediated by a social media technology, and how learners were engaged in the course in a gameful manner.

Keywords: gameful assessment, graduate course, avatar, game-based learning

I do not play video games and to be honest, I feel a high level of anxiety whenever I use the controllers of consoles such as the ones for the x-box and PS3 although my children are able to use them flawlessly.

Ms. Pacman, Reflection Paper

Introduction

Concerned about providing meaningful learning, many higher education instructors strive to provide authentic contexts analogous to the knowledge usage outside of academia in preparing future practitioners in their disciplinary practices (Herrington & Herrington, 2006). One important and authentic practice in teacher education should be about playful and gameful learning: teachers' practices involve young people who are apt learners in their social worlds, invent new ways of doing things, and examine their own practices, including their game play (Thomas & Brown, 2011). Some instructors incorporated game principles into the course activities and assessments, and found their efforts motivational for students (Fishman & Aguilar, 2012; Sheldon, 2011). It is acknowledged that many behaviours and efforts involved in gameplay (e.g., risk-taking, persistence, problem-solving, concentration) are highly valued in many life situations. On the other hand, many perceive that time spent in playing games in all ages is wasted and could be used elsewhere. Similarly, teachers may not identify with today's generation of young students as gamers, as seen from Ms. Pacman's (screen name of a student) reflection above. I argue that participating in gameful assessments and activities should also be valued for its authenticity in the context of in-service teacher education (i.e., facilitating learning for young people). In the past years, using game-like elements in (or gamification of) higher education courses has gained attention to support students' meaningful experience (Johnson, Adams Becker, Estrada, & Freeman, 2014; Sheldon, 2011). Borrowing the term 'gameful' used by McGonigal (2011), this paper introduces the design of a summer course in the Master of Education program on Digital Game-Based Learning at a Western Canadian university and describe how the participating students interacted with course activities in a gameful manner.

Perspective on gameful learning

The efforts to incorporate gameful activities and assessments in higher education are growing not only for the courses related to games (e.g., Sheldon, 2011) and game-based learning (e.g., Fishman & Aguilar, 2012), but also in other science and engineering areas (e.g., Barata, Gama, Jorge, & Gonçalves, 2013). Sheldon's (2011) multiplayer classroom experimentation initiated in 2009, set out a prominent example. The course was designed with the assumption that students would earn their points by embarking on quests and participating in guilds (collaboration) in order to eventually receive grades above F. The authors and researchers mentioned above equivocally argue that simply mapping the game elements to course activities does not necessarily make students' learning gameful. McGonigal (2011) used the term 'gameful' to emphasize on the seriousness of game play, which may not be captured from the word 'playful.' Building on this notion, Holden and colleagues (2014) provide a useful framework in conceptualizing the experience of gameful learning. They suggest three elements, including attitude, identity, and ignorance, as dynamic influences that bring about gamefulness. The activities and assessments are not in and of themselves gameful; conversely, gameful learning happens through the learners' interactions with them. The element of attitude considers what Suits (2005) calls 'lusory attitude,' with which players accept rules and constrains of a game and make efforts to achieve its goals. The element of identity is also played out by the learners: they negotiate identities in and out of the game and the learning setting (Holden et al., 2014). The element of ignorance can also be found from Salen's (2011) account on Quest to Learn, where the community of questers (i.e., learners) constantly identifies and embraces its lack of knowledge and a need to share and provide feedback.

Methods

The course, Digital Game-Based Learning, incorporated some game elements, with the intention that the participants would immerse into the concepts and practices of game-based learning. The author designed and initially taught this course during the summer 2013 two-week residential period for an online Master of Education program. In order to foster a community of players, the course design used game concepts, such as experience points (XPs) and multiple battles for students' learning tasks (Johnson et al., 2014; Sheldon, 2011). XPs were to be earned in everyday activities during the two-week intensive course. The 3-hour class sessions allowed the students to collectively develop and articulate design principles for learning and games, informed by theories and practices. They also participated in the community of designers (teachers) to exchange and develop ideas. This happened both face-to-face and online using Google+ community page to share, accumulate, and trace evolving ideas and digital resources (see Figure 1). However, an apparent tension surfaced between the university-credit course evaluation and social practices common in playing games (Kim, 2014). Many game-like elements were directly associated with assessments (i.e., everyday XPs), and students were not comfortable with sharing the accumulation of those points (i.e., leaderboard), which is a common practice in many social games.

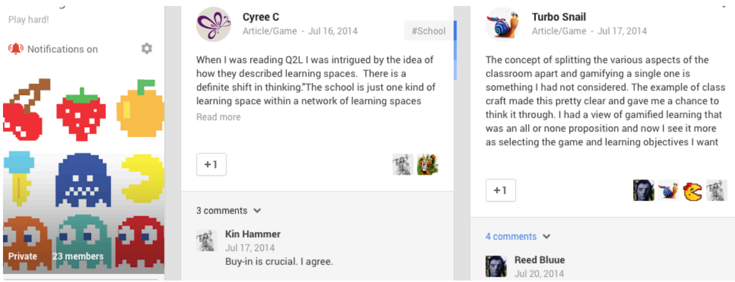


Figure 1. Google+ group page for microblogging as avatars

This paper reports on the second iteration from the two-week intensive course offered in Summer 2014. A new element required students to create their avatars for anonymity and to self-score their XPs for the leaderboard everyday. Another prominent element of games that is often lacking in higher education is immediate feedback. We reviewed activities daily and reflected on self-scored XPs for selected avatars (e.g., microblogging on games they reviewed). A researcher took observation notes everyday during the course. The instructor took occasional reflective notes and conducted an informal survey about microblogging using students' avatar identities. The assignments and the electronic artifacts posted online were collected from the 15 students out of 17 enrolled students who agreed to share their work (ages between 25 and 55). The aim of the course design was to create engagement and a playful culture in a graduate classroom, through which students experience the benefits (and/or pitfalls) of gameful learning activities and assessments. In the following, I present the preliminary findings on one aspect of the course, i.e., microblogging through avatar identities, to understand how students worked (or played) with this particular activity in a gameful manner.

Findings

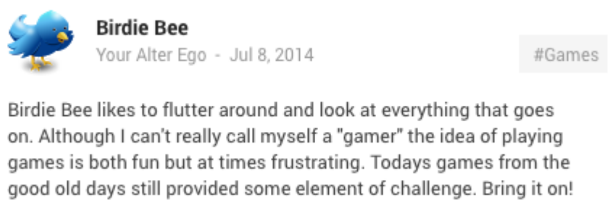
The use of avatars and a self-reported XP leaderboard was an important design change implemented from the previous course. In a typical university classroom, points or numbers associated with a student's performance are private between the instructor and a student, even though each other's participation and contribution are easily visible to all students. Adopting game concepts, as XPs and a leaderboard, would inevitably challenge the exiting rules and structure of a graduate course. The self-reporting of XPs as avatars, therefore, was intended to provide some level of privacy, to eliminate the surprises of finding out their XPs from the instructor, to encourage learners' agency in their own performances, and to possibly provide an opportunity to express their opinions from different perspectives. The instructor conducted an informal online survey at the mid-point of the course, to find out whether or not all students were comfortable to reveal their identities on the last day and to hear their thoughts on this practice. All agreed to reveal their avatars. Names mentioned below are either pseudonyms or their actual or pseudo avatar screen names depending on participants' indicated preferences.

Gameful learning with the new rules of a graduate course

In the open-ended question to comment on using avatars, 10 out of 17 students mentioned that they enjoyed figuring out who the person was. Doc Claw, for example, mentioned, "I thought the avatar thing was a great idea! It is fun trying to figure out who everybody is just by their comments online." Interestingly, using avatars as a protective measure for the XP leaderboard was not much of a concern once they became familiar with the routine practice. In fact, they showed their 'lusory attitude' of accepting this new rule of using avatars, which is different from typical threaded online discussions. At the same time, they engaged in reflective practices in action (Salen, 2007) in the game of 'figuring out,' not only as they read the posts online but also as they attended to what their classmates discussed in the classroom. At the same time, students made different types of moves in their use of avatars. For example, some students found themselves focusing more on ideas rather than associating the opinions with particular classmates. James mentioned, "I think that the use of avatars was an innovated teaching strategy that encouraged me to construct understanding through a more candid and open communication and (reducing potential for bias)." Other students, on the other hand, mentioned that they tried not to say something similar in class so that they would not accidently reveal their identities to others. There were, of course, few students who did not see the value of logging into a different Google account (or changing their names/photos) as they appreciate connecting online posts with face-to-face conversations. Most of the students were part of a Master of Education program cohort, and many thought they figured out everyone. However, there was a general element of surprise on the last day when everyone revealed their identities.

Gameful learning and identities

Students in the course constantly navigated their identities as gamers, non-gamers, teachers, parents, graduate students, and so forth, in discussing what they were reading and experiencing and in trying out different games online or during the class time. The names and looks of their avatars did not necessarily affect their own (or projected) identities, but some made a connection with how they liked to act. Introducing themselves as avatars might have given a chance to see themselves as protagonists who embark on a quest as gamers and designers of learning. Birdie Bee discussed how she related to games, when she introduced herself online in Figure 2. Happy Face also posted on the first day, "Day one. Excited and anxious. I haven't played video games for about 7 years. I have however used a lot of ed. games in the classroom and had a serious look at what they offer in context to what I need. I'm very curious."



<u>Figure 2.</u> Birdie Bee's post on introducing herself

Students' identities as gamers, past-gamers, or non-gamers played out when microblogging about games they played in relation to each day's topic. Turbo Snail in his discussion of violent games posted, "As a product of these early shooters I personally do not feel they have made me a more violent person and am very curious as to why these games seem to affect different individuals differently." He, as an in-service teacher, reflected on his own identity as a gamer in relation to the day's reading assignment about violent games.

Embracing ignorance in gameful learning

Students seemed to be much more open about their ignorance or critical to what they were reading when microblogging online. On day five, Angel of Life shared 15 game-related acronyms she found while reading an article. In response, two other students acknowledged that they had to look up what COTS (commercial off the shelf) stands for, and another questioned why no one asked what CI (collective intelligence) meant during the class. In fact, some students thought there could be more open communication using avatars. Ms. Pacman questioned, "I wonder whether having the avatar made people feel safer when they were posting and enabled them to write more freely." In requiring each team to share their progress everyday, the instructor as an avatar, Bumble Bee, posted their work on behalf of the teams in order not to reveal their membership to particular teams. At the beginning of this process many teams seemed to send their typed up notes for the sake of fulfilling a requirement. This started to change when all the teams had short presentations and clearer needs and value of sharing and receiving feedback were established in day five. This is similar to the account by Salen (2011) on the conditions of student learning. The teams identified the aspects of their designs that required particular attention from their peers and sought feedback. Some students started posting their group work using their own avatars, giving others a clue that they are members of particular groups. At this point, the game of hiding behind an avatar became less important than receiving feedback from peers.

Conclusions and implications

In the NMC Horizon Report: 2014 Higher Education Edition, games and gamification are highlighted as digital strategies, which transcend conventional learning activities and are likely to drive technology-related decision-making in higher education in the next two or three years (Johnson et al., 2014). The tensions exist in incorporating structurally different concepts into the university course: even though we position the course as a game, one does not have infinite chances to fail and repeat like a game for a university credit course (Kim, 2014). The course redesign described in this paper, using avatars and self-reporting of XPs, was an attempt to navigate and mitigate such tensions and to explore how to bring about the gamefulness in a graduate level course. The gameful learning practices and creative engagement with avatars came from students who accepted the new rules of a graduate course, navigated their identities as gamers, non-gamers, teachers, and students, and embraced and created a need to share their work and learn from one another. The future design iteration may pay more attention to how to facilitate students' establishing the needs to share as well as accepting and creating new rules for the course to better bring about the graduate students' gamefulness into their learning. This research provides implications for ways in which we deliver instruction in higher education, especially in the context of educating in-service teachers. I again argue that engaging in a course in a gameful manner should be valued for its authenticity in the context of in-service teacher education: they facilitate learning for young people and at the same time, many of them may not identify with young people's gaming practices. The practice introduced in this paper provides a strong connection between the course pedagogy and its content, and positions the course as an opportunity to deconstruct their current learning, teaching and gaming experiences.

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Co-construction of Knowledge Objects in Computer Engineering Education

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Abstract: This study examines Computer Engineering undergraduate students' collaborative design and development of knowledge objects (e.g., webpages). Computer Engineering is a resource-rich, dynamic domain, which offers opportunities for inquiry and the construction of complex knowledge objects. However, the students must learn how to engage meaningfully in such knowledge production practices and to make use of the domain's large pool of available resources. This study provides a better understanding of how students employ programming strategies, select and mobilize knowledge resources and collaborate to co-construct knowledge objects. A rich set of data enabled a detailed examination of these aspects. The findings emphasize the necessity for students to understand the strategies and knowledge underlying the (collaborative) programming practices, besides knowing how to apply these and to develop the capacity to explore, select and assess new knowledge resources; and, for the institutions, to provide the appropriate guiding structures for this type of learning activities.

Introduction

This study examines Computer Engineering undergraduate students' participation in the collaborative design and development of knowledge objects (e.g., webpages) and aims at providing a better understanding of how students employ programming strategies, select and mobilize knowledge resources and collaborate to co-construct knowledge objects.

In recent years, higher education programs are challenged to prepare students to be competent knowledge workers. This implies ambitions for students to be more than just users of knowledge, mere "course-takers", but to develop capacities to process, assess and employ knowledge, and to become knowledge producers (Shaw, Holbrooke & Burke, 2011). Generally, there is wide agreement that such activities can be beneficial for students' later involvement in knowledge work (Spronken-Smith & Walker, 2010) and study programs are, progressively, including this type of learning activities in their curricula. Recent studies (Aditomo et al., 2013) indicate, however, that meaningful participation in learning activities that involve investigative work with knowledge and knowledge construction is not a straightforward matter, and more research is needed to understand, and be able to support, students' engagement in this type of activities within the context of knowledge domains.

Empirical studies in higher education that examine inquiry-based learning and collaborative work, which are characterized by a question-driven mindset and require sharing, understanding and building new knowledge collaboratively, appear to focus predominantly on the students' discursive participation and experiences with investigative work. These studies identified collaborative problem solving, processing of information from (scientific) sources or creating shared understanding of ideas and concepts as main features of the inquiry processes. They also indicated misunderstandings regarding the nature of these activities, which students' described as knowledge gathering (Levy & Petrulis, 2011) and difficulties they encountered when required to solve open-ended problems or to participate in unstructured tasks (Spronken-Smith & Walker, 2010). Few studies examined knowledge construction, the knowledge objects being developed and the way collaborative work is organized around these. Studies of collaborative knowledge creation in small project groups showed that such processes involve shared understanding, joint actions at the epistemic level, and a good balance between work with knowledge and the management of the process (Damşa, 2014; Muukkonen & Lakkala, 2009). This lead to the conclusion that students have difficulties to accomplish both the knowledge-productional aspect, and an active participation in the collaborative process.

This study aims at providing a better understanding of the process of collaborative work that involves the construction of knowledge objects (i.e., webpages) and the use of domain-specific knowledge resources by students in computer engineering education. The study addresses the following questions: 1) How are these knowledge objects co-constructed by the student groups through collaborative programming? 2) How do groups mobilize and use domain-specific knowledge resources? and 3) Do the developing knowledge objects and the used resources enhance the inquiry process? Ultimately, the study aims at accounting for how these activities facilitate the emergence of programming practices students are expected to learn.

Characteristics of the computer engineering domain

The characteristics of the *computer engineering* domain practices create a specific context for the knowledge practices students are expected to learn. The knowledge artifacts are a prominent feature of the domain (Mackenzie, 2005), which appears to have a high degree of structure and specialization in terms of collectively shared technologies, standards, and procedures, and a broader, outwards orientation towards evolving and dynamic epistemic practices. The knowledge content of this domain is geographically dispersed and often represented in online resources (professional databases and forums). Professionals are oriented towards these global information structures and take responsibilities for keeping up with new skills and technological advancements. Furthermore, studies of the computer engineers' epistemic practices (Nerland & Jensen, 2010) have shown a tendency to engage in solving problems and developing knowledge artifacts by using sophisticated solutions because these are considered intellectual challenges. In this context, for students, the challenges emerge to construct a deep and solid understanding of the domain-specific knowledge, develop the ability to apply key technical and professional skills fluently, and engage in authentic engineering projects (Litzinger, Hadgraft, Lattuca & Newstetter, 2011).

Knowledge object: Conceptualizations and empirical insights

Socio-cultural perspectives of learning serve the purpose of depicting the mechanisms and arrangements through which knowledge is produced and circulated (Knorr Cetina, 1999). At a micro-level of these activities, ideas regarding the mediated nature of learning, i.e., by various (intellectual) means and tools (Säljö, 2004) are of relevance. Knowledge resources are such mediational means that accumulate collective knowledge and experience and have instrumental value. Knowledge objects, inter alia, are developing entities and can be addressed in collaborative settings by negotiating, drafting, developing and materializing new ideas and solutions (Miettinen & Virkkunen, 2005).

Knowledge objects are depicted as being the same with research objects or epistemic things, which are "material entities or processes […] that constitute the objects of inquiry" (Rheinberger, 1997, p. 28). An inner contradiction in relation to the nature of the object is highlighted, namely, that it is considered to be both of a material and ideational nature; thus, it can be both a realization of a material reality, respectively, the object of thought. Rheinberger (1997) and Knorr Cetina (1999) distinguish technological objects or objects as instruments, i.e., clearly defined and finished objects with an instrumental role, from the epistemic or knowledge objects, which are question-generating, open to transformation and further exploration, and have the potential to open new lines of inquiry.

For the purpose of this study, it is exactly the dual potential of the knowledge objects that is important. The complexity of this construct lies in its dynamic position in relation to inquiry processes, which can allot the object the role of mediating tool or object of inquiry. In the case of the former, the knowledge objects are represented by an amalgam of material and conceptual (ideatic) resources, which activate a set of opportunities when they are employed. In the case of the latter, it is the open character of the knowledge objects, which makes them more processes and projections rather than definitive things. The defining features are the changing, unfolding character and their incomplete, continuously evolving nature, which makes them rather open-ended projections and generators of new conceptions and solutions.

Methods

As part of a larger research project examining knowledge practices and student learning in higher education, this study was conducted in a Computer Engineering bachelor's degree program at a university of applied sciences. This program offers bachelor's degrees in the engineering and information technology field and was selected because of its specific domain delimitation and the measures taken to introduce a research-based curriculum. Direct access to the sample group was obtained through a call to the students and teachers, with the participating students signing up voluntarily. The sixteen participating (2 female, 14 male) students were organized in four project groups. Activities in an introductory course in web design and development – *Web Project*, was observed and documented. The course contained varied learning and instructional strategies aimed at introducing students to the domain. Bi-weekly lectures were provided during a period of seven weeks to introduce the programming languages of web design and development (i.e., HTML5, CSS, PHP, Java software); ten other lectures introduced students to the field of project management. In bi-weekly lab sessions, the students worked on individual assignments on basic programming skills. A four-weeks collaborative *web development project* required student groups to design and develop a functional webpage, by using the programming languages learned during the course and web-based resources, and to write a justification report. Each group employed online platforms and tools, tailoring the use in accordance to their own needs. Github, an online repository and collaborative platform used by programmers, was used by the teacher to make available course materials, assignments, guidelines and links to resources. All groups used this platform to access these materials, and one group also as a workspace. All four groups used Facebook group pages for communication. Three groups used Dropbox to store and share their developed object versions, resources and other materials. Various online platforms (e.g., w3schoools, Stack Overflow) were used as main resources for the programming work; an online tool was used to assess the codes at different stages of the programming process.

Interaction data (video recordings of group meetings, online communication), knowledge objects (notes, mock-ups, versions of the products), and course materials were collected. The qualitative analysis focused on identifying: a) how the design and development took place through the collaborative process; b) the way knowledge resources were accessed and mobilized; and c) how the developing object mediated the collaborative work. In the analyses, relevant aspects were allowed to emerge from the data (an inductive approach). I employed a technique building on thematic analysis (Braun & Clarke, 2006) of the conversational data, the knowledge objects and resources to examine how and what the groups constructed and used in terms of knowledge. In addition, a thick description of the process was created.

Findings

The student groups organized their collaborative programming, aimed at the *development of the knowledge object,* by employing a structured set of steps. The programming work consisted of individual coding and frequent discussions of coding strategies, problems emerging, and an iterative trial-and-error strategy. The latter involved mutual progress updates, identification and improvement of errors, integration of individual contributions when correct, re-assessment when invalid; followed by a new iteration and the production of a new version of the knowledge object. The group discussions frequently raised new issues and questions, which contributed to advancing both the inquiry and the knowledge object. Generally, the discussions were object-bound, employing technical language and content, without much elaboration of knowledge but attempting to "fit" the process and product in a pragmatic way. The data excerpt below illustrates such a discussion.

Data excerpt 1. Group 3 discussion: Collaborative search for a solution; references to used resources

1. Paul: … Does it need an 'ID' there? (*points with the mouse on the screen*)
2. Lee: Yeah, does it need an 'ID'? Ethan, can you take a look?
3. Ethan: Yeah… ehm…(*looks at the screen and takes his time to think*), that would be a key to click on, right?
4. Paul: Ehm….
5. Ethan: Oh, not a key, but you use it to retrieve that (*points with his finger at the screen*). No, something like… you use JavaScript, remember? […] We figured that out with the w3schools, remember?
6. Ethan: …ehm… we must make a jQuerry to (*points at the code*)… call up, to make this key work, that part of the menu (*stands up and walks to the screen, talks while indicating specific points the code with his finger*). So here is the button you need to press (*points in the code*), and then you can use JavaScript to call jQuerry, to call this up (*points in another place in the code*), so you can call it up.
7. Paul: Ok, then I'll try to make something in CSS… we have to find out how to put these together…

We observe in this excerpt how the group deals with a problem identified in the coding work. The problem emerging in the individual programming (performed by one of the group members, but projected on a screen) is addressed by the entire group. First, the group members try to identify the exact problem (turns 3-5). This is done in conversation, by considering alternatives, identifying and pointing (though physical gestures) at the problematic point, and by drawing upon resources (turn 5, 6). Strategies learned during their own inquiry and resources mobilized are being identified as instrumental in generating a solution. The collaborative discourse, and the problem-solving actions are closely bound to the knowledge objects itself – Ethan is thinking aloud to identify the problem and, at the same time, envisioning the future use of the object. This short excerpt shows how the work on the object triggers a problem solving behavior, elicits knowledge and resources, and directs both the collaborative discourse and the programming work.

The use of online knowledge resources provided by the expert programming community was one aspect revealed by the analyses so far. Some of the sources were suggested by the teacher, such as the w3schools and the online validation tool. The students searched themselves for other resources that could support them in solving programming problems, in finding alternatives for and improving the quality of their design.

Data excerpt 2. Group 4 end interview–On the use of sources

1.	Interviewer:	… why online resources?
2.	Emma:	Because it's the most updated one. Because programming and stuff changes and the books are getting outdated.
3.	Seb:	And speed as well. Indexing. You're right there on your computer. You just need to look it up instead of 'oh, is that book, in the index, and which page and which word'. It's instant access to exactly what is necessary to continue the work...

The end interview with the four groups shows that the pursuit of online resources was not incidental or random. The students appeared very aware of the characteristics and practices of the programming domain, where the knowledge resources can be found and how they must act in order to access them. In the above excerpt, members of Group 4 explain that the online resources are the most updated ones, and that in a dynamic field such as the one of software programming working with up-to-date knowledge is essential (turn 2). Also, resources that can be accessed fast and efficiently are preferred (turn 3), because of the pressure to finalize the project in time. They mentioned also that it is the instant access to resources that is appealing, which indicates lesser focus on in-depth processing of knowledge or strategies, but inclination to use ready-made procedures and materials to support their programming work.

Discussion

Preliminary results show that creating a concrete knowledge object appeared to serve the construction of shared imaginations of this object, which guided the co-construction process at various stages. In the case analyzed in this study, the process is supported by a domain rich in easily accessible coding strategies and guidelines, procedural structures, validation standards and tools, all artifacts that enable the pursuit of productional work. Students were able to access various resources, which facilitated their programming, and opened their horizons towards the practices of the professional programmers.

The design and development work was supported by a set of procedural structures, validation standards and technologies that supported the coding process. Such knowledge artefacts (programming techniques, techniques, tools, troubleshooting procedures) offer alternative strategies and tools for programming (Mackenzie 2005). A challenge that may emerge from the existence of this rich and continuously changing pool of resources, but which is in essence 'blackboxed' within the community of expert web developers, is that it can lead to a superficial application. Rather than opening tools and representations for in-depth investigation and developing an understanding of the logics of programming, there is a danger that the resources are used merely as technical objects. While the students envisioned ways of dealing with this challenge, this study suggests, in agreement with Litzinger et al. (2011), that close guidance and support in opening up resources for scrutiny is a challenge in this domain. More concretely, I suggest that these programs support their students' entrance into this practice by providing an introduction to the conceptual knowledge underlying the web development domain. Showing personal interest and performing applied inquiries does not mean students are completely aware of the complexities that accompany such interesting tasks or that they will pursue in-depth understanding of the logics of inquiry and the knowledge construction principles of the domain. Sustained guidance and feedback during this process are also desirable to support students in exploring both the technical and the epistemic aspects of knowledge resources. Depending on how the knowledge domain is organised, different mediating tools and support structures are needed for the students to make sense of knowledge and utilise resources in productive ways.

This study yields implications for education programs that attempt to employ knowledge construction elements in the learning activities and, more generally, to support students to develop capacities to, independently, generate knowledge. From a general research perspective, this study opens up further lines for investigation and analysis that can provide deeper insights into strategies that enable students to participate meaningfully and become competent in constructing knowledge objects.

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Online Knowledge Communities as Student-Centered Open Learning Environments: How Likely Will They Be to Integrate Learners as New Members?

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Abstract: Using online knowledge communities (OKCs) from the Internet as student-centered, open learning environments (SCOLEs) poses the question how likely these communities will be to integrate learners as new members. This premise of learning in SCOLEs is analyzed in the current study. Based on the approaches of voices interanimation and polyphony, a natural language processing tool was employed for dialog analysis in integrative vs. non-integrative blog-based OKCs. Three dialog dimensions were identified: participants' individual content-oriented contribution, social contribution, and their position within the social network. Hierarchical clusters built upon these dimensions reflect socio-cognitive structures including central, regular and peripheral OKC members. OKCs with a stronger layer of regular members appear more likely to integrate new members, whereas OKCs with a stronger layer of peripheral members appear less likely to do so. Consequently, the study suggests an automated prediction method of OKC integrativity that may sustain the educational use of OKCs.

Keywords: virtual communities of practice, student-centered open learning environments (SCOLEs), natural language processing, dialogue analysis, polyphony, interanimation

Introduction

Online knowledge communities (OKCs) are frequently regarded in educational research as collaborative learning environments, for instance in the particular shape of student-centered, open learning environments (SCOLEs; Hannafin, Hill, Land, & Lee, 2014). However, using existing OKCs from the Internet as SCOLEs poses the question how likely these communities will be to integrate learners as new, legitimate peripheral members (Lave & Wenger, 1991). The following study contributes to understanding and predicting this premise of learning in SCOLEs, which will further provide a tool and method to sustain the educational use of OKCs.

Theoretical background

SCOLEs are a special case of learning environments in which the individual learner determines his or her learning goals, learning means, or both. The learner is thus central in defining meaning; participation is scaffolded in authentic, often ill-structured tasks and socio-cultural practices; learners access diverse resources, roles and perspectives; prior individual experiences are the main ground of knowledge construction (Hannafin et al., 2014). Nistor et al. (in press) posit that SCOLEs can be designed as OKCs, in which students may participate in the community discourse and thus collaboratively learn while applying domain-specific knowledge and argumentation strategies. As described by several authors (Bereiter & Scardamalia, 2014), knowledge building communities display multi-layered socio-cognitive structures. Accordingly, Lave and Wenger (1991) make a difference between (1) central, (2) regular and (3) peripheral participation. Accordingly, central participants assume more responsibility and perform more difficult tasks than peripheral members; therefore their identity is that of an expert. A more recent classification with finer granularity (Wenger-Trayner, 2011) indicates five categories: (1a) leaders and (1b) core group, regarded as sub-categories of the central participants' group; (2) active or regular participants; and finally (3a) occasional participants and (3b) transactional participants, two relatively distinct groups at the periphery of the community of practice (CoP).

After a few decades of mainly qualitative research on communities, researchers are beginning to apply quantitative methods. This line of research is mainly illustrated by Borgatti et al. (2009) who apply social network analysis (SNA) to describe group social structure. Nistor and Fischer (2012) apply SNA in combination with further quantitative methods to validate a model of the relationship between expertise, participation and expert status in academic communities of practice. In the newly emerged domain of Learning Analytics, particularly in Discourse Analytics, methods including SNA, clustering, and factor analysis are applied to identify socio-cognitive structures and predict learning in technology-based learning environments (Baker & Siemens, in press). In this vein, Nistor et al. (in press) use an automated dialog analysis tool, *ReaderBench* (Dascălu et al, 2013; Dascălu, 2014), to identify and assess OKCs as potential SCOLEs on the Internet.

The automated assessment of OKCs is based on the idea that community discourse is tightly connected with socio-cognitive structures, practice and learning (Hannafin et al., 2014; Lave & Wenger, 1991). The *ReaderBench* tool is based on Bakhtin's (1981) dialogism and on the polyphonic model of discourse (Trău□an-Matu, 2010). The tool is described in detail by Dascălu (2014) and validated by Nistor et al. (in press). It provides several indicators describing the personal and social dimensions of a collaborative dialog, emphasizing dialogue coherence and overall coverage of a given topic. These dimensions are strongly correlated with participants' expertise (Nistor et al., 2014) and critical thinking (Nistor et al., in press) expressed in online, text-based discussions.

Such methods and tools evidently support the educational use of OKCs as collaborative learning environments. However, a closer examination of the idea to use existing OKCs from the Internet as SCOLEs suggests at least two design possibilities for the educational practice. In one of them, OKCs may be created for educational purposes in line with a given curriculum. In the other, learners may peripherally participate (Lave & Wenger, 1991) in existing OKCs from the Internet. Given that communities need relatively long time to form and become functional, the former option may be very restrictive if only short time (e.g., one term or academic year) is available. The latter option seems less restrictive from this point of view, however, it raises a major question: *How likely is an existing OKC to integrate learners as new, legitimate peripheral members?* The following study aims to answer this research question.

Methodology

The study explores the socio-cognitive structures of OKCs that were likely vs. unlikely to integrate newcomers (in the following called integrative vs. non-integrative OKCs), following three steps: (1) analyze the community discourse using the *ReaderBench* tool (Dascălu et al, 2013; Dascălu, 2014); (2) cluster the community members based on the resulting discourse characteristics; (3) compare the clustering results in integrative vs. non-integrative virtual communities.

The analysis was conducted on the Internet, in blogger communities publicly available on the blogspot.com and wordpress.com platforms. In a prior study, the researchers had attempted to initiate discussions in several blog communities. Two situations emerged: one in which the blog participants responded to the initiated dialogue, another in which the communication attempt was ignored. Consequently, it was assumed that the former group consisted of integrative ($n = 5$), the latter of non-integrative ($n = 4$) OKCs. After these $N = 9$ blogger communities with a total of 308 participants were chosen, the entire community discourse produced within three months (beginning with the researchers' communication attempt) was downloaded and automatically analyzed. No personal data of the participants was collected.

The *ReaderBench* tool provides 13 dialog indicators: two overall indicators (Number of comments, Total collaborative dialogue quality), one indicator of the individual contribution to the dialog (Individual collaborative dialogue quality), five indicators of the social contribution to the dialog (Number of initiated threads, Length of initiated threads, Cumulative interanimation of voices, Social collaborative dialogue quality, Social collaborative dialogue quality in initiated threads), and five SNA centrality indicators (Indegree, Outdegree, Closeness, Eccentricity, Betweenness).

Findings

Discourse analysis

The absolute values of the variables ranged in large limits; hence they were standardized. Further on, they were strongly correlated with each other; therefore, a principal component analysis was performed. Thus, the number of components was reduced to three factors with eigenvalues greater than 1, which explains 80.35% of the total variance. The three dimensions resulting after varimax rotation are based on different sets of the initial variables, as follows. *Factor 1R* is mainly based on the Quality and Number of Initiated Discussions, the Individual Collaborative Dialogue Quality, Outdegree and Betweenness. As such, Factor 1R is related to the individual *content-oriented contribution* to the dialogue. *Factor 2R* is mainly composed of the Social Collaborative Dialogue Quality, the Cumulative Interanimation, Indegree, and the number of comments. Thus, it describes the individual *social contribution* to the collaborative dialogue. *Factor 3R* mainly includes the SNA variables Closeness and Eccentricity, therefore it describes the individual *position within the social network*.

Cluster analysis

In the second step of the analysis, the three dimensions resulting from the principal component analysis (Anderson-Rubin method) were used as input for a hierarchical cluster analysis according to the Ward method with quadratic Euclidian distances. The optimal separation of clusters was reached for the following five clusters.

First, Clusters 4 and 1 are most visible due to the high individual contribution to the dialogue (Factor 1R). Cluster 4 consists of n = 3 participants, who are all blog owners and, as such, initiate the most and the longest discussions. Cluster 1 consists of n = 13 participants, including 6 blog co-owners from blog 5, the only analyzed blog that has multiple owners. These participants are highly active with respect to initiating and sustaining discussions, however somewhat less than Cluster 4, nevertheless more than all other clusters. For these reasons, Cluster 4 and 1 reunite the *central OKC members*, from which Cluster 4 includes OKC leaders, and Cluster 1 the core group of the OKC.

Second, Cluster 2 includes n = 42 blog members with the strongest contribution to the social collaborative quality of the dialogue (Factor 2R). They even contribute more to the interanimation of voices, and the display higher Indegree than Cluster 1. These appear to be the *regular* or *active OKC members*.

Third, two large clusters, Cluster 3 (n = 157) and Cluster 5 (n = 93) reunite the least active OKC members. The blog participants from Cluster 5 are positioned at largest distance from the OKC center, they never initiate discussions, and they participate only occasionally in existing discussions; however, they contribute new information to the discussions. In contrast, Cluster 3 participants contribute to the interanimation of voices within the dialogue. These, as well, exercise little activity and stand at the periphery of the social network, however not as far from the center as Cluster 5. Hence, Cluster 3 and Cluster 5 can be described as *peripheral OKC members*. From these, Cluster 3 seems to correspond to occasional participants, and Cluster 5 to transactional participants.

Integrative versus non-integrative blogger communities

By comparing the identified clusters between integrative and non-integrative blog communities, it appears that integrative OKCs include a larger active subgroup of regular members than non-integrative OKCs. In 4 out of 5 integrative OKCs the regular:peripheral proportion is higher than 10%, whereas in 3 out of 4 non-integrative OKCs the same proportion lays under 10%. Choosing a threshold value of 10% leads to a correct integrative vs. non-integrative classification for 7 out of 9 blogs. Blog 3 becomes then a false non-integrative, Blog 9 a false integrative blog.

Discussion

In summary, this study lays the ground for the design and development of OKCs as SCOLEs (Hannafin et al., 2014), in which learners are supposed to go out of traditional or virtual classrooms, into existing OKCs, discuss topics of interest, come back with results, and draw conclusions. This requires that the OKCs integrate the learners in their community discourse. This study assumes that the integrativity of an OKC is tightly connected to the community discourse and practice, hence it can be assessed by discourse analysis, as follows.

In the first step, the polyphony-based (Trăușan-Matu, 2010) tool *ReaderBench* (Dascălu et al, 2013; Dascălu, 2014) was employed to analyze the blog-based OKC discourse. From the multitude of provided results, the following ground dimensions were extracted: (1) individual participants' content-oriented contribution, (2) their social contribution to the collaborative dialogue, and (3) their position within the social network. These dimensions result from Bakhtin's (1981) polyphony theory and Trăușan-Matu's (2010) analytic approach. They describe the interanimation of voices within a collaborative dialogue, and appear appropriate for automated discourse analysis.

In the second step, the community members were clustered based on their discourse characteristics (Nistor et al., 2014). The hierarchical cluster analysis offered two classifications that both correspond to the socio-cognitive structures described in the CoP research. A classification with lower granularity reflects the same community layers described in the early CoP literature (Lave & Wenger, 1991): (1) central, (2) regular/active and (3) peripheral members. A classification with higher granularity indicates five categories that correspond to later CoP literature (Wenger-Trayner, 2011): (1a) leaders and (1b) core group, that can be regarded as sub-categories of the central participants' group, again the – relatively homogeneous – category of (2) regular/active participants, and the categories of (3a) occasional and (3b) participants, as two relatively distinct groups at the OKC periphery.

In the third and final step, knowing from prior experiments the integrativity of the analyzed OKCs, the clustering results were compared and the decision threshold (integrative vs. non-integrative) was determined. This threshold indicates that a minimum number of regular members (at least ten percent of the periphery) is necessary for the OKC to be integrative. Thus, the role and importance of the regular/active members becomes evident. In line with Lave and Wenger's (1991) observations, it is this community subgroup that mainly carries out the daily tasks and activities, including the integration of new members. Notably, no significant differences in the (very small) central member groups were observed.

Conclusions

For the practice of computer-supported collaborative learning, the conclusions of this study are straightforward: Existing OKCs from the Internet can be used as SCOLEs, for example in higher education. Appropriate instructional design should be developed and evaluated in the near future. For OKC research, this study adds empirical evidence for the existence and importance of finer socio-cognitive structures, and for the relationship between community discourse and practice. However, the result validity may be limited by several conceptual and methodological shortcomings. Although the number of participants was fairly high, there were a small number of OKCs involved in the study. Also, integrativity was assimilated to OKC members' response to relatively simple information requests. Upcoming research aims to extend both the samples and the perspective on integrativity by observing the long-term interactions between regular OKC members and visitors.

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Common Ground and Individual Accountability in Literature Selection of Groups: Three Different Group Learning Techniques

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Abstract: Libraries heavily changed over the last decades, supporting more and more the collaborative learner in providing adapted spaces and technologies. The transformation seems not surprising, as group learning is generally considered to be better than individual learning, although the mechanism behind is still unclear. In a single factor experiment with 180 students, 3-person groups jointly selected research literature for a Geology course at a Multitouch Tabletop. Based on the notions of common ground and individual accountability one third of the groups performed the task collaboratively. Another third had a preceding cooperative stage involving a division of labor, whereas the remaining third of groups had a preceding "parallel" stage. Results indicate a significant difference in learning achievements favoring the parallel condition. The results are discussed in the context of learning environments in libraries.

Keywords: library, problem-solving, group learning, multitouch tabletop, experiment

Introduction

In the last decades, libraries experienced a tremendous transformation by providing more and more secluded rooms for groups to work and learn together using digital technologies (Gabbard, Kaiser, & Kaunelis, 2007). This transformation comes to no great surprise as the benefits of group learning has been shown for more than forty years, summarizing that learning in groups is better than learning alone (e.g. Springer, Stanne, & Donovan, 1999). There are many techniques to learn effectively in groups (e.g. collaboration, cooperation). Nonetheless, the way how group learning should be structured and fitted to real world scenarios is still unclear.

For the purpose of this paper, we build on socio-cognitive research, arguing for the combination of two factors: common ground as a social factor, and individual accountability as a cognitive factor. Based on this rationale, we report first results of an empirical study altering the two factors in three specific group learning techniques (collaboration, division of labor and parallel cooperation). The task involves computer-supported face-to-face problem-solving, which is situated in the context of literature screening and selecting in a library-based setting.

Three techniques of group learning

Collaboration (C) can be regarded as the gold standard of group learning. Working permanently together, one of the many benefits of C is that over time learners gain a common ground about the task at hand. Common ground refers to shared knowledge, mutual beliefs and mutual assumptions to coordinate activities (Baker, Hansen, Joiner & Traum, 1999). By the means of grounding (Baker et al., 1999), groups not only overcome gaps in their shared understanding, they also build a group knowledge, which is especially important while performing problem solving tasks.

However, research on motivation losses also identified effects, such as social loafing, which hamper group achievement in collaboration (Kerr & Tindale, 2004). To bypass this problem, scholars studying cooperative learning techniques found that individual accountability plays an important role in motivating each group member to contribute to a group learning process (Johnson, Johnson, & Smith, 2007). Hence, instead of permanently working together, multi-stage approaches are introduced, including an individual stage and a collaborative stage. One way to initiate an individual stage, and therefore individual accountability, is to rely on techniques using some division of labor (DoL). In stages of DoL, mostly no or just part of the task material is being shared in the group. Accordingly, it can be assumed that group learners who first use a DoL are motivated to gain individual expertise as the group has to rely on it in a subsequent collaborative stage. However, the downside of DoL is that learners will not possess common ground, and therefore a shared understanding of the whole material, when entering the collaborative phase.

In order to induce both common ground and individual accountability at the same time, a two-stage technique of group learning is used to which we refer as the parallel cooperation (PC). In the first stage, learners individually work on an identical task (i.e share the same material/no DoL), while in the second stage individual results can be discussed. Thus, a "divergence of labor" in the first phase results in heightened individual accountability producing idiosyncratic viewpoints with both varying and redundant contributions. At the same time, it creates a common ground as every learner needs to elaborate on the same material. We like to use the technique in a computer-mediated setting, which allows us to not only capture individual learning contributions systematically, but make them even comparable for the second stage, so that awareness about each group member's understanding is increased.

In order to address the possibility of comparing group member's learning activities, we decided to use a Multitouch Tabletop (MTT) technology. According to Jermann and Dillenbourg (2008), the MTT can either reflect individual and group activities, or transform these activities in a way that makes them more comparable and accessible for the group. While the former is important for collaborative and DoL groups, the latter characteristic might account especially for PC groups.

The present study

The present study compares the three techniques of group learning in a problem-solving task that involves the joint activity of screening and selecting research literature in a computer-supported library setting. Three-person groups were asked to select four out of twelve journal articles, which they would further employ in a seminar report on "Water Scarcity in Sub-Saharan Africa". To make the selection of four, participants read the abstracts of each article and rated them on a scale ranging from 0 (very irrelevant) to 6 (very relevant). Even though abstracts provide just a blink of information compared to full-text articles, we decided to use abstracts because in real-world literature selection tasks rarely all relevant articles are fully read before deepen into the material. After rating every article, the four highest rated articles were automatically selected if the group decided to finish the task. Groups in the C condition did the entire selection task in a one-stage approach as a group. In the DoL condition, a first stage had individuals rate four out of the twelve articles individually. In the second stage, individual ratings were transferred into a shared external representation, and learners had the opportunity to change these ratings collaboratively. In the PC condition, the first stage required learners to individually rate all twelve articles. For the second stage, individual ratings were also transferred into a shared external representation, and learners had the opportunity to change ratings collaboratively. In order to address the practical question of whether group learning outperforms individual learning, we employed a fourth condition as our base line with learners who did the entire task in a one-stage approach alone and without a group context.

Based on the considerations about common ground and individual accountability, it was expected that the C condition and the PC condition will be associated with common ground and shared understanding about the task at hand, reflected in a higher degree of post-interaction shared mental models (*Hypothesis 1*). Further, the DoL technique and the PC technique should benefit from heightened individual accountability, resulting in a higher motivation to contribute to the collaborative discussion in the second stage, reflected by a higher equality of participation (*Hypothesis 2*). Finally, we expected that the PC technique which benefits from both common ground and individual accountability would yield the highest problem-solving performance compared to the other group techniques, reflected in the similarity of the final selection compared to an expert solution (*Hypothesis 3*).

Methods

Participants and design

To conduct our experiment, we recruited a total of 180 students (119 women; 61 men; mean age = 24.39 years) from the University of Tübingen. Students were either paid 8 Euros, or received course credit. To reduce the effect of prior knowledge, we excluded students from Geography. The experiment had a single factor design with three different interventions (group learning techniques): collaboration, DoL and PC. Moreover, we also investigated an individual condition as our baseline. Participants were randomly assigned to the conditions.

Materials

Articles

In a preliminary study, the twelve articles had been selected from a set of 21 articles, by having 30 participants individually rate article abstracts on readability and understandability. The items were presented as 5-point scales ranging from 1 (e.g. not readable at all) to 5 (e.g. very readable). Based on the results, we selected 12 articles with the highest ratings of readability (M = 3.89; SD = 0.37) and understandability (M = 3.81; SD = 0.31). After having the set of twelve articles, we additionally asked a subject matter expert (SME) to rate each article on a 7-point scale to conduct the final relevance ratings according to the task and the seminar theme. These relevance ratings have later been used to evaluate performance measures.

Multi-touch tabletop (MTT)

As an MTT device for both the group conditions and for the individual condition, we used a Samsung SUR40. To make article reading and rating possible, we further developed a tool which allowed the handling of articles with multi-touch interactions.

In the collaboration condition and in the individual condition, the participants used the same interface for the whole time. In the DoL and PC condition, in order to allow individual working before discussing results, first, three distinct private spaces were presented, providing the functionality of reading and rating articles. Depending on condition, either four (DoL) or twelve (PC) articles were presented, and articles were color-coded to allow better distinction afterwards. Once all group members submitted their individual rating, private spaces disappeared, and the screen changed to the full-screen interface version. In the DoL condition, it showed the individual ratings as a cumulated representation, keeping the color-coding, so that participants knew which article was rated by whom. In the PC condition, it showed a transformation of the individual ratings to arithmetic means. Additionally, individual, color-coded ratings were preserved for each article, making it more comparable to distinguish which article was rated by whom to which degree.

Procedure

On arrival at the laboratory, participants were assigned randomly to one of the group conditions. Participants first read task descriptions and filled out a pre-intervention questionnaire asking for demographic data and prior knowledge. After finishing the questionnaire, participants were invited to test all functionality (moving, opening and rating articles) in a demo version of the basic interface with three non-related articles for around five minutes. Afterwards, the group started the task as described above having no time limit to finish the task. The whole task procedure was videotaped. Once participants agreed upon their selection of four, they filled out a post-intervention questionnaire. Finally, participants were debriefed and rewarded for their participation.

Measures

Shared mental models

In the post-intervention questionnaire we measured shared mental models about selection criteria (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Nine rating criteria have been presented to the participants (e.g., currentness of date or relatedness to the region) asking to indicate for each criterion whether it played an important role for the group during discussion or not (categorical: y/n). Frequencies and percentage of complete agreements (three times yes or no) upon one criterion were measured and transformed to odds ratio (-1 / 1, where 1 means perfect agreement upon all nine criteria).

Equalization of participation

To calculate equalization of participation, we used the standard deviation of talking time (in seconds) across group members in the collaborative stage. The lower the standard deviation, the more equal the participation (whereas 0 would mean perfect equalization). Using the coding software ANVIL (Kipp, 2001), two coders double-coded 33% of the videos with an interrater-reliability of .765 (corrected Cohen's kappa), which indicates a substantial agreement.

Performance

Before we started calculating the performance, data has been cleaned by dropping all ratings which a group set to a value between 0 and 1 (of a scale from 0 to 6) in the discussion phase, classifying them as dismissed (non relevant) articles. Then, we took the final rating of all not-dismissed articles from the log files and calculated differences to the corresponding subject matter expert ratings. Finally, the mean difference upon all articles (ranging between 0 and 6) of one group was computed—the smaller the mean difference, the better the group performance.

Findings

Hypothesis 1 predicted that groups in which common ground is established (collaboration, PC) will have a greater degree of sharedness among post-intervention mental models about selection criteria. Using an odds ratio for calculating agreement, a one-way ANOVA of shared criteria mental models between the three group conditions showed no significant effect, $F < 1$. There was no difference between the collaboration condition ($M = .27$, $SD = .82$), the DoL condition ($M = .51$, $SD = 1.07$), and the PC condition ($M = .15$, $SD = .75$). This means that hypothesis 1 has to be rejected.

For testing our hypothesis that individual accountability has a moderating effect on equality of participation (Hypothesis 2), we measured the total time of talk of each participant (in seconds) and looked on the standard deviation of each group. As a Levene's test of equality of error variance was significant ($p < .05$), we ran a Kruskal-Wallis-Test. Results indicate a difference among the three group learning techniques ($H(2) = 14.387$, $p = .001$, $w = .52$), with a mean rank of 38.72 for collaborative groups, 24 for DoL groups and 19.78 for PC groups. Further post-hoc analysis using the Mann-Whitney-U test, revealed significant differences between the collaborative condition ($Mdn = 129{,}8$) and the DoL condition ($Mdn = 67{,}6$), $U(34) = 74$, $Z = -2.78$, $p = .005$, and significant differences between the collaborative condition and the PC condition ($Mdn = 39{,}1$), $U(34) = 74$, $Z = -3.607$, $p = .000$. No differences were found between the DoL condition and the PC condition ($U(34) = 137$, $Z = -0.79$, $p = .429$). On the basis of these data, Hypothesis 2 can be confirmed.

Hypothesis 3 tested whether there were differences in group performance among all four conditions. Therefore, we performed a one-way ANOVA of selection performance (mean rating differences to SME ratings) between the four conditions to see which condition reached the lowest mean differences (best performance) at the end. Results indicated a significant difference of $F(3, 68) = 5.576$, $p = .002$, $\eta^2 = .197$. Further analyses using Tukey-HSD revealed that this effect was due to a better performance in the PC condition. This condition ($M = 1.06$, $SD = .29$) differed significantly from the collaborative condition ($M = 1.49$, $SD = .43$, $p = .009$), from the DoL condition ($M = 1.51$, $SD = .44$, $p = .006$), and also from the individual condition ($M = 1.50$, $SD = .43$, $p = .007$). Thus, Hypothesis 3 could be confirmed.

The design of the experiment also allowed to further analyze whether groups in the two-stage conditions (DoL, PC) had different performance levels over time, as both the performance of collated ratings after the first, individual phase and of collated ratings after the second stage could be compared. A 2 (condition: DoL and PC) x 2 (time of measurement: before and after discussion phase) ANOVA with time as within-subject factor revealed a disordinal interaction effect $F(3, 68) = 19.756$, $p < .01$, $\eta^2 = .368$. Further paired t-tests comparing measurement times (pre/post discussion phase) revealed that performance increased for the PC condition, $M_{pre} = 1.42$, $SD_{pre} = .29$, $M_{post} = 1.06$, $SD_{post} = .29$, $t(17) = 4.943$, $p < .001$. In contrast, performance in the DoL condition slightly decreased over time, $M_{pre} = 1.29$, $SD_{pre} = .22$, $M_{post} = 1.51$, $SD_{post} = .44$, $t(17) = -2.028$, $p = .059$. In other words, these results lent further support to the idea that the PC technique was effective.

Discussion

This study compared different techniques of group learning, based on the rational that they differ with regard to common ground and individual accountability. While our results underscore findings on cooperative learning emphasizing individual accountability as an important role in group problem solving, common ground seemed to have no effect in our setting. As the collaborative condition and the PC condition did not differ in regard to shared understanding of literature selection criteria, we need to question whether the advantages in group achievement of the PC condition were due to common ground. Calling for other possible factors, one candidate might be the increased comparability of group members' individual contributions. The external representations used in the PC condition did not only show collated rating averages after the first stage, but also made differences between individual ratings visible. In providing valuable cues for groups to compare and support negotiation, different instructions for evoking comparability seems a promising approach for future research. This accounts not only for learning scenarios involving libraries, but for learning environments in general.

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Concept Mapping Narratives to Promote CSCL and Interdisciplinary Studies

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Abstract: Concept maps are used to organize and represent information. In the context of creating narratives, concept maps can be used to represent the elements of a plot and/or the relationships between characters. Concept mapping has been shown to be an effective pre-writing strategy leading to an improvement in student writing. We have investigated the use of concept maps to help students develop narratives in an introductory undergraduate English composition course. We found that students participating in an interdisciplinary learning community (LC) who implement their narratives collaboratively as a video game using computer programming produce better concept maps than students in a traditional English composition course. We conclude that the synergies that develop between English composition and computer programming in the interdisciplinary context of a LC result in more effective concept maps leading to an improvement in students' performance in English composition courses.

Keywords: collaborative writing, concept maps, creative writing, narrative, game-based learning

Introduction

An effective approach for teaching introductory English composition is using concept maps as part of a first-year learning community (LC), a group of students who enroll in two or more courses, generally in different disciplines that are linked together by a common theme, in an academic semester. LCs are one of the ten high-impact educational practices recognized nationally to improve student performance and increase student retention (Kuh, 2008). In this case, students enrolled in Computer Systems (an introductory course to problem solving and computer programming, CS1, and an introduction to the field of computer systems, CS0) and English Composition, EG1, which previous research studies have found to improve student retention and academic performance (see Cabo & Lansiquot, 2014; Cabo & Lansiquot, 2013; Lansiquot & Cabo, 2011; Lansiquot, Satyanarayana, & Cabo, 2014). In our LCs, students develop narratives (schematic structuring of temporal actions or a plot: for instance, the hero's journey structure) and implement their narratives as a video game prototype. In EG1, students collaboratively write original video game narratives in groups and explore human-computer interaction (HCI); in their CS1 computer programming class, students implement these stories using *Alice*, a computer programming environment that supports the creation of three-dimensional animations; and, in the CS0 survey course, students explore artificial intelligence (AI) and hardware issues to describe a possible game delivery platform. The concepts and skills introduced in the computer courses are contextualized by a problem (game design) that is relevant to students and connected to concepts and skills developed in the writing course. The common assignment across the three courses in this LC is a design document, which includes three sections: analysis (video game narrative, target audience, review of competing games, and delivery platforms); design (player characteristics, game mechanics, challenge, and description of the media platform); and project description (video game prototype, review of relevant literature, pseudo code, flowchart, concept map, and storyboards). The review of relevant literature section concerns AI and HCI as these relate to their video game project.

In the LC EG1 course, students used the hero's journey plot structure to write an original background story for a video game and then presented their ideas to the class. A few ideas were chosen to be developed further, and students collaboratively revised these chosen stories with their group, first using concept maps to represent the current story. Finally, students individually developed an engaging character side-quest and accompanying concept map, including the rationale for the importance of such a quest to the protagonist as well as to the target audience of the game.

In the non-LC EG1 course, students integrated digital media to further develop their stories as, for example, a movie. In this course, the design document included the analysis (background story, target audience, literature review, review of existing related narrative projects and unique characteristics, and media selection) and project description (narrative of project design, concept map, and storyboards), but not the design section. The review of relevant literature was replaced by a review of what makes a good narrative related to the genre of their stories. Student focus was placed creating a background story for a character, and the hero of a video game was used as an example, including the target audience of the story, not of a game.

Students created both group and individual concept maps, which were added to the concept map of the video game narrative. Concept maps are used to organize and represent information. As visualization tools, these diagrams show the relationships between ideas and, in this instance, include linking concepts enclosed in circles and relationships between concepts indicated by a connecting line. These concept maps illustrated, for example, a summary of a background story and the stages in the hero's journey—depicted as a circle, it begins with the Ordinary World then moves to a Call to Adventure; the Refusal of the Call; Meeting the Mentor; Crossing the Threshold; Tests, Allies and Enemies; Approach the Inmost Cave, The Ordeal; Reward; the Road Back; Resurrection; Return with the Elixir and eventually returns to the Ordinary World (Campbell, 1949; Vogler, 2007). Findings demonstrate that the intentional interdisciplinary contextualization of technology-supported collaborative learning helps students make connections that improve general academic performance.

Methods

Students used the *Visual Understanding Environment* (VUE), a free application that provides a flexible visual environment for structuring, presenting, and sharing digital information. VUE also provides support for in-depth analysis of concept maps, with the ability to merge maps. One proposed method of assessing concept maps based on the components and structure of the map (Novak & Gowin, 1984) assigns points for valid propositions (1 point each), levels of hierarchy (5 points for each level), number of branches (1 point for each branch), cross-links (10 points for each valid cross-link), and specific examples (1 point for each example). The number of hierarchical levels addresses the degree of subsumption, the number of branches indicates the differentiation, and the number of cross-links indicates the extent to which the knowledge has been integrated. Another approach to assessing concept maps is to use, and provide students with, a rubric.

Table 1: Concept map assessment rubric

Criterion	4	3	2	1
Breadth of net	Map includes the important concepts and describes domain on multiple levels	Map includes most important concepts; describes domain on limited number of levels	Important concepts missing and/or describes domain on only one level	Map includes minimum concepts with many important concepts missing
Embeddedness and inter-connectedness	All concepts interlinked with several other concepts	Most concepts interlinked with other concepts	Several concepts linked to other concepts	Few concepts linked to other concepts
Use of descriptive links	Links succinctly and accurately describe all relationships	Links are descriptive and valid for most relationships	Some links unclear or vague; some invalid or unclear	Links are vague; show inconsistent relationships
Efficient links	Each link type is distinct from all others, clearly describes relationship; used consistently	Most links are distinct from others; discriminate concepts; present variety of relationships; used fairly consistently	Several links are synonymous; don't discriminate concepts well; don't show a variety of relationships; used inconsistently	Most links synonymous or vaguely describe relationships and aren't distinct from other links
Layout	Map is contained in a single page, has multiple clear hierarchies, is well laid out and provides a sufficient number of relevant examples with links	Map is contained in a single page, has several clear hierarchies, is fairly well laid out and provides a sufficient number of fairly relevant examples with links	Map is not contained in a single page, has unclear hierarchies, is poorly laid out and provides some fairly relevant examples with links	Map is not contained in a single page, is confusing to read with no hierarchical organization

Note: Criteria are evaluated on a 4-3-2-1-0 basis.

We further adapted the concept map assessment rubric found at the Knowledge Innovation for Technology in Education (KITE, 2003), with additions by Josephine McMurray, removing the last criterion "Development over time (for concepts maps where a 'base map' is constructed at the beginning of the course and a corresponding 'final map' at the end of the course" (cf. Table 1; Center for Teaching Excellence, Rubric for assessing concept maps, n.d.). In order to analyze individual student creations, a concept map developed over time was not applicable as their first iteration was developed as a group. Student concept maps included their group story and their individual highlighted side-quest section. In the design document, the group story map was synthesized and all side quests were added to show the complete video game narrative.

Student and school sample

Our institution is one of the most racially, ethnically, and culturally diverse institutions of higher education in the northeast United States: 31% of our students are African American, 35.6% are Hispanic, 20.6% are Asian or Pacific Islanders, 11.6% are Caucasian, 0.5% are Native Americans, and 1.2% Other. The College's fall 2014 enrollment was 17,374.

A typical English Composition course does not include a video game narrative theme and students do not have the opportunity to implement their stories; however, both the LC and non-LC courses help students to develop their ideas by using rhetorical modes including narration, analysis, argumentative, compare and contrast. LC students are recruited randomly and then given a list of linked course options.

Analysis

To quantify student performance, we compared the concept maps of students in our LC (n = 14), with students taking EG1 with the same instructor, but not as part of our LC in fall 2013 (n = 14). All students taking the LC course were majors in the Computer Systems degree and the non-LC students comprised different majors; no two students had the same major. For our analysis, we compared the rubric criterion (0-4) for the different categories of the concept maps (Table 1) between the LC and non-LC groups. For the statistical analysis, group means differences were considered significant at the 0.05 level. We also qualitatively measured student performance by observing their discussions during the group background story concept map production.

Findings

Figure 1 below shows the performance of LC and non-LC students in developing an effective concept map of their story. Performance of LC students was significantly better than non-LC students in all categories except in the use of descriptive links category, which was not statistically significant. When the average of all categories was considered, students in the LC also performed better than students not in the LC.

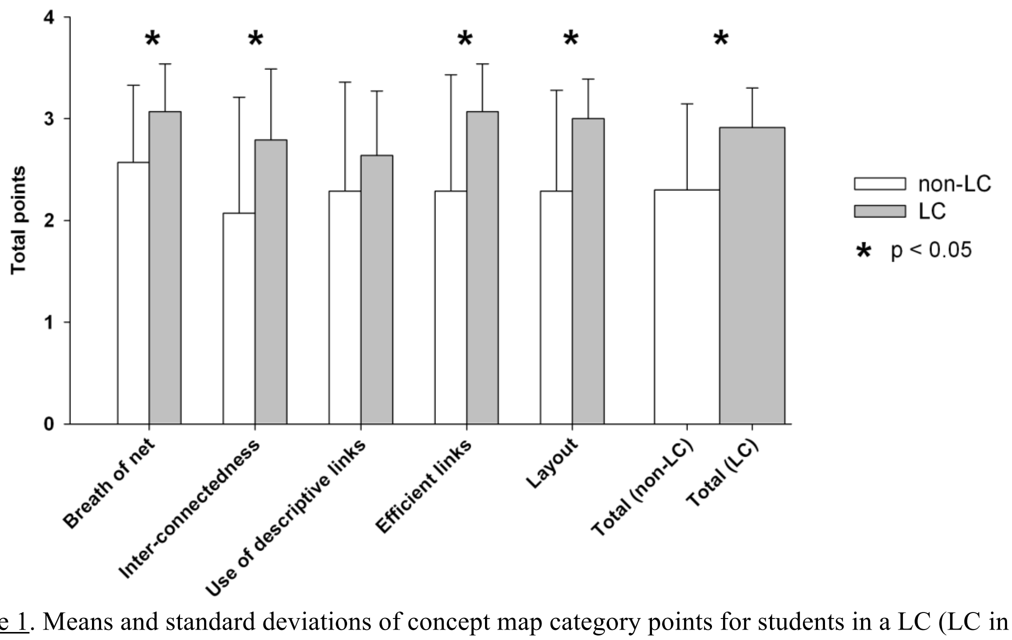

Figure 1. Means and standard deviations of concept map category points for students in a LC (LC in grey; n=14), and not in a LC (non-LC in white; n=14). Totals are the average of all categories. $p < 0.05$ indicates that the difference of the group means is statistically significant.

Students' conversations during the production of the concept maps shed light on these results. Students are not clear on the difference between a flowchart and a concept map, in the excerpt below.

LC Student 1: Is this concept map the same as a flowchart?

LC Student 2: I think so. It's what happens in the story.

LC Student 1: I think we need to show how to make it [the story] happen.

LC students, in the above excerpt, confused a flowchart that illustrates a problem, includes an input, processing, and output with a concept map that represents a story, includes the relationship between ideas. This confusion may explain LC students' non-significant performance in the use of descriptive links as they did not focus on the relationship between links.

Conclusions and implications

Concept maps are not only useful as a learning tool but also as an evaluation tool (Mintzes, Wandersee, & Novak, 2000; Novak, 1991). Based on these data, we can conclude that students in the LC group are able to develop better concept maps than students in the non-LC course. Since it has been shown that the creation of concept maps is an effective pre-writing strategy that improves student writing, it is likely that the use of concept maps will result in an increase in performance in EG1 courses. Therefore, we propose that that increase in performance is the result of the contextualization of the learning experience that occurs in the LC: students apply writing and narrative concepts and skills to problems which are relevant to their interests (gaming) and to their major (computing). The benefit of contextualization could be understood in terms of Ausubel's cognitive psychology idea that learning occurs (Ausubel, 1968) when new concepts are assimilated into existing knowledge and frameworks held by the learner (i.e., into the learner's cognitive structure). The increase in performance could also be related to the fact that students in the LC find meaning in their learning because it relates to previous knowledge (gaming) and since they can relate the EG1 to their major they are more motivated and engaged. It is also possible that the LC environment also contributed to the success of LC students in developing concept maps (Zhao & Kuh, 2004). Further studies will be necessary to understand in more detail the effect of our results, and to assess and compare performance in more specific concepts and skills both in writing and computing for students taking those courses in the context of a LC and outside a LC. For example to correlate the quality of the concept maps with the quality of the actual outcomes such as video game designs, storylines, plots and characters. Students outside the LC were also taking other courses in addition to EG1. It is possible that teaching EG1 in an interdisciplinary LC with courses outside computing may also lead to improved concept map performance.

Computer programming and creative writing in context is effectively a collaborative activity. Not only integrated digital media, but also intentional interdisciplinary approaches to writing allow students to purposefully connect and integrate knowledge. Linking English composition with computer programming in the interdisciplinary context of a LC results in the improvement of students' performance in English composition to similar to the increased level of their performance in the computer courses shown in our previous study (Lansiquot, Satyanarayana, & Cabo, 2014). Therefore, as to allow students outside the major to benefit from the synergies that occur between writing stories and writing programs, we created general education (liberal arts and sciences) interdisciplinary writing-intensive co-taught course, *Programming Narratives: Computer Animated Storytelling*, in which students leverage problem-solving, computer programming and writing skills to produce a narrative-driven video game prototype. Students study the structure of narratives and are introduced to concepts of problem solving using constructs of logic inherent in computer programming languages. Emphasis is placed on creative writing and computational thinking. This course will be offered for the first time in spring 2015 and will include formative and summative assessment of our pedagogical approach.

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Fostering and Reflecting on Diverse Perspective-Taking in Role-Play Utilizing Puppets as the Catalyst Material under CSCL

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Abstract: Role-play is a powerful strategy that helps learners broaden their perspectives in a given subject area through communication. As a vehicle of role-play, puppetry achieves this benefit while creating a psychological distance from the role-player's actual identity, meaning that the player's anxiety or apprehension toward evaluation is reduced. EduceBoard is a tangible system that enables participants to conduct role-play using puppets and foster reflection based on the diverse perspectives of the characters in the role-play. Preliminary evaluation of EduceBoard demonstrated that it allowed participants to play various roles in role-play and helped them reflect on their role-play from a variety of perspectives. In this paper, we also discuss how we can foster successful transfer of what they have learned to their self-performance in role-play or in real-life context.

Keywords: role-play, puppetry, perspective-taking, reflection

Role-play has been researched widely from various perspectives and is still an active topic in CSCL research (Strijbos & De Laat, 2010). Role-play provides a very effective way for students to "dive in" (Resnick & Wilensky, 1997) to a particular situation, and has been established to address a wide range of learning needs from interpersonal or group communication skills to various concepts in history, economics, and sociology (Forsyth, 1999) and science. Participants in role-play learn to adopt another perspective, often that of another person in a simulated situation.

Role-play is a particularly powerful learning strategy in that it involves improvisation, which helps overcome biases through the development of new beliefs (Friedman, 2004). This is because in role-play, participants are sometimes required to behave counter-attitudinally, and the improvisations by which they do so are often based on the role-players' experience and reflections in areas of their daily lives.

However, some participants still cannot play their roles very well due to excessive self-consciousness (Ladrousse, 1989) or evaluation apprehension (Cottrell et al., 1968). For example, microteaching role-play, that is, role-play that trains teachers to engage in communication and decision-making in the classroom, requires participants to play the roles of teacher and young pupils in a realistic way. However, the reactions and feedback provided by student teachers acting as young pupils tend to be unrealistic when they self-perform, especially in that they disproportionally often play honest students who follow the teacher's instructions.

When we consider the matter of providing scaffolding to achieve more realistic role-play, we can be inspired by Holzman (2009)'s ideas about the possibilities of play as imitation in learning, which can elicit an active, creative and fundamentally social process that is essential to creating a zone of proximal development (Vygotsky, 1978). Holzman pointed out that through play, children often imitate what is beyond them in their environment and relationships, and that this enhances their learning. She noted that even adults can learn through play.

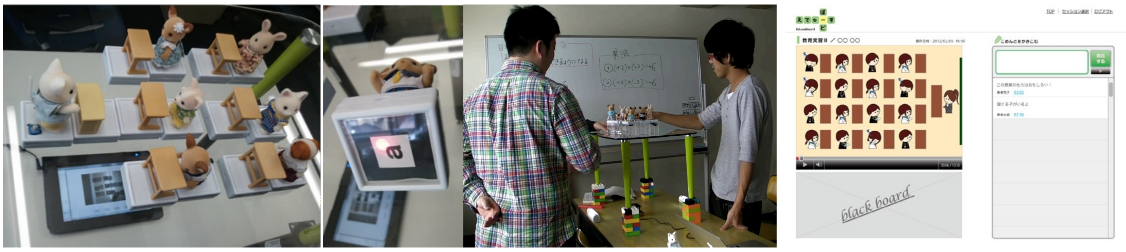
Mochizuki et al. (2013) proposed that puppetry can serve as a powerful device for allowing people to overcome emotional or interpersonal obstacles to face-to-face role-play and for eliciting reactions including inner emotions or unconscious experiences that they have had in a problematic situation. Puppetry is a familiar form of play from infancy through adulthood, a fact that helps participants anticipate and prepare for a number of possible, even unusual, roles. The most important function of puppetry in this regard is that it allows each participant to obtain participant–observer balance by creating a clear separation between self (puppeteer) and non-self (puppet) as well as character (puppet) and observer (puppeteer) while playing a puppetry story. Playing a role distinct from one's own personae can encourage social interaction among shy or passive students who normally have trouble learning from or with their peers (Aubusson et al., 1997). The puppet contains recognizable elements of the self that the puppeteer can identify with. Such projection in puppetry provides a "margin of safety," a balance between underdistance and overdistance (Aronoff, 2005). Thus, puppetry can facilitate the taking of various perspectives by playing roles that rarely appear in self-performed role-play.

EduceBoard: A tangible puppetry role-play support system

We have previously presented the EduceBoard system (Wakimoto et al., 2013), which is a tangible puppetry-based role-play support system intended to enable users to achieve and dramatize possible insights of various characters in the role-play. The system has two functions: 1) engaging in and recording puppetry-play on the table and 2) playing the recordings online to help participants reflect on their performance and choices.

The system records the actions and conversations of the participants (hereinafter, the "actors") on top of a glass table (Figure 1 (a)). In Figure 1, photo (a) shows the system when it is ready to implement. Each puppet or prop is attached to a transparent box with an AR marker on the bottom. In addition, there are red and blue LED lights in the box, and each actor can express his or her puppet's condition by manipulating a switch to change the color of the LED (Figure 1 (b)); for example, in a microteaching role-play, a red LED may represent a sleeping/careless student, and a blue LED an attentive/note-taking student. A web camera and microphone under the table record the puppets' movements and conversations (i.e., the behavior of the actors), by detecting the AR markers. After the role-play (Figure 1 (c)), the system sends the recorded data to a server; the actors can view it online to inspire reflection (Figure 1 (d)). The webpage displays the role-play in animated form, from a bird's-eye view; the actors exchange comments in the box at right and reflect further on their conversations and actions.

This presentation reports the results of a preliminary evaluation of EduceBoard, observing whether the actors can concoct an effective improvisational role-play that dramatizes a variety of reactions to the conversation and whether they can then reflect fruitfully on it from a variety of perspectives using the system.



(a) (b) (c) (d)

Figure 1. The EduceBoard System

Preliminary evaluation: Methods and analysis

The evaluation was conducted using a microteaching role-play because that is a common means of role-play training useful especially when informal discourse appears during the role-play, and there are many schemes to analyze communication among a teacher and students (see Table 1 below). Six university sophomores majoring in informatics and training to get teaching licenses participated. They formed two triads; each of them played once as a teacher and twice as pupils using puppets. Each puppetry session took 10 minutes; then, students watched the recorded role-plays and gave mutual feedback in the comment box on the webpage. Furthermore, they discussed three sessions based on the feedback while watching the recording, and the feedback appeared alongside the animations. All the discussions were video-recorded and transcribed.

Table 1: Definition of codes for utterances in the role-play simulation of microteaching (Fujie (2000))

Utterances	Definition
Teacher-Formal	A teacher's utterance that follows his/her lesson plan or is academic related
Teacher-Informal	A teacher's utterance based on his or her individual experience and reaction to the students
Teacher-Double barreled	A teacher's utterance reflecting the features of both "formal" and "informal" types
Student-Formal	A student's utterance that follows the teacher's instructions or is academic related
Student-Informal	A student's utterance based on his or her individual experience and intention (not academic)
Student-Double barreled	A student's utterance reflecting the features of both "formal" and "informal" types

In addition, to examine the impact of puppetry role-play on self-performed role-play, the students conducted self-performed microteaching role-play in the same group after the puppetry. All the self-performed role-plays had the same topics as the puppetry and were video-recorded. After the role-play, students again watched the videos, and gave mutual feedback on paper. Then they discussed three role-plays based on the feedback. All of the discussions were video-recorded and transcribed.

Table 2: Definition of codes for participants' comments on the recorded role-play (Rosaen et al. (2008))

Comments	Definition
Focus on Teacher-Management	Managing students' behavior, role in organization for a smooth lesson flow
Focus on Teacher-Instruction	Instructional strategy that facilitates the cognitive and social interaction around the goals of the lesson; focuses on the teacher's role
Focus on Student-Management	Managing students' behavior, organization for a smooth lesson flow; focuses on the children's behavior or attitudes
Focus on Student-Instruction	Instructional strategy that facilitates the cognitive and social interaction around the goals of the lesson; focuses on how the students responded to the instruction
Student Achievement	Preservice teacher indicates attention to student learning and achievement or assesses student learning
Other	Other comments or utterances to maintain the conversation

Adapting Fujie (2000)'s coding scheme for teacher-student discourse (Table 1), we coded all of the utterances in the puppetry and self-performed role-plays to examine how the students performed. This scheme was designed to study how classroom discourse is organized, especially focusing on formal academic utterances versus informal or everyday utterances. We wished to identify any differences in role-play discourse that were due to puppet use. Two of the authors carried out independent ratings (κ =.791). In addition, we analyzed the paper and online feedback, adapting Rosaen et al. (2008)'s coding scheme (Table 2) in order to examine how the students reflected on their role-playing in both conditions (κ =.869). The student discussions after giving mutual feedback were coded with the same scheme. Coding discrepancies were reconciled by mutual agreement.

Findings

The discourse analysis shows that the coding categories "Teacher-Formal," "Teacher-Informal," "Student-Formal," and "Student-Informal" are found to have significant differences (Table 3). This explains that the participants tended to use informal discourse more in the puppetry than in the case of normal self-performed role-plays where they rarely used informal one. Consistent with our previous study (Wakimoto et al. 2013), this result indicates that puppetry can allow an improvisational role-play that elicits a variety of reactions from the actors.

Table 3: Total number of categorized utterances in the discourse in the role-play

Utterances	Puppetry	Normal	
Teacher-Formal	353(-)	309(+)	
Teacher-Informal	88(+)	9(-)	
Teacher-Double barreled	23	14	$\chi^2(2) = 50.956$, $p < .01$
Student-Formal	121(-)	88(+)	
Student-Informal	55(+)	8(-)	
Student-Double barreled	26	16	$\chi^2(2) = 17.780$, $p < .01$

Note: (+)(-) are the results based on the residual analysis.

The analysis of the mutual feedbacks and the student discussions finds that the participants tended to give more feedbacks focusing on "Student-Management" and less on "Teacher-Instruction" in the mutual feedbacks and the discussion (Table 4). The participants also talked in the discussion less focusing on teacher-management. These results indicate that the EduceBoard system has possibility to allow the participants to shift their points of view from teacher-centric to student-inclusive even during the reflection.

Also there is an interesting finding is that the participants tended not to play their roles with a variety of informal reactions as is expected in everyday conversations, even after the puppetry. This indicates that the characteristics of normal or self-performed role-play are robust and that there is need of some additional intervention in addition to the use of EduceBoard in order to conduct successful learning transfer.

Table 4: Total number of categorized ideas in comments and discussion

Comments	Comments		Discussion	
	EduceBoard	Normal (Paper)	EduceBoard	Normal
Focus on Teacher-Management	10	9	75(-)	91(+)
Focus on Teacher-Instruction	26(-)	56(+)	147(-)	161(+)
Focus on Student-Management	39(+)	0(-)	112(+)	28
Focus on Student-Instruction	8	10	29	32
Student Achievement	0	0	21	14
Other	0	0	81	107
	Fisher's exact test, $p < .001$		$\chi^2(5) = 50.305$, $p < .01$	

Note: (+)(-) are the results based on the residual analysis.

Discussion

This study shows how the use of puppets as transitional objects that elicit a projection of self (puppeteer) to non-self (puppet) elicited a variety of informal discourse that is rarely used in self-performance but is useful for learning communication in role-play. The EduceBoard system, which records the puppetry role-play, also facilitates reflection from the viewpoints of each of the actors. However, there are some procedural issues remaining with this approach.

One important issue is transfer to the self-performed role-play or actual practice. On the basis of the self-performed role-plays we found that transfer was not effective even immediately after the puppetry role-play with EduceBoard. Hence, more intervention to broaden and deepen students' perspective-taking ability is needed, including development of new curriculum materials. One promising way to foster deep perspective-taking may be through the use of new media, for example virtual environments. Lindgren (2012) indicated that experiencing a first-person perspective on a virtual world can generate a person-centered learning stance and perspective-taking. We consider this to be a potentially effective way to elicit more discussion about not only the performance of a variety of characters in role-play but also the content of reflection and conversation on this performance from the viewpoints of diverse characters. The EduceBoard system can introduce such technologies in order to foster participants' reflection more effectively.

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Enhancing Teacher Education Students' Collaborative Problem-Solving and Shared Regulation of Learning

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Abstract: This study aims to explore how collaborative problem solving (CPS) and socially shared regulation of learning (SSRL) can be enhanced in practice in a technology-rich collaborative learning context within the domain of mathematics. The participants of this study are first-year teacher education students in two Finnish universities. This paper will elaborate how collaborative problem solving (CPS) and socially shared regulation of learning (SSRL) can be supported by scripting and prompting. It is argued here that we need theory-based pedagogical designs for developing effective collaborative learning practices that aim to provide students with possibilities to experience the new collaborative, technology-rich learning culture as teachers-to-be.

Keywords: collaborative problem-solving, socially shared regulation of learning, teacher education

Introduction

21st century skills, such as skills for collaboration and collaborative problem solving, and an ability to take an active role in one's own learning and in the learning of others as well as to make use of technologies in these areas are highlighted as success factors in modern society (e.g. Griffin, McGaw, & Care, 2012). Teacher education students have a significant role in acquiring first-hand experiences of novel learning practices to graduate not only with task mastery but also with adequate skills required in the 21st century. However, skills for collaborative learning do not occur naturally, and the experiences gained by the students are not always positive (Häkkinen et al., 2010; Näykki et al., 2014). For example, when learners are left alone without any guidance, they rarely engage in productive and knowledge-generative interactions (Kirschner et al., 2006) and varied cognitive, motivational, and socio-emotional challenges may emerge (Näykki et al., 2014; Van den Bossche et al., 2006). To face these challenges, we need theory-based pedagogical designs for effective collaborative learning practices that aim to provide student teachers with opportunities to experience the new collaborative, inquiry-based and technology-rich learning culture.

Albeit collaborative problem solving (CPS) skills (Griffin et al., 2012; Griffin & Gare, 2015) and skills for regulation of learning (self-regulated learning, SRL and socially shared regulation of learning, SSRL) (Hadwin, Järvelä, & Miller, 2011) are theoretically characterized as an important part of collaborative learning, little is known about how those skills can be promoted with pedagogical instruments (i.e. scripting, prompting and utilizing technological tools). To rise to these challenges, this study aims to operationalize and combine the notions of CPS and SSRL theories into practice and to implement a theory-based pedagogical and technological design to support CPS and SSRL skills development as a part of inquiry-based teacher education practices in the mathematics domain.

CPS and SSRL skills in collaborative learning

Problem solving, in its individual meaning, points to the activity involving problem identification and analysis, problem representation, planning, executing, and monitoring (Hesse et al., 2015). Collaborative problem solving (CPS) (Griffin et al., 2012; Griffin & Gare, 2015) is a specific form of collaboration, where two or more learners need to externalize the aforementioned problem solving stages (Hesse et al., 2015). That is, to communicate, exchange and share the identification of parts of the problem, their interpretation of the connections between the parts, relationships between action and effect (rules) and the generalization they propose in search for the solution (Hesse et al., 2015). In the PISA 2015 study (OEDC, 2013), CPS competency is defined as the capacity of an individual to effectively engage in this joint and shared problem solving activity. In order to reach the common goal, CPS requires participants to share their understanding and successfully combine their knowledge, skills and efforts (OECD, 2013). However, CPS does not rely on a uniform skill, but draws on a set of sub-skills defined in the ATC21S™ project (Assessment and Teaching of 21st Century Skills; Griffin et al., 2012; Griffin & Gare, 2015). CPS skills consists of five strands of individual and group level capacities under the broad skill classes of social and cognitive skills (Hesse et al., 2015). Following Hesse and colleagues (2015), social skills (i.e. participation, perspective taking, social regulation) are about managing participants (including oneself), referring to the “collaborative” part of collaborative problem solving. Cognitive skills (i.e. task regulation, knowledge building), then, are about managing the task, referring to the “problem solving” part of collaborative problem solving. These skills do not proceed linearly but may overlap and run parallel between the different stages of the CPS process

High-level collaborative learning requires metacognitive, motivational and emotional efforts, which are operationalized here through the theories of self-regulated learning (SRL) and socially shared regulation of learning (SSRL) (Hadwin et al., 2011). Regulation (SRL at individual level and SSRL on group level) in group context means that students are engaged in metacognitive monitoring and controlling of motivation, cognition, and behavior – in addition to and as a requisite for task-level activities. Effective regulation processes in collaborative learning require, for example, groups to set goals and standards together, and to jointly monitor and evaluate their progress against these standards (Zimmerman, 1989). Self-regulated learning theory and the concept of SSRL extend ideas of successful (collaborative) learning beyond cognitive processes and outcomes, acknowledging the interactive roles of motivation, emotion, metacognition, and strategic behavior in successful learning (Järvelä & Hadwin, 2013). Järvelä and others (2014) summarize the need for supporting the challenging factors of collaboration in terms of the cognitive level (i.e. task understanding, content understanding, use of learning strategies), motivational level (i.e. goals, interests, beliefs, expectations), and emotional level (i.e. trust, sense of community).

CPS and SSRL processes both target the cognitive and metacognitive levels: i.e. problem identification, problem representation, planning, execution and monitoring (Hesse et al., 2015; Winne & Hadwin, 1998). Furthermore, both theoretical constructs include the social level, as (meta)cognitive functioning is targeted within group interaction. Like SSRL, CPS, at its core, considers students’ academic engagement in joint and shared problem solving activity as an intentional and goal-oriented activity. But even though CPS competency includes regulation activities and the understanding of the role of students’ engagement in successful problem solving (Hesse et al., 2015), CPS seems, to a large extent, to stay in the cognitive domains of regulation. Also, except for the knowledge building strand of CPS competency, CPS mostly highlights the individual levels of collaborative problem solving (Griffin et al., 2012). However, SSRL expands on these cognitive and group-level aspects of regulation and provides broader understanding of motivation and emotion as essential parts of successful collaborative learning processes. The advantages of combining these approaches within the same framework make it possible to extend from collaborative problem solving to socially shared regulation of learning in collaborative problem solving. Furthermore, we expect that more profound and more permanent CPS and SSRL skills can be enhanced by designing theory-based pedagogical models that enable, in practice, together with the cognitive and metacognitive aspects of collaborative learning, also motivational group processes to become more visible to the teacher students.

CPS and SSRL skills in collaborative learning

Following Järvelä and others (2014), three design principles are further developed and implemented to support CPS and SSRL: (1) scripting, (2) prompting, and (3) utilizing technological tools in collaborative learning tasks. The general aim of the design principles is to increase, first, students’ awareness of their own, other group members’ as well as groups’ learning processes. Second, the aim is to support students’ externalization of situational cognitive, motivational and emotional interpretations and third, to activate problem solving and regulation skills.

Collaborative learning scripts are defined as activity models that aim at enhancing knowledge generative activities during collaborative learning (Tchounikine, 2008). In brief, the scripts may vary from rather coarse-grained macro-scripts (i.e. pedagogical models, such as jigsaw) to more fine-grained micro-scripts (i.e. a model of argumentation) (e.g. Dillenbourg & Hong, 2008). This paper relies on the first approach. In this regard, we have designed a macro-script, a pedagogical PREP21 model that combines elements of both CPS/SSRL processes. The structure of the designed model implements the cyclical idea of SRL learning theories (e.g. Zimmerman, 1989). Starting with orienting and planning whereby groups set goals for their learning (forethought phase), followed by strategic learning activities that are constantly monitored and controlled (performance phase), and completed by reflection and evaluation (reflection phase). The pedagogical model thus includes the elements of purposeful, intentional, and goal-oriented collaborative activity, also recognized as essentials of successful collaborative problem solving processes (Hesse et al., 2015).

To activate and to enhance CPS and SSRL skills, specific prompts utilizing iPads will be designed and used as a part of the pedagogical model of PREP21. Prompting is defined here as an instructional method for guiding and supporting students to activate their problem solving and regulation activities while engaged in task performance (Bannert & Reimann, 2012). Such prompts will focus students' attention on their group members' thoughts and understanding and stimulate cognitive and metacognitive processing. Question prompts will thus instruct groups to stop and reflect on their thoughts or consider the efficiency of their strategies. It is presumed that individual and group level awareness is one of the main factors supporting group members to set goals, monitor and control group functioning as well as evaluate groups' performance and outcomes.

Methods

Design and participants

The study described here is an ongoing sub-study of a four-year research project that aims to promote future teachers' CPS and SSRL skills, and competencies and attitudes towards the use of ICT in teaching and learning. The project includes long-term data collection (during 2014-2016) that combines a quantitative self-report approach and a qualitative process-oriented approach. The sub-study here is part of the latter approach. The participants of the sub-study are first-year teacher education students (n=90) from two Finnish universities, following a mathematics course in early spring 2015. The course design implements the ideas of inquiry-based education to engage students in authentic, ill-structured and complex problem solving. During the task, the students will be working as groups of three to four members. To support the students' working processes, a theory-based pedagogical model that includes prompts and technological tools will be utilized. Technological tools will be implemented for two purposes; firstly, to activate the groups' CPS and SSRL processes and secondly, to support the groups' knowledge co-construction (i.e. through domain specific tools, such as GeoGebra).

Procedure and expected outcomes

The focus of this sub-study is on evaluating groups' learning processes in regard to CPS and SSRL skills (i.e. video observation data) and in terms of their own interpretations of their groups' learning process. In-depth content and interaction analysis will be used for video data in exploring groups' CPS and SSRL processes in detail. It is assumed to be able to recognize different types of groups in regard to the CPS and SSRL skills and processes (differences in terms of quantity and quality of CPS and SSRL). It is also expected to find out how CPS/SSRL processes are activated and sustained; i.e. what kind of interaction triggers the actualization of the specific processes at group level. The groups' task products will be evaluated according to task-related, academic requirements and they will be used as an outcome measure of their group learning. By combining process analysis with the outcomes it is possible to find out whether groups with high and low levels of CPS/SSRL skills and processes also differ in terms of their academic outcomes. Data examples of the implementation will be presented.

Conclusions

The particular challenge in this study is to combine CSP and SSRL processes within the same theoretical framework, which aims to extend from collaborative problem solving to socially shared regulation of learning in collaborative problem solving. There are many crossings between CPS and SSRL skills. For example, the capacity to be a purposeful and engaged learner (as part of a collective) is common to both CPS and SSRL. In this regard, we might here also speak in terms of engaging in collaborative problem solving, which aptly relates to both the cognitive and motivational areas of regulation as well as to strands related to collaborative problem solving. However, it is apparent that conceptual studies and empirical experimentations are needed to operationalize and re-define the theoretical construction utilized in the ongoing sub-study described here.

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The Mediating Role of Interactive Learning Activities in CSCL: An INPUT-PROCESS-OUTCOME Model

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Abstract: Computer-support for collaborative learning has been shown to be most effective if it is designed to foster productive social interactions. In this conceptual paper, we propose an INPUT-PROCESS-OUTCOME model to guide research on the defining features, and on the conditions and effects of such productive interactions in CSCL. The model builds upon the recently proposed *interactive-constructive-active-passive*-framework of overt learning activities (ICAP; Chi, 2009). We propose that the *interactive* mode of learning is a fruitful concept for specifying what constitutes productive social interaction in CSCL, given several conceptual and methodological clarifications. The mediating role of *interactive* learning activities in CSCL is highlighted by the proposed INPUT-PROCESS-OUTCOME model, and supported by recent empirical findings. Building on a brief review of exemplary findings, we discuss challenges and opportunities for future research in CSCL.

Keywords: input-process-output model, interactive learning activities, process analysis, mediation

Introduction

Computer-support for collaborative learning has been shown to be most effective if it is designed to foster productive social interactions, such as mutual explanation, shared regulation, or argumentation (Dillenbourg, Järvelä, & Fischer, 2009). In order to identify such productive interactions, CSCL researchers typically analyze process data, for instance from automatically generated log files or from audio-video-recordings (Rummel, Deiglmayr, Spada, Karimanis, & Avouris, 2011). However, it still remains unclear what exactly constitutes productive social interaction in CSCL. This is true even when restricting this question to the socio-cognitive perspective of learning, as adopted by the authors of this paper. The socio-cognitive perspective views individual knowledge and skill acquisition as the most relevant outcomes of CSCL, and productive interaction as a means of fostering individual learning. In this paper, we propose an INPUT-PROCESS-OUTCOME model designed to guide research on three questions that are at the heart of CSCL research (cf. Dillenbourg et al., 2009): What constitutes productive social interactions in CSCL? Under what conditions do such productive social interactions occur? What effects do they have on learning?

To address the first question, we build on the recently proposed interactive-constructive-active-passive-framework (ICAP; Chi, 2009). We propose that the *interactive* mode of learning is a fruitful concept for specifying what constitutes productive social interaction in CSCL. We briefly introduce the framework and add necessary conceptual and methodological clarifications. To address the second and third question, we introduce an INPUT-PROCESS-OUTCOME model and provide some exemplary empirical evidence which demonstrates the mediating role of interactive learning activities in CSCL. Note that we do not claim to be answering the second and third question yet. The model is designed to guide research efforts targeting these questions.

Productive interactions in CSCL

The ICAP framework

According to the ICAP-framework educators achieve the highest learning gains in their students if they succeed in facilitating so-called *interactive* learning activities. In line with previous research on productive social interactions in CSCL, being interactive in ICAP entails the co-construction of novel ideas in dialogue in which “both partners [are] taking turns mutually creating” (Chi & Wylie, 2014, p. 228). For instance, both students might give and incorporate feedback, compare and integrate alternative perspectives, or challenge one another’s ideas. Such interactive learning activities are differentiated from three lower levels of overt learning activities: *Constructive* learning activities comprise processes of inferring new information and integrating new information with existing prior knowledge, through learning activities such as self-explaining, constructing concept maps or otherwise making sense of learning materials. *Active* learning activities include activities such as selecting and summarizing new information, without going beyond the information presented in the learning materials. *Passive* learning activities denote attending to information, without actively engaging with the learning materials. Higher levels of learning activities subsume all lower levels. In consequence, being *interactive* (e.g. replying to a peer`s argument with a counterargument) requires also being *constructive* (e.g. constructing one`s argument), *active* (e.g., selecting which aspect of the peer`s argument to address), and *passive* (e.g. reading the peer`s argument). In terms of their effectiveness for learning, the framework hypothesizes the following sequence: interactive > constructive > active > passive learning activities.

In summary, the specification of productive learning activities, in particular *interactive* ones, within the ICAP-framework is in line with existing research on productive social interaction in CSCL (Dillenbourg et al., 2009). However, ICAP adds the benefits of a systematic taxonomy, and yields fruitful hypotheses for the differential effectiveness of different kinds of observable activities (e.g., *interactive* versus *constructive*). Recent research has yielded coding schemes for classifying observable learning activities (e.g. from log files, discourse, collaboratively and individually produced texts) according to the levels of the ICAP taxonomy (Deiglmayr & Schalk, 2013, submitted; Olsen, Rummel, & Aleven, 2015; Vogel, Kollar, Reichersdorfer, Ufer, Reiss, & Fischer, 2013, submitted). This line of research also proposes to further differentiate interactive learning activities, for example according to the level of symmetry of the collaborative relationship (instructive vs. joint dialogues; Chi, 2009), according to the function of the interactive activity (argumentation vs. co-construction; Vogel et al, submitted), or according to the relevance with regard to domain principles (principle-based interactive turns; Deiglmayr & Schalk, submitted).

Limitations of the ICAP framework

The ICAP framework has received initial support from empirical studies (for an overview, see Chi & Wylie, 2014), and we will provide further data supporting it in this paper. Nevertheless, important conceptual and empirical questions remain yet to be answered.

As we know from a rich base of studies in CSCL, a collaborative learning setting does not automatically entail productive social interactions, that is, *interactive* learning activities (Dillenbourg et al., 2009). For example, a student might merely read messages, explanations, and arguments posted in a chat-based learning environment, thus demonstrating only *passive* learning activities. Other students might work towards quick consensus building by copying solutions from a worked example and signaling agreement, thus engaging in only *active* learning activities. Other students might construct elaborated arguments in a form of "individual dialogue" (Chi, 2009), that is, without taking up a partner`s feedback or contributions, thus being *constructive*, but not interactive. Only once students build upon each other's contributions they would be said to engage in *interactive* learning activities. Similarly, Chi and Wylie (2014) state that it is the enacted learning activities that count (i.e., the activities actually shown by the learners) and not the intended learning activities (i.e., the ones the instruction was designed to trigger). Yet, the exemplary studies cited by the authors of ICAP in favor of the hypothesized benefit of interactive over constructive learning activities (Chi, 2009; Chi & Wylie, 2014) operationalize this contrast as a comparison between an individual learning condition (e.g., individual concept mapping or individual note taking) and a collaborative learning condition (e.g., collaborative concept mapping or collaborative note taking). While these conditions were designed to trigger either constructive or interactive learning activities, Chi and Wylie (2014) do not present data on how the learners actually engaged with the learning materials. Therefore, additional research is needed, which addresses the effectiveness of interactive learning activities by looking at process data (i.e., actually enacted learning activities), and which also compares the effectiveness of different kinds of enacted learning activities within collaborative settings. The studies employing coding schemes for assessing interactive learning activities, as summarized above (Deiglmayr & Schalk, submitted; Olsen et al., 2015; Vogel et al., submitted), are among the first to test the validity of the ICAP framework based on actual process data. These studies show that a collaborative setting – even if designed to facilitate interactive learning activities – does not guarantee that all students engage in interactive learning activities. The extent to which students do participate in interactive learning activities at critical moments of the collaborative process, however, appears to be positively correlated with their learning outcomes (see below for details).

Conditions and effects of interactive learning activities in CSCL

To guide further research efforts, we propose an INPUT-PROCESS-OUTCOME model highlighting the mediating effect of interactive learning activities in CSCL (Figure 1). Learning activities, and in particular interactive learning activities, are deemed to be the most important PROCESSES that mediate between design decisions and outcomes in CSCL. The occurrence of productive social interactions, that is, *interactive* learning activities, are dependent on the INPUT conditions, such as specific features of CSCL environments (e.g., the presence of a collaboration script), or individual learner characteristics (e.g., prior knowledge). Further, context features such as the learning setting, teacher variables, or characteristics of the learner group, play important roles. OUTCOMES can be described on different levels and dimensions (e.g. group vs. individual; cognitive, metacognitive, affective, motivational); it is important to note that we focus on individual, cognitive learning outcomes here (i.e., individual knowledge and skill acquisition).

Introducing a formal taxonomy of learning activities, such as ICAP, allows for testable predictions about the causal mechanism by which given INPUTS (e.g., the presence of a collaboration script or the feedback from an adaptive CSCL system) have effects on selected OUTCOMES (e.g., individual acquisition of content knowledge and/or collaboration skills). The model is adapted from models of statistical mediation (e.g., Hayes, 2013), and allows the specification of both direct effects (INPUT-OUTCOME LINK) and indirect, that is, mediated, effects (INPUT-PROCESS-OUTCOME link). INPUT-PROCESS-OUTCOME models are also popular in the literature on teamwork (e.g., vanKnippenberg, de Dreu, & Homan, 2004). However, in that literature, the OUTCOME of interest is typically some measure of team performance (e.g., quality of group products; team creativity). Individual learning and transfer is of interest only as far as it contributes to team performance; that is, individual learning is a PROCESS feature rather than an OUTCOME in models of effective teamwork (e.g., Ilgen, Hollenbeck, Johnson, & Jundt, 2005). Further, PROCESSES such as specialization and division of labor, are often conducive to team performance, but may actually hinder individual learning (Deiglmayr & Schalk, 2013, submitted). Therefore, it is important that CSCL research continues to develop its own theories of what constitutes effective interaction. We propose that integrating the ICAP framework in an INPUT-PROCESS-OUTCOME model is one useful starting point. In the following we will provide examples of recent studies that yielded first evidence for the presumed causal links in the model.

Evidence for the direct INPUT-OUTCOME link

As already mentioned, Chi and Wylie (2014) cite several studies which demonstrate that collaborative learning settings designed to facilitate *interactive* learning activities (INPUT) led to higher individual learning OUTCOMES, compared to structurally similar individual learning settings designed to facilitate *constructive* learning activities. While we can take these studies as support for the direct INPUT-OUTCOME link, process data are needed to show that the benefits really are mediated by higher levels of enacted interactive learning activities.

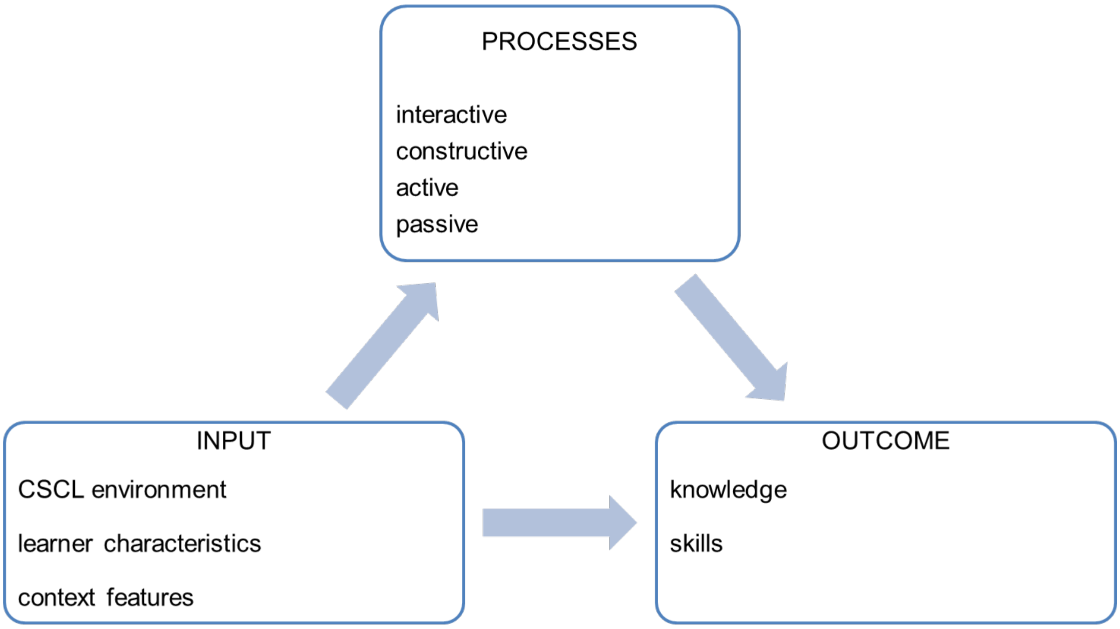

Figure 1. The mediating role of interactive learning activities in CSCL

Evidence for the INPUT-PROCESS link

Evidence for the INPUT-PROCESS link is provided by studies which show that specific features of a CSCL environment (INPUT) actually lead to higher (or lower) levels of *constructive* or *interactive* learning activities (PROCESS).

Vogel et al.(2013, submitted) assessed students' argumentation and knowledge co-construction in mathematical proof tasks. They differentiated between *constructive* learning activities and two types of *interactive* learning activities: *interactive* argumentation and *interactive* co-construction (PROCESS). In line with the authors' hypothesis, introducing a collaboration script (INPUT) led to higher levels of *interactive* argumentation and of *constructive* learning activities, but did not influence *interactive* co-construction.

Olsen et al. (2015) assessed the proportion of *interactive* dialogue, as compared to other types of talk (PROCESS), which resulted from three design features implemented in their CSCL environment. These INPUT features were the presence/absence of a role script, of cognitive group awareness features, and of the distribution of information across partners. The results show that the three design features led to different proportions of *interactive* dialogue vs. other talk. The highest proportion was obtained for distribution of information, while the two other INPUT features yielded smaller amounts of *interactive* dialogue.

Evidence for the PROCESS-OUTCOME link

Evidence for the PROCESS-OUTCOME link is provided by studies which show that higher levels of *interactive* learning activities in students` dialogues (PROCESS) lead to higher levels of individual learning (OUTCOMES). The findings obtained by Vogel et al. (submitted) show that students` participation in *interactive* argumentation with their partner (but neither *interactive* co-construction nor *constructive* activities) was a significant predictor for their acquisition of argumentation knowledge, thus yielding evidence of the PROCESS-OUTCOME link in addition to their evidence for the INPUT-PROCESS link (see above). However, evidence for the INPUT-PROCESS link does not automatically entail evidence for the PROCESS-OUTCOME link. For example, Olsen et al. (2015) did not find a positive correlation between the amount of interactive dialogue (PROCESS) and indicators of individual learning (OUTCOME).

Evidence for the indirect INPUT-PROCESS-OUTCOME link

To demonstrate the indirect INPUT-PROCESS-OUTCOME link, evidence for the two partial links is not sufficient. Rather, evidence for the mediating role of PROCESS features needs to be established, for example employing the statistical techniques of path analysis, regression-based mediation, or structural equation modelling (Hayes, 2013). One example of evidence for the indirect link is a recent study by Deiglmayr and Schalk (2013, submitted). These authors showed that two different ways of distributing learning resources among learners in a jigsaw-type collaboration script (INPUT) led to different levels of interactive and constructive learning activities during a subsequent collaborative problem solving phase (PROCESS). In particular, learners with low prior knowledge participated much more frequently in interactive learning activities (operationalized as the co-construction of principle-based explanations) if the distribution of learning materials created weak rather than strong knowledge interdependence between learners. Further, higher engagement in interactive (but not constructive) learning activities (PROCESS) was positively related to individual learning (OUTCOME). A series of regression analyses showed that the effect of experimental condition (INPUT) on individual learning (OUTCOME) was partially mediated by the level of participation in interactive knowledge construction (PROCESS), yielding evidence for the indirect INPUT-PROCESS-OUTCOME link.

Challenges and opportunities for future research

As demonstrated by the cited studies, varying the INPUT does not automatically lead to the intended PROCESSES or OUTCOMES. There are several explanations for a lacking effect, which each yield hypotheses for future research, conceptual refinements of the proposed model, and the development of improved methods:

1. *Interactive learning in CSCL needs to be defined and analysed more carefully.* The study by Vogel et al. (submitted) indicates that not all interactive learning activities may be equally affected by INPUT variables (such as a collaboration script) and, more importantly, that these different interactive learning activities do not seem to be equally effective for learning. Thus, CSCL research needs to carefully differentiate between different kinds of interactive learning activities.
2. *Methods for measuring the degrees to which learning is passive, active, constructive, or interactive need to be refined.* The studies summarized in this paper all used different, study-specific coding and rating schemes for assessing the degree to which learners` contribution in CSCL were constructive or interactive. Conceptual clarifications of what constitute effective interactive learning activities in CSCL (see bullet point above) will also allow for more refined methods of analysing process data, and for greater comparability across studies.
3. *There might be an optimal degree of interactivity*, beyond which no increase (or even a decrease) in intended outcomes might be observed. Rather than the total amount of interactive learning activities,

their proportion in relation to other activities, their timing, or possibly their number in comparison to some threshold might be most relevant measure for predicting OUTCOMES.

4. *INPUT features affect OUTCOME through other PROCESSES than interactive learning activities.* While interactive learning activities, such as the co-construction of knowledge, are the main goal of many CSCL designers and educators, they are not the only processes that may lead to learning. Thus, even within a collaborative setting, CSCL research needs to also pay attention to other productive activities, such as constructive or active learning activities that occur at an individual level rather than in learners` interaction.
5. *Third variables moderate the effects.* As the findings by Olsen et al. (2015) demonstrate, some INPUT variables may affect PROCESSES in the intended way, but without affecting the intended OUTCOMES. Potential explanations include third variables, such as learner characteristics (cf. Deiglmayr & Schalk, submitted), the specified learning goals, or the type of assessment. For example, third factors, such as prior knowledge, may lead to higher learning gains as well as higher engagement in interactive learning activities. Thus, CSCL research should carefully consider possible moderators (cf. Hayes, 2013).

To conclude, the proposed INPUT-PROCESS-OUTCOME model which incorporates the ICAP-framework as PROCESS component can guide future research efforts. While the model has already been supported by some findings, future work is needed to address the open questions highlighted above.

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Orchestration Challenges Raised by Transposing a Paper-Based Individual Activity into a Tablet-Based CSCL Activity: An Example

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Abstract: This article presents an analysis of the implementation and orchestration challenges raised by turning a traditional paper-based activity (dictation) into a CSCL activity. It illustrates how implementing a CSCL version of a classical teaching setting can raise many new issues for teachers. Teachers must make design (scripting) decisions at different stages, both before and during the session. Some support must therefore be provided, such as means to manage learner productions, focus learner tasks or support learner interactions in different ways. Although the concerns identified and the features implemented here relate to a particular study, they may have a wider scope of application.

Keywords: orchestration, CSCL scripts, tools for teachers, tablets

Introduction

A limiting factor to the introduction of CSCL in standard practices is that collaborative activities, especially computer-based collaborative activities, may be more complex for teachers to manage than traditional ones. This issue may be addressed using the notion of orchestration, which has been defined as "how a teacher manages, in real-time, multi-layered activities in a multi-constraints context" (Dillenbourg, 2013). The balance between the interest of the CSCL activity (with respect to an individual and/or not-computer-supported activity) and the difficulty of orchestrating it is a crucial issue. To promote adoption of CSCL activities, teachers should be offered tools that help them orchestrate the setting. At this level, a known issue is that tools that are not sufficiently user-friendly and adapted to the unpredictable context of a classroom may discourage teachers from engaging in CSCL activities (Roschelle, Dimitriadis, & Hoppe, 2013).

In the context of scripted collaborative activities, orchestration may be seen as comprising scripting (primo- and runtime scripting) and conducting activities (Tchounikine, 2013). Primo-scripting consists in defining the learners' tasks, roles, and resources before the session. Conducting consists in monitoring and analyzing learner performance and, on this basis, engaging in actions such as providing hints or adapting details (e.g., moving a learner from one group to another if it will not change any important aspect of the setting rationale). Runtime scripting consists in making or reconsidering design decisions according to the actual performance.

In this ongoing project, we are investigating what means should be proposed to teachers to orchestrate CSCL settings. For this purpose, we identified a paper-based pedagogical activity that is traditionally conducted individually. Then, using an iterative and participative methodology, we designed a computer-based collaborative version of the same activity. This version includes a task-related system that allows learners to perform the activity and a minimal version of an orchestration system that, for the moment, just allows teachers to set the session and carry out the necessary conducting and runtime scripting actions. Working with teachers on the design of these systems and then conducting preliminary tests shed some light on orchestration issues and the requirements for a full-fledged orchestration tool.

In the next section, we will present the pedagogical activity we used as an example and identity the implementation and orchestration challenges encountered. We will then present and discuss the lessons learned from preliminary experiments.

From a paper-based individual activity to a CSCL activity

Dictation is a standard primary school exercise. The teacher dictates a text to the class, and students must write it out with as few mistakes as possible. The educational objectives are numerous: learning new words; translating spoken language into written language; applying knowledge of grammar and conjugation; and learning to correct oneself using this knowledge. However, this last objective is probably the hardest one to reach as it is difficult for students to identify their own mistakes.

To address this issue, negotiated dictation is an option (Cellier, 2004). First, students do a regular dictation. Second, the teacher retrieves all the students' productions, examines them, and creates groups of three or four. Each group has to collaboratively rewrite a common version of the text using their individual dictations. This task involves spotting the differences in the individual texts, agreeing on a common version, and justifying the final text. During this phase, the teacher interacts with groups only to unblock/support them or solve conflicts. Finally, in an institutionalization phase, teachers may (for example) retrieve all the groups' dictations and engage in a discussion with the whole class. This is the scripted setting we implemented: we respected its rationale and individual/collective structure, and worked out how to support it using electronic devices.

In the national context within which this project is conducted, implementation of negotiated dictations in basic practice is still uncommon. The four school teachers with whom we worked, and all the ones with whom we informally discussed, unanimously acknowledged that it is a highly interesting setting. Yet, it is also much more complex for teachers to manage, and its implementation raises many interrelated orchestration issues. Working with these school teachers allowed us to identify some of these challenges.

Due to space limitations, in this section we will both introduce our design and explain the orchestration challenges (*in italics*).

The first design decision was to equip all students, and the teacher, with an individual tablet. With respect to the collaboration objective, the mobility of tablets enables students to join their group with their tablet. Moreover, the possibility to lay them flat on a table prevents the devices from being seen as physical barriers and promotes face-to-face interactions between learners (Alvarez, Brown, & Nussbaum, 2011).

With respect to orchestration issues, the use of tablets presents the following advantages:

- *Respects learner pace*. The dictation is stored in an audio file and cut into small sections that students listen to using headphones (see Figure 1, A). This allows each student to type and edit the dictation (individual phase; see Figure 1, B) at his/her own pace, and to listen to sections again as needed. From a teacher perspective, it makes it possible to respect individual differences, which is impossible when orally dictating to the class.
- *Facilitates teacher support*. Using a tablet allows the teacher to conduct the session while physically going from one student/group to another and helping them as needed.

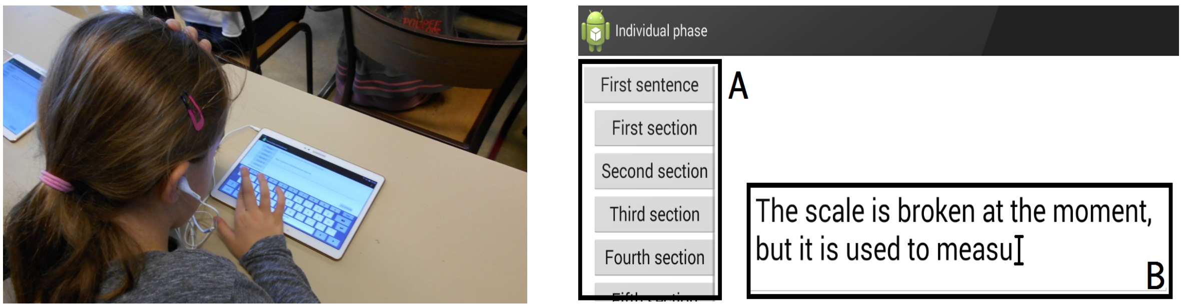

Figure 1. Student interface during the individual phase (using an example in English).

The students produce a digital file (list of characters), which may thus be computationally manipulated. This allows for different issues to be addressed, including the following:

- *Facilitating teacher management of learner productions*. In the described setting, this issue is critical because groups are created between the individual and the collective phase. In the paper-based version, collecting and analyzing the student's dictations is time-consuming, and the collective phase is often delayed to the day after. In our design, the teacher is presented with a compilation of the individual dictations immediately after the individual phase, and provided with tools to set and launch the collective phase with no delay (see below).
- *Focusing learner tasks*. In the paper-based version, when students work together they have to copy the entire text again, which is tedious. In our design, when a group is constituted they can manipulate their individual productions to create their collective version. This makes it possible for groups to focus on the goal of the exercise, i.e., to collaboratively consider the grammatical rules and their applications, instead of wasting time rewriting the dictation.

- *Allowing grouping flexibility*. Because of the static nature of paper, it is impractical to modify groups during the collective phase of a traditional negotiated dictation. In our design, groups may be changed on the fly, with data managed accordingly on the tablets (this is also another example of *facilitating teacher management of learner productions*). A student may thus be prompted to negotiate the first sentence with two peers and the second sentence with two others. This allows the setting to be scripted by implementing *a priori* strategies—such as creating homogeneous groups (as a way to promote collaborative construction of justifications) or heterogeneous groups (as a way to promote tutoring interactions)—and then, while groups enact the collaborative phase, adapting the groups on the fly.

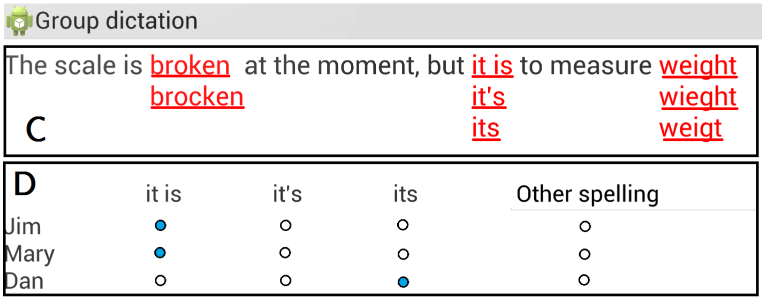

Figure 2. Student interface #1 during the collective phase: aligned dictation and voting tool

Considering together the design of the system offered to students and the orchestration issues led us to elaborate new notions such as “aligned dictation”. An aligned dictation merges the group’s three individual dictations (see student view in Figure 2, C; each word appears as many times as there are different spellings for it in the individual dictations; following the teachers’ suggestion, the dictations are not tagged with the students’ names to avoid stigmatization). This calls the students’ attention to the differences and allows them to fully focus on their negotiation/justification tasks. The aligned dictation also opens up further possibilities to *focus learner tasks* by designating and/or ordering words that a given group should negotiate (in red and underlined in Figure 2, C). These words may be designated before the session (primo-scripting) or once the teacher has analyzed students’ individual productions (run-time scripting), by selecting these words in the aligned dictations.

The “aligned dictation” notion, however, raises *teacher management of learner productions* issues, including a very practical one. As students may write words in an incorrect way (e.g., writing “your self” instead of “yourself”) or omit some words, the words in individual dictations may not correspond one to one. To address this orchestration issue, we designed a production management tool that displays the dictations one below the other on the teacher’s tablet and offers him/her features to align the dictations by merging multiple words into a single word, dividing words into multiple words, or adding blank words (via “gestures”, i.e., direct manipulations on the tablet screen, Figure 3). In Figure 3, the first line shows the correct sentence as the reference for aligning the dictations as necessary. Here, the string “moment,but” must be separated into two words. In some cases, such as this one, the required treatment is obvious and may be more or less automated; in others it requires human intervention, which is the rationale for this tool.

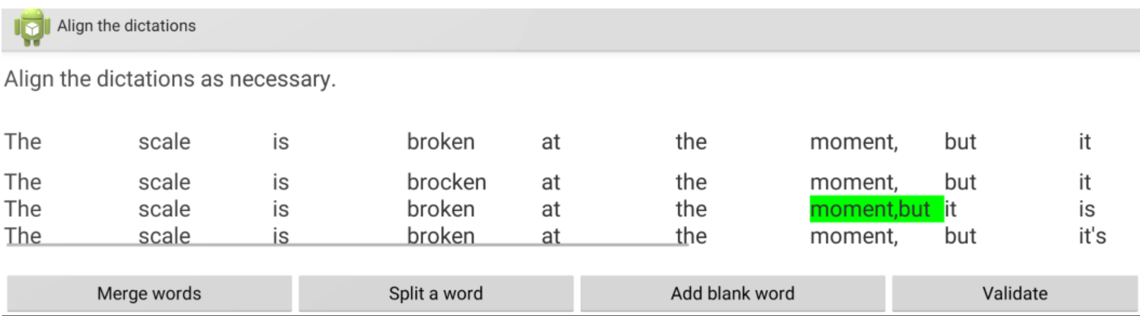

Figure 3. Teacher interface to align the students' dictations.

Another important orchestration aspect is *offering teachers different ways of supporting learners*. The *raison d’être* of negotiated dictations is to make students discuss grammar and conjugation rules and how they apply. Researchers and practitioners agree that it is difficult for students/groups to engage in such interactions and propose well-constructed justifications. This difficulty depends on multiple factors, such as the students' characteristics, group composition, the dictation, or students' experiences with this exercise. To deal with this, teachers are interested in means for adapting the support provided to students.

To explore this issue, we designed an agreement/justification support tool that functions as follows: During the collective phase, the groups of three students share two dedicated tablets. On the first one, they start by selecting the word or group of words to be negotiated by touching it on the screen (Figure 2, C). The system then displays a voting tool (Figure 2, D) on that same tablet. This voting tool requires students to adopt an individual position (which may be the same as or different from that of their peers) by selecting a spelling (i.e., agreeing on one of the solutions submitted by students) or proposing a new one. When they have voted, the system displays a justification tool on the second tablet. Different options are available for this phase (Figure 4). For example, support can be provided in the form of predefined justifications, or students can be asked to type their own justification in a blank text box.

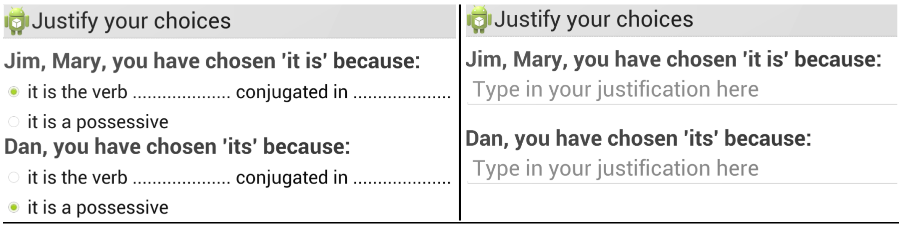

Figure 4. Student interface #2 during the collective phase: two different justification tools.

As a final summary, the activity proceeds as follows: Students first copy a predefined sentence to get used to the tablet, and then engage in their individual dictation. The teacher then terminates that phase, aligns the dictations, creates the groups, and then defines the words groups should negotiate. The students are assigned to a group via a message on their tablet and join their peers. Each student/tablet in a group is associated with a role: one tablet displays the group's aligned dictations and the "voting" device (Figure 2, C and D); one tablet displays the selected justification tool (Figure 4); and the third tablet displays some help (e.g. conjugation tables). Here again, this gives options, such as switching roles. Finally, the teacher receives all the group dictations and justifications and can proceed to the institutionalization phase. Although we have not yet addressed this phase, teacher interviews and overall design characteristics suggest many strategies based on displaying/sorting the different dictations and/or justifications.

Preliminary tests and lessons learned

We conducted preliminary tests with three successive groups of three students (grade 4, 9-10 years old) and then a second test in a classroom (grade 4, 28 students). The first test included the individual and collective phases. It aimed to verify technical functioning and usability of the student system; to determine whether students negotiate; and to verify technical functioning of the system (i.e., that it enables setting the session, visualizing and aligning dictations, creating groups, and prompting students to join their group for the collective phase). The second test focused on the individual phase. It was conducted in half-classes, i.e., approximately 15 students working on the dictation while the others worked on other activities. It aimed to verify that the setting could be deployed in an actual classroom, i.e., given the potential technical and pedagogical issues related to use of the system by 15 students, and to identify further orchestration issues. The considerations identified hereafter are based on data collected during these two preliminary tests.

Some of the students were already familiar with tablets because they had one at home, while others were discovering this type of device for the first time. None of the students, including those who were unfamiliar with tablets, had serious difficulty in manipulating the tablets or, most critically, typing the dictations. All of them quickly became familiar with the system. There were, however, important differences in how long it took to type the dictation, with times ranging from 13 to 26 minutes, and average and median times close to 20 minutes.

All the students tested indicated high appreciation of being able to listen to the audio dictation at their own pace and to listen to sections again as needed.

The first test, within which the groups used the system during the negotiation phase, showed they do collaborate. This corroborates the findings of not-computer-supported negotiated dictations. How the system's overall design (e.g., the aligned dictations) and the justification interface (e.g., use of predefined sentences) impact this negotiation will be examined in future studies with a larger number of groups. However, studies related to scripted argumentation (Stegmann et al., 2007; Weinberger et al., 2010) suggest that such design may positively impact collaboration.

With respect to orchestration, teachers were afraid that students' dictations would be difficult to align. In fact, very few required merging or dividing effective words. However, many dictations did not respect typographic conventions regarding the use of whitespace characters with punctuation marks. This suggests a need to support teachers by implementing an automated preprocessing phase prior to manual alignment to manage easy cases (i.e., another *teacher management of learner productions* tool). Similarly, it may be useful to facilitate teacher grouping process. In both cases, interactions with teachers clearly define the design strategy to be adopted: propose a solution to the teacher, who can accept or refine it as needed.

These tests also suggested additional features that the full-fledged orchestration tool should provide, including the following:

- *Heterogeneity management*. The counterpart of the (positive) fact that students go at their own pace is that, in a given amount of time, they will write a significantly different number of sentences (see the figures on dictation typing time). In the tested groups, there were also disparities in the time spent justifying words. This highlights the importance of helping teachers deal with heterogeneity. In our case, it may be addressed by offering teachers the means to decide when to stop the individual phase (typically, when all students have advanced sufficiently to have issues to negotiate on), then adapt the number of words to justify, and finally manage the groups accordingly. Another option is to offer teachers means to decide whether some students should skip to the collective phase while others continue the individual one, and to manage the activity accordingly.
- *Management of technical issues*. Teachers are often reluctant to use technology because the systems may not work. This is wise. Addressing this issue presents a technical challenge. In our case, given how tablets function, it is technically impossible to prevent students from quitting the application and/or generating events that may cause the application or network to break down. Therefore, it has proven essential that the technical architecture be natively designed to account for the fact that such problems will occur and deal with them, i.e., that teachers be offered features to seamlessly reintegrate students facing technical issues into the activity without disturbing others.

Discussion

The first test we conducted allowed us to check technical aspects of the system and its usability. The second test confirmed the usability and provided hints for further orchestration means. Both of these tests, although involving a limited number of students/groups, suggest that the CSCL version of the exercise works well. However, because of the innovative nature of this project, the setting has two important characteristics that make it difficult to analyze results.

The first issue concerns disentangling the effect of the system's designed properties from the impact of using a new technology in classroom. The students were not used to working with tablets in a school context, and some were even manipulating tablets for the first time. Their general reaction was very positive, as suggested by their enthusiasm when they discovered the tablets, their use of the devices and their wishes to use the system again. At this level, however, it is difficult to separate the effects of the system and its designed features from the effects of using some "cool" technology in class.

The second issue involves disentangling the tool from the procedure. Negotiated dictation is still very uncommon, and none of the teachers or students had participated in such a task before. The positive feedback from teachers and students may thus be partly related to the negotiated dictation principle and partly to how the system supports it.

Disentangling these aspects is not easy, and requires repeating experiments.

Nevertheless, these tests at least illustrate how the technology facilitates the negotiated dictation procedure (e.g., by avoiding copying text) and provides teaching options (e.g., by offering different types of justification support). They further suggest that the design is usable (students reported no difficulty and acted intuitively).

Conclusion

We have presented a case study that illustrates different aspects of CSCL scripted settings orchestration issues. First, implementing a CSCL version of a very classical teaching setting may raise many new orchestration issues for teachers, which may prevent "teachers acting in standard situations" (as opposed to "teachers acting with researchers") from taking the plunge. It is therefore important to consider teachers' perspectives and requests as such, and offer them high flexibility. Second, considering the task-oriented system and the orchestration system jointly suggests design options for both systems. Third, orchestration requires that teachers make design (scripting) decisions at different stages, both before and during the session.

Although this is far from an exhaustive typology, we have highlighted and illustrated a number of orchestration features that were implemented in a context-specific way but have a larger scope of application: facilitating teacher management of learner productions; focusing learner tasks; enabling grouping flexibility; offering different ways of supporting learners; offering means for managing heterogeneity; and offering means for managing technical issues. These features include conducting features (means to respect individual learning paces, offer different supports, facilitate teacher support for learners, facilitate teacher management of learner productions, manage heterogeneity, and manage technical issues) and scripting features (means to facilitate the grouping process, to allow group flexibility, to focus learners' tasks, and to support learners interactions in different ways).

The research agenda includes deepening these orchestration features, studying how to avoid overwhelming teachers with too many options or too much information, and empirically studying whether the proposed features allow them to satisfactorily orchestrate the session.

Whether the system allows teachers to adequately orchestrate the session may be regarded from different perspectives. One is the output in terms of learner collaboration and learning. The other is the teacher's perception of how the system allows him/her to set and manage the session. For instance, we mentioned that teachers proposed different ways of supporting/constraining learner interactions (allowing differences or imposing one group answer; asking for individual or group justifications; proposing a predefined justification sentence to be instantiated or no support). The outputs of these strategies in terms of learner collaboration and learning may be tested by empirical work. From an orchestration perspective, however, another interesting aspect is that teachers had different opinions on the strategy they would like to use, and reported that it would vary by learner and over time. Offering teachers the flexibility to decide (and to change decisions on the fly if/when needed) was perceived positively, whereas imposing an option could prevent adoption of the system. Studying these aspects is a critical issue for research on orchestration and, more generally, educational software design (Tchounikine, 2011).

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AutBlocks: Using Collaborative Learning to Develop Joint Attention Skills for Children with Autism Spectrum Disorder

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Abstract: The development of Joint Attention skills for children with Autism Spectrum Disorder is an important pre-requisite to them achieving their full potential in terms of social and emotional interaction skills as they progress through childhood. This paper describes the development of a multiuser collaborative game using gestural interaction to provide autistic children with social interaction difficulties a means to build, practice and consolidate their joint attention skills. The feedback and experiences of a group of teachers of children with Autism are also presented for analysis and planning for future work.

Keywords: autism spectrum disorder, joint attention, gesture control, game design

Introduction

Social interaction and communication skills play a pivotal role in the development of a child's ability to form meaningful social and emotional relationships in later life. For typically developing children the development of social interaction skills follows a predictable developmental trajectory. For children with Austism Spectrum Disorder (ASD) the ability to correctly understand social behaviours is impaired such that they have difficulties identifying, interpreting and reproducing the general palette of behaviors that we use when interacting with others.

ASD is a neurodevelopmental disorder that is characterized by the presence of a triad of symptoms: communication disabilities, impairment of social interaction and the presence of repetitive, restricted and stereotyped patterns of behavior (Wing & Gould 1979). Difficulties in social interaction presents as one of the most significant problems faced by children with ASD, impacting upon their ability to communicate and cooperate with parents, siblings, peers and other adults. Children with ASD will often be unable to interpret verbal and non-verbal social cues such as speech, facial expressions or gestures and are less likely to initiate interactions with others or engage in cooperative play. This leads to more limited opportunities social interaction or to practice social strategies restricting children to playing on their own or engaging in a narrow repertoire of behaviours and interests. *Joint attention* refers to a child's ability to "coordinate attention between interactive social partners with respect to objects or events in order to share an awareness of the objects or events" (Mundy et al 1986). It can include verbal and non-verbal behaviours such as visual attention, following the attention of others and directing the attention of others. Children develop joint attention in a developmental manner evolving through three types of joint attention: shared gaze, dyadic and triadic. Typically children with a diagnosis of Autism do not demonstrate joint attention on a consistent basis with care-givers, or other children. Joint attention has also been indicated as a predictor of future cognitive, socio-emotional, language development and verbal and communication skills (Sigman and Ruskin 1999).

Computers have been used widely as a tool to assist in learning and skill development for children with ASD in a range of different domains (Kagohara et al 2013). Some authors suggest that children with ASD demonstrate an affinity for using computers and technology (Ploog et al 2013). To this end, there has been a variety of development projects reported exploiting the multi-media, interactive and flexible features of technology such as special input devices (touch screens and surfaces), interactive and virtual environments, eye tracking and social robotics (Boucenna et al 2007).

Related work

Computers assisted learning (CAL) approaches that support and facilitate the learning of children with ASD are well reported in the literature (Watson 2014). The value of educational games as a medium for collaborative learning for the general population of typically developing children is also documented (Wang et al., 2009). Moreover, recent work has examined the potential of newer technology interfaces to support collaboration and learning for children with ASD. Giusti & Zancanaro (2011) describe the development and use of a suite of games on a tabletop device to support the training of social competence skills for children with ASD. It has also been suggested that direct touch interfaces may be more effective than using multiple traditional input devices such as mice or switches. Regardless of the technology being used, Battocchi and colleagues (2009) indicate that children with ASD required more support and encouragement from teachers or therapists during the initial phases of using collaborative or cooperative games.

Virtual reality or virtual worlds also present a viable alternative to more traditional ASD CAL approaches. People with ASD understand, or have the potential to understand, virtual worlds are a representation of reality (Parsons & Mitchell 2004, Moore et al 2004). To this end, such environments can be used to repeatedly practice and rehearse social skills while eliminating the stresses often experienced by children in face to face activities. For instance, Fabri (2006) suggests that using avatars, particularly emotionally expressive avatars, is a key element in enhancing the experience of the teacher-learner and learner-learner interaction. A further area of related research explores the use of motion or gesture based control to allow children with ASD to engage with a CAL game. Bartoli and colleagues (2014) point to the potential of using commercial solutions such as the Kinect™ by Microsoft as a tool for working on specific social interaction skills such as attention. Although her work offers some positive outcomes, it is made clear that to date, there is still a significant lack of empirical evidence demonstrating efficacy of such systems.

Game development

This section describes the development of a prototype collaborative game called "AutBlocks". The game itself is a simple, block building or tower game for two players requiring a range of behaviours from participants to foster collaboration and develop joint attention skills.

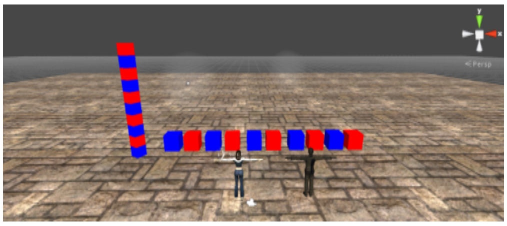

Figure 1. AutBlock Screenshot

The game environment was built using the Unity SDK (http://unity3d.com/) a popular cross platform game creation environment. The game interaction was designed using the Kinect for Windows SDK version 1.7 to control and utilize the four main data streams: Video, Skeletal, Color and Depth. In order to speed the development process a further development tool, ZDK for UNITY3D (http://zigfu.com/en/zdk/unity3d/) a development kit for developing motion controlled applications to provide a set of pre-defined C# scripts that initialize skeletal detection and Skeletal / player tracking. In terms of the user model around which this game was designed a constraint from the outset was the high variability of social interaction skills amongst the population of children with ASD as a whole. Unlike other similar projects targeting children and young adults with a diagnosis of High Functioning Autism or Asperger's Syndrome the target population for this particular application are those children with more significant impairment of social interaction skills. This suggested a more minimalist and simplified interface with a simple gameplay narrative involving a small number of core activities, such as moving, selecting, grasping and carrying.

Game based collaboration patterns

Related studies have applied a model defining four patterns of collaboration that encourage collaborative learning amongst users with ASD, although primarily for those with High Functioning Autism, these were used to guide the storyboarding of this game during development. The table below presents the collaborative patterns adapted for use in this project from the original with the required game tasks and the levels of joint attention demanded by the activity. In the proposed model, collaboration patterns are defined as follows: *Passive sharing pattern:* users engage with their own objects, using visual attention skills to identify their assigned block and follow patterns of play as demonstrated by the avatar. *Active sharing patters*: users begin to select from shared resources (blocks from a shared pile) moreover, users have to understand turn taking in order to select their own block for use. *Active sharing and joint performance pattern*: users must build on their turn taking skills to assist each other in building the tower, it is expected that they will shift attention from their own blocks to the other player's block either when prompted by the game narrative or by each other.

Table 1: Collaborative patters for game elements linked with joint attention

Collaborative Pattern	Game Element	Joint Attention
Passive Sharing Pattern	Identifying own avatar Identifying assigned bricks Selecting bricks from personal store Moving bricks to "Tower Building" area	Requires visual attention skills (individual) and shared gaze
Active Sharing Pattern	Selecting from shared resources Turn taking for selections and actions	Requires dyadic joint attention skills and turn taking
Active Sharing and Joint Performance Pattern	Sharing and giving blocks Requesting missing blocks Problem solving the building pattern for the tower	Requires active, triadic joint attention skills, including sharing and

Methodology

After the development of the game prototype, informed by the literature, related projects and the experiences of the authors working with children with ASD in a specialist Assistive Technology service, our objectives were to: 1) test the relevance of the overall concept with users/stakeholders; 2) get a firsthand perspective of teachers' requirements from games addressing social interaction, and specifically Joint Attention. Since case studies offer the possibility to study ideas and/or theories as they regard people in their real settings, and they enable researchers to establish cause and effect relationships as they occur in their authentic context (Cohen et al., 2000; Yin, 2003) we opted for this methodology. The case study took place at specialist school for children with ASD outside of school hours and comprised 6 teachers and 5 therapists (2 OT, 1 SLT, 2 ABA Therapists) working at the center. Both groups were facilitated by the same researcher, both groups felt uncomfortable with video as such data was gathered using the fieldnotes collected by a second researcher.

Findings

Generally both groups reported that they were positively inclined toward the use of a game to develop joint attention skills, although both groups reported concerns with the transferability of skills learnt outside of the game environment. Group 2, comprising mainly therapists (4 therapists, 2 teachers) were very interested in motion based games, particularly for children with difficulty sitting at desks for any functional time period. Furthermore, they expressed an interest in further developing the game to provide more simulation activities for real-life scenarios with the avatar developing a role demonstrating key behaviours in specific contexts. One issue that emerged for both groups independently was that for multiplayer games to be truly practical in a classroom setting they must be extendable beyond two players to include up to 6 children playing simultaneously. Group 1, comprising mainly teachers (4 teachers, 1 therapist) highlighted the role played by teachers, parents and others in facilitating gameplay for children suggesting that the role played by human assistance in the process is sometimes more important that the feedback or encouragement provided by the game itself. Group 1 continued in their elaboration to suggest that in until a child has developed a certain mastery of the procedural elements of any game that adult guidance is required. This issue in particular was the most valuable gained from this process and requires further analysis and consideration prior to embarking upon further work.

Conclusions and implications

Considering the fact that the game described here is at the earliest stage of development and that the use of Focus Groups for evaluation is far from robust as a methodology it was heartening to hear that most feedback has been generally positive. Future work should give consideration to the need to incorporate more than two players into games was also noted and may be possible as the Kinect™ technology matures further. Further work on the game should also incorporate the wider context within which the game is played. It was clear from the feedback on teachers in this study that a host of other people facilitate children with ASD playing games. This can range from verbal encouragement and reinforcement through to explanation of rules and sometimes physical facilitation. This should inform future development of games aimed at developing skills such as social interaction for children with ASD. Attention should be given to exploring the use of collaborative scripts as a means of ensuring that the "players' involved in the overall game environment are utilized to the maximum (Dillenbourg 2002). One area that requires careful examination in any future work is the measurement of joint attention by children with ASD. A potential area for development however would be the integration of gaze tracking technology such as that used in marketing, usability and advertising research. More recently its potential is being recognized as a tool in computer supported collaborative learning (Jermann et al 2013).

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Designing Automated Assessment FOR Collaborative Argumentation in Science Classroom: A Pilot Study

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Abstract: In the realm of CSCL research, collaborative argumentation is regarded as a key type of knowledge construction process that should be mastered by students to enable knowledge advancement. We designed an automated assessment system to support students' collaborative argumentation in Science learning. This paper describes the system design and explores how it was used by teachers and students in Singapore classrooms from a pilot study.

Keywords: collaborative argumentation; assessment for learning; automated assessment

Introduction

There is an ever-growing need to engage students in collaborative argumentation as coherent arguments to justify solutions and actions are important 21st century skills. Argumentation per se can be regarded as a significant knowledge construction activity that leads to knowledge advancement (Weinberger & Fisher, 2006). In the science classroom, the necessity to engage students in argumentation experience is more stressed as the process of arguing is an essential aspect of the epistemic practice in doing science, the discourse processes in talking science, and scientific thinking (Jimenez-Aleixandre et al., 2000) that are need to be appropriated.

Being aware of the significance of both "learning to argue" and "arguing to learn" (Scheuer et al., 2010) to the development of 21st century competencies and scientific content knowledge in students, the absence of argumentation in the current pedagogy of science learning, and the difficulties teachers and students face in enacting argumentation activities (Clark et al., 2007), support for collaboration and argumentation is needed to bring the learning processes into fruition. Such support can be envisioned and engendered with in-situ assessment of group learning. Being cognizant of the inadequacy of current assessment practices of collaborative learning which are mostly summative, individual-based, cognition-oriented, and conducted only by the teacher (Strijbos, 2011), we aim to develop an assessment-oriented system for supporting collaborative learning in secondary school classrooms. This is an on-going project which is still at the first cycle of the design research. This paper describes the design of the system and explores how the system was used in Science classroom from a pilot study.

Design considerations

Teachers do need technological and pedagogical support for designing, implementing and assessing collaborative argumentation activities in classrooms. CSCL researchers have developed a good number of online learning environments to support students' collaborative argumentation (Scheuer et al., 2010), and established a variety of analytical frameworks to assess the quality of this type of learning activity (Clark et al., 2007). However many research in technology-enhanced collaborative argumentation and assessment projects are not conducted in real school classroom context. This project is motivated by the need from teachers in designing and implementing collaborative argumentation in classroom. The research team did several focus group discussions with Singapore teachers to find out what are needed in supporting classroom collaborative argumentations. The focus group discussion results become the design considerations of the system. Due to the page limit the detailed focus group discussion results are not presented in this paper. These considerations are summarized as follows:

1. Make argumentation intuitive for students by providing graphical scaffolding. A diagram-based argumentation which includes an organized set of argument elements represented by nodes and/or directed links will help students focus on important tasks in argumentation.
2. Provide multi-dimensional assessments to have holistic assessment on collaborative argumentation
    a. both the individual level and the group level (to achieve inter-dependence and avoid free-rider);
    b. both the learning outcomes (usually reflected in group co-constructed artifacts) and the collaborative learning processes (to enable timely regulation);

c. both the cognitive and social processes enacted in collaborative learning;

3. Provide assessment FOR learning instead of assessment OF learning so that students can make meaning out of the assessment immediately and act upon it.
   a. providing real-time assessment (students as autonomous and responsible learners; students themselves should make the decision for their future learning; self-awareness and meta-cognition);
   b. provide dynamic visualizations of assessments to help teachers and students make interpretations and decisions (managing cognitive load).

Based on these design considerations, a set of multi-dimensional indicators for assessing collaborative argumentation have been derived. The assessments of both the argumentation process and outcome were pursued. The outcome assessment is concerned with the evaluation of the argumentation artifacts that a student or a group of students created when asked to articulate and justify claims or explanations; the process assessment is about judging the process of constructing the argumentation artifacts (Sampson & Clark, 2008). The assessment addresses both individual performance and group performance. The current assessments are mainly used for evaluating secondary school students doing argumentation in science. The particularity of the learning context dictates the advancement of scientific knowledge and the engagement in the epistemic practices in doing science (e.g., coordinating between theory and evidence; taking alternative perspectives into consideration), the application of reasoning and epistemic strategies, and the participation in the collaborative knowledge construction processes as the prior pedagogical goals. This prescribes the interpretation and operationalization of the selected indicators for each dimension and the specification of the measurements. The establishment of the indicators and their measurement in essence are the adaptation and translation of existing valid and reliable analytic frameworks of collaborative argumentation while accommodating the specific demands and characteristics of the user and the environment involved in our study (e.g., Erduran et al., 2004; Weinberger & Fisher, 2006; Zhang et al, 2011). The operationalization of the indicators and the specifications of the measurements are introduced in Table 1.

Table 1: The indicator and operationalization of assessment

	Indicator	Operationalization	Level
Social Process	Engagement Level (Unit: Group / Individual)	The frequency of contribution to the group work either in the form of constructing the shared argument graph or participating in group chat. The higher the frequency, the higher the level of engagement is.	The setting for the critical value for each level depends on the normal distribution of all acts of student.
	Centralization (Unit: Group)	The degree to which the group members equally participate in group interaction. It is measured by the inequality of interactions by different members within the group. The higher the inequality, the lower the centralization is.	The setting for the critical value for each level depends on the normal distribution of all centralization value.
Learning outcome (argument as the outcome)	Structural Completeness (Unit: Group)	The presence of the essential structural components in an argument generated. The better an argument is, the more components are included. In the present context, an argument contains a claim, one (or more than on) evidence for, and more than one evidence against is regarded as a complete argument. The structural completeness of the argument diagram is measured by the sum of scores of all the arguments it contains.	Level 1: Claim Level 2: Claim+ Evidence for; Claim+ 1 Evidence against Level 3: Claim + Evidence for (>=1) + 1 Evidence against Level 4: Claim + Evidence for (No. >=1)+ Evidence against (No.>1)
	Relevance (Unit: Individual argument element produced by a group/ individual)	Whether the evidence provided is related to the topic under argumentation and whether it can support the claim or the evidence that it is directed to.	Level 1: Irrelevant information/facts. Level 2: Some relevance but no logic coherence. Level 3: Relevant and logic but not reflect the key points. Level 4: Relevant and logic, and reflect the key points.
	Scientific Sophistication (Unit: Individual argument	The extent to which students have moved from an intuitive toward a scientific framework. Scientific sophistication represents the level of success a student has achieved in processing an idea at a certain complexity level. The higher the sophistication, the	Level 1: Misconception; naive conceptual framework. Level 2: Misconceptions that have incorporated scientific information but show mixed misconception/scientific

	Indicator	Operationalization	Level
	element produced by a group/ individual)	more scientific the idea that produced is.	frameworks. Level 3: Basically scientific ideas based on scientific framework, but not precisely scientific. Level 4: Scientific explanations those are consistent with scientific knowledge.
	Epistemic Complexity (Unit: Individual argument element produced by a group/ individual)	The extent to which students make effort to produce theoretical explanations and articulations of hidden mechanisms central to the nature of science (i.e., providing and elaborating explanations or justifications) besides providing descriptions of the material world (i.e., providing unelaborated facts). It represents the level of complexity at which a student\group chooses to approach an issue. Epistemic complexity of an argument is measured by the cognitive effort taken to processing it as reflected in the content. The greater the cognitive effort, the higher the complexity is.	Level 1: Unelaborated facts: Description of terms, phenomena, or experiences without elaboration. Level 2: Elaborated facts: Elaboration of terms, phenomena, or experiences. Level 3: Unelaborated explanations: Reasons, relationships, or mechanisms mentioned without elaboration. Level 4: Elaborated explanations: Reasons, relationships, or mechanism elaborated.

System design

According to the derived design considerations and conceptualized assessment indicators, we have developed the system. The graphic representations (i.e. the shared argument diagram) are supported (see Figure 1). On the diagram-based argumentation space, an argument refers to an organized set of argument elements represented by nodes and/or directed links. The specific types of argument elements adopted are in accordance with Toulmin's Argumentation Pattern (TAP) (1958). For pragmatic considerations (e.g., understandability of secondary school students) (Scheuer et al., 2010), the original TAP model is simplified. Three argument elements, namely claim, evidence for (support), and evidence against (rebuttal) are identified as the essential components of an ideal argument. These elements are represented by: 1) the type of Node: Claim vs Evidence and/or; 2) the type of directed Link: For vs. Against.

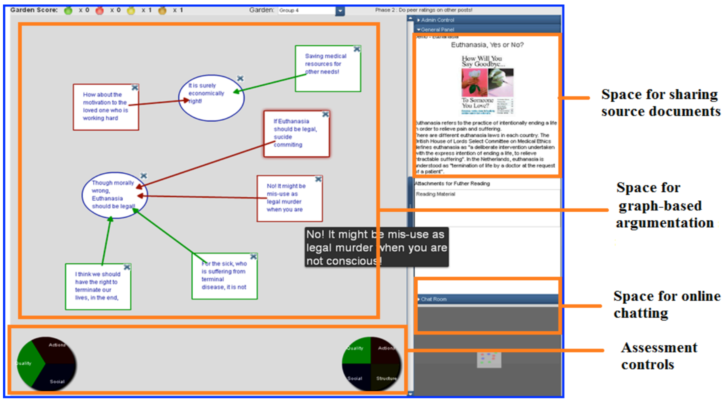


Figure 1. Interface of the System

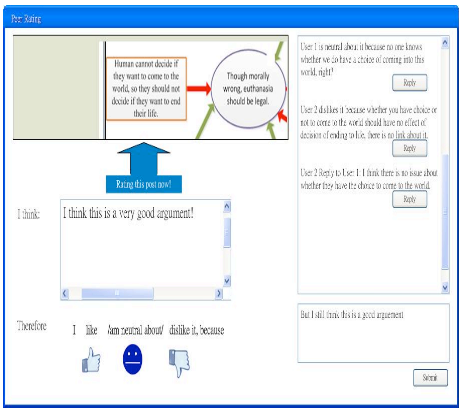
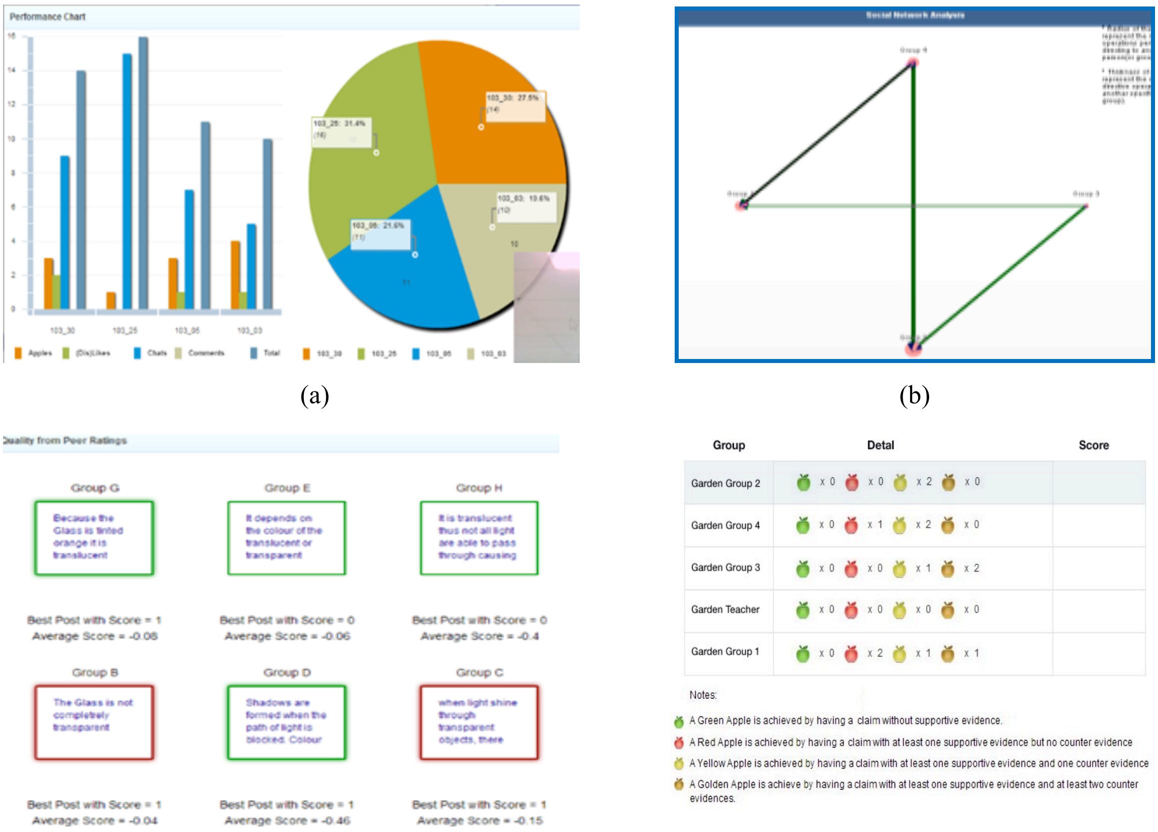


Figure 2. Peer-rating on the system

The automation of scoring complex data remains a motivating goal in educational assessment (Griffin, Care, Bui, & Zoanetti, 2013), and it is also the key to realize real-time assessment for learning. The measurement of the action frequency for the social participation is easy to achieve. Automated assessment of the quality of argumentation is a challenge. The system engages peer-rating for assessing the quality of argumentation as outcome (Figure 2). The peers who are working on the same task are prompted to provide quality ratings for the elements of the argument diagram once finished. Peer-rating is regarded as a good way to quantify the qualitative data as the feedback of peers can lead to reliable and accurate assessments (Cho & Schunn, 2007). Prompting students to rate peers' contributions may have a learning effect as they reflect on and assess their own and others' contributions (Scheuer et al., 2010).

Visualization is important for student and teachers to do real –time assessment which inform then what to do next. Figure 3 shows the visualization of various assessment indicators.



(a) (b) (c) (d)

Figure 3. Assessment visualizations
Participation (a); interaction (b); content quality (c); and structural completeness (d)

The pilot study

The system was deployed in a secondary school in Singapore. As this pilot study is exploratory in nature, we did not adopt experimental design to examine the effectiveness of the system in comparison with a control group. Data collected and analyzed in this pilot study was to investigate whether: students could improve their scientific content knowledge using the system; teacher could improve their instruction using the system; and the automated assessment was reliable. Altogether, 4 Secondary 1 classes (40 students per class) taught by two science teachers (two classes by each teacher) participated in collaborative argumentation activities using the system in 1 physics lesson (1 hour per lesson) with the topic on Colors of Light. The lesson was co-designed by the teachers and researchers. Before the lessons, two sessions of technical training and 2 teacher professional sessions were conducted. Due to the page limit, we summarize the general findings from multi-facet data. In general there is positive result of using the system on learning and teaching from three aspects.

Learning outcome. To examine the effect of the system on students' development of scientific content knowledge, pre-test and post-test was conducted. A same test paper designed by teachers and another group of science teachers help validate the test items in terms of alignment of lesson deign and difficulty level etc. Two teachers scored students' test papers independently with good inter-rater reliability (Pearson r =.91). There is significant improvement in the scores from students' pre-test score to post-test for all the 4 classes (Table 2).

Table 2. Paired-sample t tests for 4 classes

Class	Type	Mean	SD	t	Class	Type	Mean	SD	t
Class A	Pre test	3.56	1.93	8.90**	Class C	Pre test	3.48	1.92	12.33**
(n=36)	Post test	7.17	1.55		(n=31)	Post test	8.24	0.99	
Class B	Pre test	3.12	1.59	6.62**	Class D	Pre test	3.45	1.79	2.69**
(n=33)	Post test	5.69	1.90		(n=34)	Post test	4.66	2.36	

Note **p<.01

Students' perception. Each student wrote reflections on their experiences of using the system for collaborative argumentation. The results revealed that students held positive attitudes towards both the lessons and the system. They liked to use the system for collaborative argumentation it is a new and refreshing way to learn science and is more interesting than a normal science lesson. Their engagement and participation in the learning activity was also enhanced as every student could and would like to express their ideas as the system supports anonymous contributions from the students. This was especially encouraging for those shy and quiet ones. Apart from improving participation, engagement and interest in learning, students also indicated that the system could help them learn the scientific knowledge and skills (through argumentation and from peers) and develop collaboration and critical thinking skills. The assessment components further advanced their learning.

Teacher's feedback. The system is envisaged as a tool to support teachers' orchestration in the classroom based on the provision of immediate assessments of student work. To explore teachers' use of the system in class, teacher interviews and post-lesson reflections were administered. Data analysis showed the positive role of system played in augmenting teaching. According to teachers, the instruction which utilizes ICTs, argumentation, real-time individual/group-based assessment, and group work, could well motivate and engage the students. Another striking feature of the system that particularly benefited their teaching was the provision of opportunities to access the thoughts and ideas of every single student. In the system, all the thoughts/ideas generated by students are accumulated and documented, and the teacher could keep track of students' misconceptions with ease and address them immediately.

Validation of assessment. For the indicators from the social aspects (i.e., Participation & Interaction), the measurement is based on frequency data generated by the system, which was affirmed accurate with human checking. The measurement of the Structural Completeness is based on the kind of data that can be accurately captured using the system (this was also confirmed by human checking). Nevertheless, the big challenge was to establish the validity of the ratings by the peers for the content quality. To achieve this, correlation between the peer-rating and the researcher rating has been conducted. In doing this, firstly, a sample (N = 77) of the posts generated by students in the second lesson was formed via random selection. It was found that the correlation between the peer-ratings and researcher ratings were not very strong (Pearson r = .51). This may be caused by the lack of scientific knowledge and rating competencies of the students. There is a necessity of equipping the raters with sufficient domain knowledge and rating competencies to achieve fair and reliable ratings.

Discussion and future work

The system is a knowledge representation tool where the structure of argumentation is explicitly represented to support students' collborative argumentation. The argumentative diagrams can clarify relations (Suthers, 2003), represent structure (Schwarz, Neuman, Gil, & Ilya, 2000), provide overviews (Larkin& Simon, 1987), maintain focus (Veerman, 2000), and enhance reflection on alternative perspectives (Kolodner & Guzdial, 1996). The assessments proposed in the system are not only about establishing what the students might have learnt. They are about providing less final and judgmental (Boud, 1995) but more interactive and forward-looking (Carless, 2002), timely and with a potential to be acted upon assessments (Gibbs & Simpson, 2004) to inform the subsequent teaching and learning activities. Analyses of data collected from the pilot study are indicative of the positive role the system play for both learning and teaching. The teacher and students not only "*assess to learn" by* finding out how student perform in the process of collaborative argumentation in order to improve their learning, but also "*learn to assess"* collaborative argumentation holistically from multi-facet perspectives.

To better inform the unfolding teaching and learning practices, the assessments designed should reflect the critical aspects of the learning activity. The assessments established are prescribed by the assessment considerations derived from literature review and through the focus group discussion with teachers. The selection of assessment indicators reflects the commonly acknowledged view on collaborative argumentation as social processes that can enable knowledge construction and creation. Teacher opinions were elicited for validating the assessment indicators included. Teaches reported that the provision of information and evaluation of students' engagement level, participation level, and understanding of the content knowledge at both the individual and group levels would definitely benefit their teaching practices, and all of these could be obtained using our system. According to them, the assessments currently available on the system are useful and comprehensive. As each assessment serves their own purpose, the teachers would like to have them all for reference.

The system is designed by reflecting the critical aspects of the collaborative argumentation and addressing the need from teachers and students in classroom learning activity. Except for the attainments, inadequacy of the current design has also been identified. The main issue identified is the validity of the peer-rating. This calls for the engagement of natural language processing and machine learning techniques to explore automated or semi-automated assessment of content quality. This project is still ongoing. We seek to establish automated assessment for more indicators to render a more complete capture of the collaborative learning processes. In the following cycle when Natural Language Processing is embedded, indicators that reflect the state of students' problem solving, argumentative knowledge construction and epistemic moves can be identified and assessed. Students' application of argumentation and thinking strategies can be examined as well. Another task ahead is to polish and enrich the visualizations of system assessments.

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Immersive Simulation on Collaborative Learning about a Complex Dynamic System

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Abstract: This mixed methods study examined the effect of Astronaut Challenge, an immersive, flight-simulation-based learning program, on the collaborative learning process and science knowledge development of high-school students (9th graders). The study findings suggested that simulation-based collaborative learning activities promoted students' scientific understanding about the dynamics of the space flight system. Although the knowledge test results did not indicate a significant differential effect of the two immersive settings (exclusive space versus classroom flight simulator) on the learning outcome, qualitative findings suggested that the higher level of the sensory immersion in a simulation-based learning environment may foster engagement while impeding collaborative conceptual understanding.

Keywords: science learning, flight simulator, computer supported collaborative learning, simulation environment design

Introduction

Immersion is a salient feature of the simulation-based learning environment. According to Dede (2009), immersion refers to "the subjective impression that one is participating in a comprehensive, realistic experience" (p. 66). It can be interpreted as a psychological experience that one perceives regarding how much s/he is attached to a learning environment, which can be provided via an active and dynamic interaction between the learner and their environment, sensory information in the 3D digital space, and authentic scenarios or tasks that tap into the learner's life experiences (Baños et al., 2004; Dede, 2009; De Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2010). Studies have shown that immersive digital simulations, delivered via a computer-assisted simulator or a virtual reality, can enhance education by allowing multiple perspectives, situated learning, and transfer (e.g., Dunleavy, Dede, & Mitchell, 2009; Freitas & Neumann, 2009; Hansen, 2008). However, research on the effects of immersion on collaborative learning among students with diverse characteristics is still limited and inconclusive. Research is also needed on the learning strengths and preferences that the different levels of immersion in the digital space of a simulation cultivate in a diverse learner group, and hence the instructional arrangement of interactive media in a simulation-based collaborative learning environment.

Prior research suggested that immersive, participatory simulation is an emerging and prominent learning platform to help learners understand a complex, dynamic science system (Colella, 2000; Barab & Dede, 2007). Learning about complex systems is difficult because complex systems aggregate multiple components that interact with each other in multiple levels (Hmelo-Silver & Azevedo, 2006). Sterman (1994) argued that approaches to learning about complex dynamic systems require tools to frame issues and elicit/create an iterative feedback-based learning cycle, and methods to improve group or team processes that will overcome defensive routines for individuals and sharpen scientific reasoning skills. Based on such a perspective, it is warranted to examine the capabilities of digital immersive simulations in promoting collaborative learning and hence understanding about a complex, dynamic system (such as the engineering system of a space flight).

Therefore, in this study we examined the design and effect of an immersive, simulation-based science learning program on the collaborative learning process and science knowledge development of high-school students (9th graders). The major research question are: (a) What are the impact of a space flight simulator program on high school students' collaborative learning processes and their science knowledge development? (b) Is there a differential effect of the immersive settings of this simulation-based learning environment on the collaborative learning process and outcome?

Methods

The study used a concurrent, mixed-method research approach (Clark & Creswell, 2011) to examine the immersive environment design and effect of a simulation-based science learning program. Student Astronaut Challenge, integrating a space flight simulator and a student manual on the basics of aerospace science, was the intervention program designed to promote collaborative, scientific discovery learning.

Participants

Twenty 9-10th graders were recruited from the General Earth Space Science classes of a local high school to participate in an after-school, Student Astronaut Challenge program. Among the program participants, 50% were girls, and 45% were learning disadvantaged (e.g., at-risk to not graduate) or had special learning needs (e.g., English language learning or medical accommodation). Participants were randomly assigned to two simulation conditions: exclusive space flight simulator condition (n=10, in two project teams) and classroom flight simulator condition (n=10, in two project teams). The wait-list students from the same classes formed a control group (n=22). The procedure, immersive simulation design, and simulation-based collaborative learning activities are outlined below.

Procedure

This current study lasted 4 weeks. At the beginning of the first week, all study participants received a pre-test on science knowledge. They were then given the Astronaut Challenge student manual to study during their weekly earth space science class and on their own at their convenient time and space. Participants of two simulation conditions also trained on space flight procedure one hour a week after school, from week 1 to week 4. Classroom simulator participants trained on the laptop-based space flight simulation, whereas exclusive space simulator participants trained on a physical space flight simulator. At the end of the fourth week, all participants received a posttest on the science knowledge. Each simulation project team also received a 30-minute, semi-structured group interview.

Immersive simulation setting

The space flight simulation encompasses the following components to provide the computer-generated immersion for the program participants:

- **Orbiter space flight simulation**: Based on the freeware space flight simulator Orbiter, a 3D flight simulation of the launch, flight, and landing of the Space Shuttle Atlantis was developed and used to enable simulated space shuttle operation and deliver sensory inputs/outputs.
- **PowerPoint multi-function display presentations**: PowerPoint presentations, pre-timed with the orbiter program to run concurrently, were used to simulate the data displays (known as multi-function displays) on the Space Shuttle. They were also used to enable the simulation of emergent situations and mission control of the space flight.
- **Shuttle switch control panels**: Four switch control panel templates were used to simulate the location of switches or control systems that must be turned on and off by the Mission Commander and Pilot during the flight.
- **Flight operational and emergency procedure checklists**: Pre-flight, in-flight, landing, and emergency procedure checklists, taken and customized from the actual ones used by space shuttle astronauts, were included as job aides for flight operations and emergency managements during flight.
- ***Exclusive* Space Flight Simulator versus *Classroom* Space Flight Simulator:** In the Exclusive Space Flight Simulator, a regular RV truck was customized to simulate a realistic space flight simulator. The physical set up, including display monitors, seats for the flight crew members, communication devices, and control panels, tried to artificially recreate the exclusive environment of a space flight. In comparison, the Classroom Space Flight Simulator was set up in a regular school classroom. Four desk computers, one overhead monitor, one computer joystick, and two radio control panels, along with regular classroom desks and chairs, were used to clone the functional setting of the space flight simulator. It is speculated that the exclusive simulator presents a higher sensory immersion than the classroom simulator.

Simulation-based collaborative learning activities

In both simulation conditions, participants were assigned into five-person teams, with each team being heterogeneous in terms of gender, ethnicity, and prior knowledge level. Each team consisted of a mission commander, pilot, mission specialist, and two mission control personnel. The initial positions in the team were randomly assigned among team members and eventually these positions were rotated between the teammates, allowing everyone to try multiple areas of responsibility. The students in each team would then practice as a group flying the space flight simulator using the procedure and emergency situation checklists. The flight operation involved normal operation controls (e.g., launching, flying, and landing) at first, and then problem solving in managing varied technical emergency situations. Successful operation of the space flight simulator requires all astronauts to work together effectively, practice their individual jobs, and be aware of the jobs and responsibilities of the rest of the crew. Communication and collaborative operations among team members are essential, and the strict control of who speaks or does at what time and to whom is critical. The communication varied in its purposes (e.g., advises, announcements, or requests on status information), and required all members to swiftly identify what their responsibilities are, who they want to speak to, and what they need to know or report. This relationship is especially important when emergencies occur, therefore consistent practice together is necessary for an effective team.

Data collection and analysis

Data in this mixed methods study were collected via both quantitative knowledge test and qualitative infield observation and interview. The science knowledge tests were developed based on the test items used in the Astronaut Challenge program of previous years. Pre- and post-program knowledge tests were analyzed using descriptive and inferential statistics. Specifically, mixed design ANOVAs were conducted to examine the potential impact of the simulation-based science learning program on participants' science knowledge test performance, with time of the measurement as the within-subjects factor and study conditions (e.g., treatment vs control, and types of the simulator) as the between-subjects factor.

Participants' collaborative learning activities during program sessions were observed and video recorded. A semi-structured, focus group interview was then conducted with each project team after the program activities. Interviews, classroom observations, and video recordings were transcribed and imported into qualitative data analysis software. The qualitative coding was descriptive in nature, while focusing on understanding when, how, why, and with whom a simulation-based collaborative learning event occurred. We also conducted *categorical aggregation analysis* (Clark & Creswell, 2011) with the recorded and observed team activities, by coding the critical properties of meaningful actions or instances of simulation-based collaborative learning and classifying them into aggregations. Peer debriefing were conducted among the two coders and member checking were performed with the participants during the interview process. Finally, we sought meaningful patterns among the categories and synthesizing naturalistic conditions and consequences of the major categories. These patterns were then consolidated with quantitative findings.

Findings

The mixed ANOVA test examining the effect of the simulation-based science learning program indicated that there was a borderline significance in the interaction between the within-subjects factor and between-subjects factor on the knowledge test outcome, $F(1, 40) = 3.99$, $p = .06$, partial $\eta^2 = .17$. The test-performance change from the pretest to the posttest differed between the treatment group (simulation-based collaborative learning) and the control group, as shown by Figure 1 below. The control or no-simulation group's knowledge test performance were generally maintained from the pretest ($M_{precrl} = 28.31$ $SD_{precrl} = 5.41$) to the posttest ($M_{postcrl} = 29.54$ $SD_{postcrl} = 8.05$), whereas the treatment group knowledge test performance improved from the pretest ($M_{pretre} = 24.75$ $SD_{pretre} = 7.48$) to the posttest ($M_{posttre} = 33.50$ $SD_{posttre} = 6.72$).

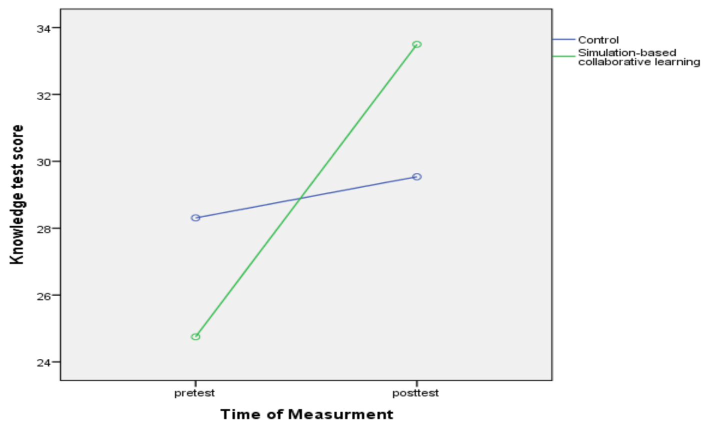

Figure 1. Pre-posttest performance by treatment condition

The mixed ANOVA test examining the differential effect of the immersive settings of the simulation environment (exclusive simulator vs. classroom simulator) on the science knowledge test did not indicate a significant interaction effect between the within-subjects and between-subjects factors. The result failed to provide evidence for the learning effects of varied immersive settings of the simulation program. It should be noticed that the observed power for the interaction analysis was only .13, suggesting that the small sample size of each simulation group might have low statistical power to detect group differences. The test did indicate a significant main effect of the time factor (p <.001), confirming that both simulation-based collaborative learning groups significantly improved their knowledge test performance from the pre- to the posttest, $M_{premsim}$= 22.5, $SD_{premsim}$= 9.57, $M_{postmsim}$= 32.25, $SD_{postmsim}$= 9.18; $M_{precsim}$= 27.00, $SD_{precsim}$= 5.03, $M_{postcsim}$= 34.75, $SD_{postcsim}$= 4.11.

Two salient themes emerged from the qualitative data and shed light on the aforementioned trends: (a) communication-action-embodied meaning making, and (b) joint feedback process. It was found that collective and raced flight operation, requiring a shared understanding and a swift enactment of the space flight communication protocol and flight-control procedures, have enforced both conceptual and procedural knowledge practice and construction. Flight communications among the flight personnel and mission control, in either "advices", "announcements," "responses," or "confirmations," were filled with the externalization and constant monitoring of the shared understanding of a variety of complicated system concepts (e.g., Reaction Control System or RCS, hydraulics). Frequently, flight crew members were required to both verbalize and embody these concepts during the shuttle operations, "APU/HYDRAULICS (1/2/3) to OFF" (accompanied by the hand movement of turning off the corresponding buttons in the control panel). These conceptual verbalization and enactments would receive instant feedback via both naturalistic, visual/audio output of the computer system and the verbal confirmation/response from their teammates (e.g., "APU/HYDRAULICS 1/2/3 to OFF *Check*!"). In other terms, the simulated flight communication and collaborative shuttle operation has created the joint, feedback-based learning loop in which students would collaboratively and iteratively practice, observe, and act on domain-specific concepts and procedures.

Notably, we found that the sensory or physical immersion of a simulation setting might have fostered learners' engagement in the procedural routine practice, while imposing impediments or distractions toward the feedback reflection and discussion for a deep conceptual understanding. In the exclusive space flight simulator, the simulated sound effects were loud and the area was restricted, thus making beyond-routine team debriefing and peer mentoring difficult. In comparison, the teams in the classroom simulator were found to be less contested by the sense of emergency, involved in more reciprocal questioning and answering, and obviously involved in more exploration and peer tutoring to achieve a better understanding, rather than memorization, of system concepts.

Conclusions and implications

The study findings suggested that immersive-simulation-based collaborative learning promotes students' learning about the dynamics of the space flight system. Although the knowledge test results did not indicate a significant differential effect of the two immersive settings on the learning outcome, qualitative findings suggested that the higher level of sensory immersion may foster engagement while impeding collaborative conceptual understanding.

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Assessing Collaborative Problem Solving with Simulation Based Tasks

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Abstract: Assessing collaborative problem solving (CPS) is an integrated part of the computer-supported collaborative learning (CSCL). We present some preliminary results from a project developed for assessing the CPS using web-based simulation. In the simulation, two participants collaborate via a chat box to complete a task on volcano science. By comparing the responses from 486 individuals and 278 teams (dyads) recruited from Amazon Mechanical Turk, we found the performance from the teams (dyads) is significantly higher than that from individuals. We also find that the item difficulty in the simulation affects both the processes and outcomes of the collaboration.

Keywords: collaborative problem solving, simulation, assessment, natural language processing

Introduction

Collaborative problem solving (CPS) is one of the 21st century skills emphasized by the Assessment and Teaching of the 21st Century Skills (ATC21S, 2012). However, developing a psychometrically rigorous assessment for CPS encounters a number of challenges. The construct underlying CPS is very complex, depending on multiple factors, such as the type of the task, the skills and the personalities of the team members, etc. Moreover, CPS has both cognitive aspect and social aspect, and the outcomes from a CPS task are generally the results of the interaction of both. In-depth analysis of the CPS process is probably the only way to disentangle the contribution from social aspect and from cognitive aspect.

In existing literature, many efforts for assessing CPS have focused on the social aspect (de Jong, 2012; DeChurch & Mesmer-Magnus, 2010; Griffin et al., 2012; OECD, 2013). On the other hand, some researchers consider the cognitive aspect of the team as a whole and report the outcomes based on a notion of collective intelligence (O'Neil, 1997; Cohen et al., 1999; Woolley et al., 2010). However, all these researches neglect the collaborative process that is vital for measuring the CPS (von Davier & Halpin, 2013). Von Davier & Halpin (2013) also emphasize the importance to measure individual's cognitive skills in a CPS task and present some psychometric modeling schemes for assessing the process of collaboration.

In this paper, we present our preliminary results from a simulation-based task for assessing CPS. In the task, two human participants work remotely via a chat box to complete a science task about volcano. The goal of this project is to log all the turn-by-turn and time-stamped process data during the collaboration in addition to the outcome data to probe the relations between the cognitive aspect and social aspect of CPS, and between the outcomes and the processes of collaborations with large empirical data.

Methods

Simulation tasks

We developed two simulation tasks for this project, Volcano single and Volcano CPS, based on an earlier simulation (Zapata et al., 2014). The two simulation tasks are almost identical except that the Volcano CPS has an additional chat box layer that allows for collaboration by texting. In Figure 1, we show the screenshots of the two simulations. In the CPS version, for each question/item in the simulation, the two participants are prompted to answer the question by the following four steps: first, each person responds separately. Second, they are prompted to discuss with their partners to get the best answer. Third, after discussion, they are given an opportunity to revise their initial answers. Finally, one of the participants in the team is randomly chosen as team representative to submit a team answer. We record all their responses as well as their conversations in a structured log file (Hao et al., 2015). Such a design permits more effective tracking.

Figure 1. Left: the single participant version. Right: the CPS version.

Participants

Our data collection strategy is crowdsourcing, which has become popular for data-driven research in cognitive and social science (Bridgeman et al, 2012). Amazon Mechanical Turk is a well-developed and supported crowdsourcing web service. For the CPS version, we randomly assign team (dyad) members. That is, when one person started a session, the next person to join is completely random and based on the arrival time. Given the large sample, we can ensure there are adequate numbers of teams in each combination of individual factors.

One limitation of Amazon Mechanical Turk for data collection is that only adults can participate. In our study, we restrict the participants to be college students. We are aiming at collecting data from 500 participants using the single participant version and from 500 dyads using the CPS version. In Table 1, we summarize the participants whose responses are collected so far. As the data collection and analysis are still ongoing, we report only some preliminary results in this paper. It is worth noting that to ensure the samples are equivalent, we have an external test consisting of 37 multiple choice items about general science knowledge to check the equivalence of the groups. The science test has a Cronbach's alpha of 0.89. Each participant needs to take this science test and the mean sum scores and standard deviations of the participants who take the single player version and CPS version are: 26.98 +/- 6.93 for single player group and 26.99 +/- 6.69 for CPS group.

Table 1: Participants summary

Version	Male	Female	Total
Single participant	290	196	486
CPS	280	276	556
Total	**570**	**472**	**1042**

Analysis

Quantitative analysis

All the responses in the simulation are recorded into structured log files. For the conversations, we developed a scoring rubric based on the definition of CPS by PISA 2015 (Graesser, A., & Foltz, P., 2013). The conversations are classified into four categories of social skills by human raters (Liu et al., 2014). At current stage, the scoring is still in progress and we will report the findings in the future. However, we can still find some features from the conversations as "proxies" of the collaboration. For example, the number of words in the conversation could be a good estimate of how enthusiastic the conversations/collaborations are.

On the other hand, each participant answers the science questions in the simulation, which provides information about the collaboration processes and outcomes. In this paper, we will use the sum scores of the first seven selected response (SR) items. It is worth noting that the reliability of seven items is generally not high, about 0.65 in terms of the Cronbach's alpha. We can boost the reliability if we have more items included after we complete the scoring. We performed the following analyses:

First, we check whether the individual initial responses to the items in the CPS version are statistically similar to those in the single-participant version by single participant. If they are similar, that means we can use the individual initial response in the CPS version as a measure of the individual skill. Second, we check whether the revised responses are improved compared to the initial responses. If it is improved, that will be a strong sign that the collaboration does have effects. Third, we check whether the team responses by the team representatives are different from the initial and revised responses. This will inform us any performance changes due to the role change in the team.

In addition to the overall performance, we also want to check the relation between item property and the collaboration processes as well as the collaboration results. In this preliminary analysis, we choose a specific item property, the item difficulty, which is defined as the proportion of correct responses to a given item. The item difficulty parameter is calculated for each item by using the responses from the single participant version. We use the number of words in the conversations for each item as a measure of collaboration process, i.e., how heated the collaboration is. For the collaboration results, we introduce the following response change parameter for each item:

$$\delta = R_1 - I_1 + R_2 - I_2$$

where R and I refer to the scores of the revised responses and initial responses to that item. The subscripts 1 and 2 refer to the first and second participants in each dyad. If δ is positive, that means there is a positive change in the response after the collaboration and we use δ as a measure of the results of the collaboration. We will check how the mean δ and the mean number of words depend on the item difficulty.

Findings

Table 2 below shows the comparison of the performance in terms of the sum scores of the first seven SR items. Dataset 1 contains the responses from 486 participants who took the single participant version of the simulation. Dataset 2 contains the individual's initial responses from those who took the CPS version. Dataset 3 contains the revised responses from those who took the CPS version and Dataset 4 contains the responses from those who are selected as team representatives to submit team responses.

Table 2: Comparison of the group means of different datasets

Dataset	Mean sum score	Standard error of the mean sum score	Standard deviation of the sum score
1	4.796	0.063	1.389
2	4.842	0.053	1.250
3	5.147	0.049	1.155
4	5.237	0.068	1.134

Based on Table 2, we run two sample t-tests and our findings are as follows. First, the individual initial responses in the CPS version are statistically similar to those from participants who took the single participant version. This means that the individual initial responses in the CPS version can serve as measures of the individual skills. Second, in the CPS version, the revised responses are statistically significantly better than the initial responses, which substantiates that the collaboration does have positive effect on the performance. Third, the team responses by the team representatives are better than the initial responses in a statistically significant way. However, the team responses are not significantly better than the revised responses. This means that the role change of the participants to team representatives does not further change many of their revised responses.

Figure 2 below shows how the collaboration processes and collaboration results (e.g., δ) are dependent on the item difficulty. From the left panel of Figure 2, we observe that the item difficulty does affect the number of communications. For moderate and difficult items (e.g., item 1 to item 4), there are much more communications than that for easy items (e.g., item 5 to item 7). The difference is statistically significant. From the right panel, we observe that the δ is small for very easy items (e.g., item 5 to item 7). This can be understood as follows: for very easy items, their initial responses are almost the best answers and there is little room for improvement after collaboration. Therefore, the δ is small. It is interesting to note that both figures show certain linear relations with the item difficulties, which suggests that the linear relations might be generalizable to other tasks with appropriate changes of the slopes and intercepts.

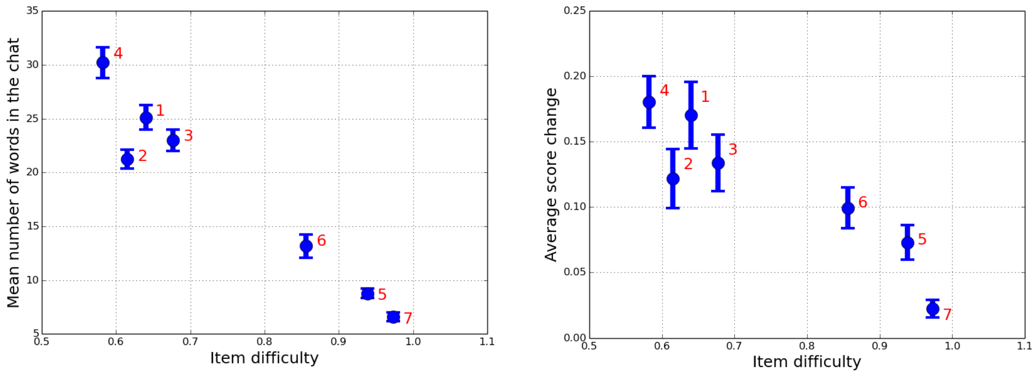

Figure 2. Left: mean number of words in the conversations for each item. The numbers in red fonts are the item number. The blue dots and error bars are the mean and standard errors of the means respectively. Right: mean δ for different items.

Conclusions and implications

In this preliminary analysis, we have shown that there is a significant performance improvement after collaboration and the collaboration processes as well as the collaboration results are dependent on the item difficulty. Though the observed effect size is small, these findings will provide guidance for us to design more appropriate CPS tasks in future. For example, looking at the right panel of Figure 2, if all items are similar to item 1, we can get much bigger increase. That way, we can get a much better effect size in terms of the sum score.

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The Use of Visual Evidence for Planning and Argumentation

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Abstract: We report on two learning environments where students used visual evidence (digital photographs) for the scientific practices of planning and argumentation. The first is a knowledge-building environment called Neighborhood Safari, where Grade 5/6 students (n=45) construct investigation plans concerning schoolyard wildlife; the second is an immersive simulation called EvoRoom/Zydeco, where Grade 11 students (n=51) capture observational evidence to support knowledge claims. We developed coding schemes to assess support levels (ranging from 0-4) provided by textual and visual evidence concerning (respectively) students' (1) investigation plans for observing schoolyard wildlife with camera traps and (2) knowledge claims about climatic conditions in an immersive rainforest simulation. Textual evidence was found to provide greater support for the scientific practices of planning and argumentation than visual evidence. High-level visual evidence made connections to investigation plans and arguments, using (1) visual annotations (e.g., arrows), (2) comparison or contrasting images, (3) explanatory captions or (4) compositional techniques (e.g., cropping).

Keywords: science practices, visual evidence, collaborative inquiry, mobile applications

Introduction

A central assumption that underlies contemporary science education standards (e.g., NGSS Lead States, 2013) is that learning should be situated within *authentic scientific practice.* In this paper, we report on two learning environments where students used *visual evidence* (i.e., non-textual artifacts, such as photographs and drawings) to support two practices that the NGSS has deemed essential for students to learn: (1) planning and carrying out an investigation and (2) engaging in argument from evidence. Our work is situated within the theoretical tradition of classrooms as knowledge communities, where students engage in methods of knowledge construction that are in line with authentic scientific practice. As students work together as a knowledge community, a collaborative knowledge base is constructed through the sharing of data, ideas, and theories within a rich social environment (Scardamalia & Bereiter, 1999).

Inspired by this work, we are investigating our own theoretical model known as Knowledge Community and Inquiry (KCI) (Peters & Slotta, 2013). This approach situates knowledge construction within a technology-mediated environment, and scaffolds student groups as they contribute new ideas, theories, data, and information to a knowledge base, allowing the community to make directed progress towards inquiry goals. The KCI model guided the inquiry curriculum design to support knowledge building in two case studies. In the first case study, we describe an environment where students exchanged digital inquiry notes concerning their planned investigations of wildlife in their schoolyard. In the second case study, we present an immersive simulation environment where students captured and exchanged observational evidence to support scientific argumentation about climatic conditions in a tropical rainforest. The goal of these two case studies is to understand how students used *visual evidence* to support the scientific practices of planning and argumentation. In our analysis, we focus on students' use of visual evidence—in the form of digital photographs—from the community knowledge base. Specifically, we ask: Does students' use of textual evidence differ from their use of visual evidence for plans and arguments? We aim to reveal the kinds of technological and pedagogical supports that learners may need to engage in planning and argumentation when using visual evidence.

Visual evidence

As a regular part of scientific practice, scientists use both written material (e.g., text) and visual material (e.g., graphs, diagrams) to make discoveries (Coopmans et al., 2014) and communicate findings with peers and the public (Tufte, 2006). As new forms of data capture become increasingly a part of students' everyday experience (e.g., using a mobile device to take a photograph), such practices are also becoming more common in science classrooms. For example, the Zydeco platform enables students to use mobile devices to contribute textual evidence (e.g., written descriptions) and visual evidence (e.g., photographs and videos) to a shared repository (Quintana, 2012). Students can review their own textual and visual data and that of their peers, and use these data to support knowledge claims. These skills align with a third NGSS practice—*analyzing and interpreting data*. They are also consistent with an expectation from the Ontario curriculum, which is that students *communicate findings* using a variety of forms, including oral, written, and visual formats (Ontario Ministry of Education, 2007). However, such use of visual evidence may introduce new challenges, and more work is needed to understand how learners make produce and make sense of visual forms (Ainsworth et al., 2011).

Neighborhood Safari: Using visual evidence to support planning

A six-week unit engaged middle school students in schoolyard investigations of urban wildlife using motion-activated cameras called "camera traps." Students set out several camera traps in succession, collecting and using images from different locations to collaboratively understand patterns of animal behavior. Students strategically positioned their camera traps in the schoolyard four times, for a period of 2-3 days each. One goal was for students to become proficient at planning investigations (i.e., *where* to place the camera trap) based on environmental cues (e.g., potential food sources) and previous results (e.g., animal sightings).

Method

Students (n=45) from two Grade 5/6 classes from an elementary school in Ontario, Canada participated in the first case study. Student groups used a Web-based application for mobile devices called Common Knowledge (Fong et al., 2013) to share investigation plans with peers. Software scaffolds prompted students to describe where they would place their camera trap, provide a rationale for camera trap placement, and attach justificatory photographs (e.g., of an annotated schoolyard map; see Figure 1). These notes were contributed to a shared knowledge base, and students were able to view the contributions of other groups in real time.

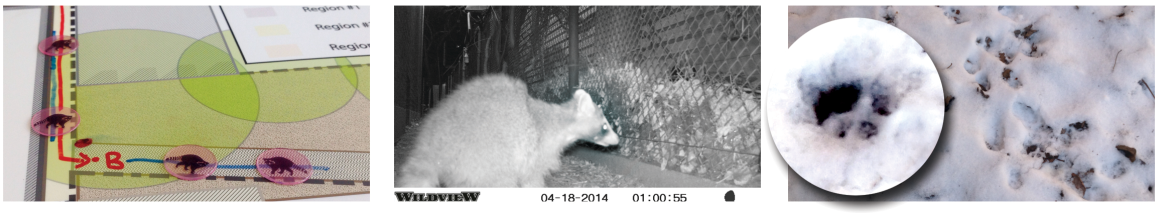

Figure 1. Left: Detail of planning map, Middle: Camera trap photo of raccoon, Right: iPad photo of footprints

Analysis and findings

We analyzed the planning notes that contained a discernable plan (n=46). First we identified the plan from each note, and then we compared textual support (i.e., the written rationale students gave for their plan) and visual support (i.e., the justificatory photographs) against each plan.

Table 1: Coding scheme for Neighborhood Safari planning notes

Level	Textual support by students for plan	Visual support by students for plan
0	No rationale given for the plan.	No justificatory photographs attached to the plan.
1	Text provides an **unreasonable** expectation for the plan (e.g., *We expect to see if the raccoon is female).*	Photograph was **irrelevant** to the plan (e.g., photograph of two students in their classroom)
2	Some of the text provides a **partially reasonable** expectation for the plan, but was too broad—*e.g., we want to see squirrels*—or contradictory).	Photograph(s) provide(s) **partial description** of plan (i.e., information needed to carry out the plan is missing).
3	Text provides a reasonable expectation for the plan and reasoning is **implicit** (e.g., *We expect to see raccoons by the garbage cans*).	Photograph(s) contain **descriptive elements** relating to the plan (e.g., map shows proposed location of camera trap).
4	Text provides evidence to support a reasonable expectation and reasoning is **explicit** (e.g., *We expect to see raccoons by the garbage cans because we have seen them there before).*	Photograph(s) provide(s) **justification** for plan (e.g., photo of planning map *and* camera trap photo of raccoons near garbage cans).

There were 65 photographs attached to these notes, with an average of 1.4 photographs per plan, ranging between 0-5 photographs per plan. Thirty-nine of the photographs were of maps, 15 were from camera traps, and 11 were taken using the iPad camera. Following the process outlined by Hruschka et al. (2004) for developing a reliable coding scheme, we created codes to assess the level of support provided by (1) textual evidence and (2) visual evidence for the plan. For both textual and visual support, we identified characteristics for five levels, from 0 (none) to 4 (highest; see Table 1).

The two raters independently coded 20% of the data, with IRR scores reaching perfect agreement for textual support and substantial agreement for visual support (Kappa=0.61, p=0.005). After independently coding all of the data, the raters reached agreement for all data through discussion. Analysis indicated that the level of textual support for plans was higher (M=3.5, SD=0.6) than visual support (M=2.67, SD=1.3).

EvoRoom/Zydeco: Using visual evidence to support argumentation

We engaged high school biology students in a 75-minute activity (part of a 10-week unit) concerning the long-term effects of climatic events (e.g., earthquake, tsunami, high sunlight, low rainfall) on a Borneo rainforest environment (Lui et al., 2014). An immersive simulation displayed four different scenarios (one per classroom wall), each of which visually depicted the effects of one climatic event (e.g., dry plants and soil indicated effects of low-rainfall). Using their knowledge of how various climatic events would impact biodiversity, student groups were tasked with identifying which of the four stations depicted their assigned climatic scenario.

Method

Students (n=51) in two Grade 11 biology classes from a high school in Toronto, Canada participated. Students used the Zydeco application (described previously) to: (1) make observations of the environment, (2) add a claim (e.g., "Station A is the rainforest affected by low rainfall") and, (3) justify their claim by explaining how the effects of a particular climatic event were evident. Using the iPad camera, students captured photographs of the simulation (either the entire screen or a detail shot – see Fig. 2) to provide evidence for their claims.

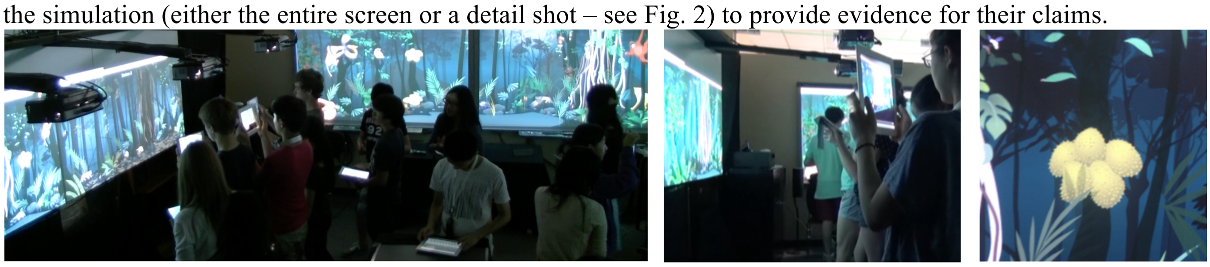

Figure 2. Left: EvoRoom, Middle: Student collecting evidence with Zydeco using iPad, Right: iPad photo detail

Analysis and findings

We analyzed the claim notes (n=33) written by student groups, coding separately the written explanations and the corpus of photographs that student-groups supplied as support for each claim. Captions that accompanied photographs were coded as part of the visual support. Ninety-six photographs were attached to these claims, with an average of 2.9 photographs per claim, ranging between 0 and 9 photographs per claim. The first two authors followed the process outlined previously to develop a coding scheme to assess levels of support provided by textual evidence and visual evidence for claims (see Table 2). For both textual and visual support, we identified characteristics for five levels, from 0 (none) to 4 (highest; see Table 2).

Table 2: Coding scheme for EvoRoom/Zydeco claim notes

Code	Textual support by students for claim	Visual support by students for claim
0	Text rationale is not provided	Photographic evidence is not provided
1	Text is **irrelevant** to the claim	Photograph is **irrelevant** to the claim (e.g., photograph of two students in their classroom)
2	Text provides **partial support** for the claim (i.e., some statements are contradictory or irrelevant).	Photographs provide **partial support** for claim (i.e., contradictory or irrelevant photographs are included).
3	Text provides **descriptive evidence** that is congruent with the claim and reasoning is **implicit**.	Photographs provide **support** for claim (e.g., an overview photograph of a simulation panel).
4	Text provides an **explanation of the evidence** and reasoning is **explicit**.	Photographs provide **convincing evidence** to support the claim, revealing specific useful details (e.g., close-ups of a simulation).

The two raters independently coded 20% of the data, with perfect agreement for textual evidence and substantial agreement for visual evidence (Kappa=0.7, p=0.001). All of the data was independently recoded, and the raters reached agreement for all data through discussion. Analysis indicated that the textual support for the claims was coded higher (M=3.0, SD=1.4) than visual support for claims (M=2.63, SD=1.34).

Conclusions and implications

For the purposes of analysis, we made a distinction between written evidence and visual evidence, although the note-sharing tools we used displayed text and photographs side-by-side, making them "colleagues in explanation" (Tufte, 2006, p. 83). However, it was important for us to tease these two evidence streams apart in order to understand if the quality of students' written support (text) differed from visual support (photographs). Our results showed that in both case studies, students achieved higher mean scores for textual evidence than for visual evidence. This suggests that these students had greater fluency in constructing written explanations that using visual evidence to support their reasoning, possibly due to curricular emphases on written literacy.

We examined the characteristics of high-level visual evidence in order to extract lessons concerning ways that learners can be supported in communicating findings using visual representations within technology-mediated environments. In Neighborhood Safari, high-level visual evidence often contained annotations (e.g., arrows drawn on a map) to provide justification for a camera trap placement plan. In EvoRoom, high-level visual evidence often included comparisons or contrasting images to more strongly illustrate claims. Captions also served to make connections between visual and written evidence more explicit. Students used compositional techniques (e.g., cropping to reveal specific details) to provide their peers with interpretive visual cues (Gilbert, 2008). These findings point to strategies that researchers and designers could use that would provide students with tools to facilitate tighter integration of textual and visual evidence, and expand work on how verbal and visual evidence are used to justify and dispute claims (e.g., Oestermeier & Hesse, 2000). For example, future designs may benefit from the ability to annotate photographs, such as the use of digital drawing tools (e.g., circles, arrows, text boxes) as overlays, drawing the viewer's attention to important elements within the visual representation. This could be particularly beneficial in cases where images are drawn from a shared knowledge base, for which students may be using a photograph for different reasons.

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Social Interaction, Constructivism and their Application within (CS)CL Theories

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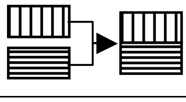
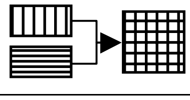
Abstract: We argue that the diversity of theories underlying CSCL research and the dispute concerning the distinction between the terms cooperation and collaboration may be explained (at least in part) by the variability of assumptions concerning the role of social interaction for individual learning. In this paper we identify different roles ascribed to social interaction in theories of learning and attempt to link them to different forms of constructivism in order to categorize theoretical conceptualizations of (CS)CL. This categorization may provide a starting point for developing a framework that enables consolidating various theoretical points of view.

Keywords: cooperation, collaboration, constructivism, social interaction, learning theories, theoretical framework

Introduction

The field of Computer-Supported Collaborative Learning (CSCL) is influenced by several scientific disciplines (e.g. psychology, sociology, philosophy, computer science). Therefore CSCL research builds upon a variety of different theoretical points of view (Stahl, 2013). The phenomena that lie at the heart of CSCL research comprise social interaction and learning in the context of information technology (Ludvigsen & Mørch, 2010). To date, no single, overarching theory or paradigm is able to explain the relationship between those terms (or concepts) comprehensively (Goldbeck & El-Moslimany, 2013). We argue that a potential reason for this may be that there is no clear and universally valid definition of the concepts social interaction and learning. Some approaches appear to be compatible, while others seem incommensurable as they diverge concerning central assumptions concerning the nature of human cognition and social interaction. In this paper, we identify different roles ascribed to social interaction within theories of (CS)CL and attempt to link these roles to different forms of constructivism (see Table 1). We hope that this categorization may facilitate a harmonization of diverging approaches within CSCL; however, we acknowledge that this short paper provides just a starting point for developing a more formal theoretical framework.

Table 1: Theoretical overview

Social Interaction	Constructivism	Product	Exemplary Theory
Contextual: variations of social interaction produce variations in individual learning	*Exogenous*: the source of knowledge is the environment	*no common product (individual)*	*Social Learning Theory (Bandura)*
Enabling: social interaction enables individual learning	*Endogenous*: the source of knowledge construction are individual processes	*additive (cooperative)* 	*Social Interdependence (Deutsch)*
Constitutive: social interaction is a part of the process that produces individual learning	*Dialectical*: the source of knowledge construction is a synthesis of both	*synergistic (collaborative)* 	*Distributed Cognition (Hutchins)*

Theoretical conceptualizations of (Computer-Supported) Collaborative Learning

Theoretical conceptualizations of (CS)CL include three major constituent parts: social interaction, individual learning, and the affordances information technology can bring to these. Due to space constraints, we focus on the first two parts. We argue that the theoretical diversity within CSCL research might be explained – at least in part – by the role ascribed to social interaction for learning. Social interaction is a complex construct and no common definition of the term exists. This also could explain the controversial issue emphasized by Lipponen (2002) concerning the distinction between the terms collaboration and cooperation within research on CSCL. There is some evidence that the term cooperation relates to a different role of social interaction within learning processes, than collaboration does. Therefore we also address this aspect in our conclusion. Social interaction broadly defined entails the exchange of information between at least two individuals. According to Jaegher, Di Paolo and Gallagher (2010), social interaction can relate to individual learning in three ways: it can be (1) a contextual, (2) an enabling, or (3) a constitutive factor for individual cognitive phenomena. We will explain these concepts below. Theories of CSCL also include several forms of constructivism (Goldbeck & El-Moslimany, 2013). Moshman (1982) distinguishes between exogenous, endogenous, and dialectical directions of constructivism. As will be detailed below, we argue that the three roles of social interaction and the three forms of constructivism can be linked to each other (see Table 1). This then allows categorizing assumptions about the nature of learning that underlie theories of CSCL.

From the perspective of empiricism, knowledge exists within the empirical or ”external world”, and can be experienced and processed by an individual (Goldbeck & El-Moslimany, 2013). According to this point of view, social interaction is a contextual factor for individual learning (Jaegher, Di Paolo & Gallagher, 2010). Variations of individual learning or behavior can be explained by variations within the social environment. Within social learning theory (Bandura, 1977) and corresponding instructional approaches, social interaction is also a contextual factor. According to Moshman (1982), the construction of knowledge is exogenous and can be explained on the basis of external input (cf. exogenous constructivism). Expanding behaviorist views, these approaches particularly focus on social interaction and the environment as a contextual factor, which serve as an input for cognitive outcomes (Moshman, 1982).

According to a rationalist point of view, and also with reference to cooperation, the nature of knowledge is described by organizational processes “imposed by the human mind” (Goldbeck & El-Moslimany, 2013, p. 43). The ideas of Piaget (1977) can be subsumed under this theoretical direction. Learning is not solely a passive reaction, but it is the process of internal knowledge construction, due to the equilibrium of cognitive structures. Moshman (1982) therefore localizes Piagets' theory within endogenous constructivism. Social interaction is not regarded anymore as merely a contextual factor for individual cognition, but it plays an enabling role in individual learning (Jaegher, Di Paolo & Gallagher, 2010). Against the background of folk theories, Marx argues, that for cooperation “a large number of workers are brought together in one place for purpose of production” (as cited in Morrison, 1995, p. 86). Further, “the effect of combined labor could not have been produced by the isolated worker and […] the combined effect creates a form of cooperation which increases the productive power of the individual” (as cited in Morrison, 1995, p. 86). This definition emphasizes the enabling character of cooperation. Translating this to educational research, cooperation is regarded as a form of social interaction that enables individual cognition. Early research on cooperative learning particularly stressed the benefits of cooperation in comparison to individual learning (Johnson & Johnson, 2002). In summary, social interaction has an enabling character within cooperation, which causes individual cognitive processes. This thought parallels the ideas of endogenous constructivism.

Further, Slavin (1995) distinguishes between motivational and cognitive theories of cooperative learning. Both threads have in common that they expect social interaction to enable cognitive development. While cognitive approaches focus on explanation-giving or socio-cognitive conflicts as an enabling factor for individual development (see Mugny & Doise, 1978), motivational approaches focus on the conditions of social interactions which foster the motivation to cooperate. Deutsch (1949) highlights the need for social interdependence, therefore social interaction becomes an enabling factor for motivation and thus for individual cognition. Social interdependence as an enabling factor illustrates the main characteristic of cooperation, the division of labor and unshared information. According to Dillenbourg (1999), the division of labor is a central aspect when attempting to distinguish cooperation from collaboration. Most concepts of cooperation comprise the idea that splitting the responsibility for the task product facilitates beneficial social interaction (Damon & Phelps, 1989). Dividing up unshared information can enable individual cognition because of explanations that arise from the interdependence of the interacting individuals (Aronson, Blaney, Stepan, Sikes & Snapp, 1978). Stahl (2004) agrees with this notion, claiming that in contrast to collaborative learning where ”the work is done by the group as a whole” (p.63), in “cooperative or coordinated work, tasks are often divided up so that individuals actually work and build knowledge on an individual basis and then attempt to share the results" (Stahl, 2004, p.63). Thus, one can trace back each individual part of the common, and thereby additive, product. In contrast, the concept of collaboration emphasizes a more creative meaning of working together (Kvan, 2000), where the common product is more synergistic, and thus the different contributions of each member cannot clearly be ascribed to just one individual effort. This attribute of collaboration lead us to an understanding of social interaction and constructivism which differs from the enabling, endogenous characterization.

Collaboration is more related to dialectical constructivism, and to the assumption that social interaction is a constitutive factor. This perspective can be illustrated by Vygotsky's zone of proximal development (Moshman, 1982). The zone of proximal development bridges between an enabling and constitutive role of social interaction. On the one hand, it emphasizes social interaction as an enabling factor, because it stresses the "gap between what individuals can do by themselves […] and what they can do in collaboration" (Stahl, 2013, p. 78). On the other hand, the zone of proximal development underlines a constitutive role of interaction. Against the background of specific requirements for development inside the learner, individual cognition and the social environment presuppose each other. The individual stage of development influences the structure of the educational environment, while the environment directs "the course that development takes" (Moshman, 1982, p. 375). This interrelation between endogenous and exogenous sources of knowledge is characterized by dialectical constructivism. According to this theoretical viewpoint, social interaction is not just a contextual or an enabling factor, it constitutes individual cognition (Jaegher, Di Paolo and Gallagher, 2010). Social interaction becomes a part of the cognitive process itself. An important view on (CS)CL which goes along with such an interrelated conception of individual learning and social interaction is the approach of distributed cognition (Hutchins, 1995). Along similar lines to group cognition (Stahl, 2006), distributed cognition emphasizes the dialectical and constitutive relation between individual cognition and the social or socio-technical environment (e.g. the speed bug within an airplane). In other words, the group product and particularly cognitive processes cannot be traced back to individual cognitive processes (endogenous) or the social environment itself (exogenous). It is a reciprocal, dialectical composition of both. Therefore the group product cannot be attributed to the actions of the individuals, but must be attributed to the group as a whole. Furthermore, cognitive phenomena cannot be described exhaustively by individual processes, nor solely by social interaction, but must be conceptualized as a complex interplay of both. Most approaches which stress the synergistic and dialectic characterization of social interaction use the term collaboration. According to Beers, Boshuizen, Kirschner and Gijselaers (2005), the enabling characterization of social interaction focuses on the development of common ground and shared knowledge, formed through negotiation and knowledge exchange. In contrast, the product of a constitutive and therefore dialectical process particularly stresses the construction of new knowledge as a result of a synergistic integration. Theoretical approaches like social interdependence theory (Deutsch, 1949) describe social interaction as an enabling factor for individual cognition. In contrast to endogenous constructivism (e.g. Piaget, 1977), approaches as distributed cognition (Hutchins, 1995) are related to dialectical constructivism, and the assumption that social interaction is a constitutive part of the cognitive process itself.

Conclusion

The purpose of this paper was to categorize theoretical accounts of (CS)CL concerning their underlying definitions of social interaction and constructivism. Both aspects are central to understanding 'collaborative learning'. Social interaction can enable or constitute individual cognitive processes. These roles of social interaction are linked to the versions of constructivism identified by Moshman (1982). We stress that theories within CSCL research can be categorized concerning both aspects. This categorization may be the first step towards a framework that allows integrating the diverse theories of (CS)CL. Though this goal of integration cannot be realized in this paper, we were able to point out the two central roles of social interaction concerning cooperative and collaborative learning. In addition we linked these roles to the versions of constructivism suggested by Moshman (1982). In doing so, we found indications for the assumption that the reason for the sometimes controversial usage of the terms cooperation and collaboration could exist because of its controversial relation concerning social interaction. Dillenbourg (1999) for example argues that cooperation relates to the division of labor, while collaboration is related to working together, not individually by solving sub-tasks. He also developed some conditions for collaboration, for example the "symmetry of knowledge". Individuals should have a common ground concerning knowledge in order to collaborate. According to that, we claim that cooperation can be used in order to generate a common ground. The process of cooperation, starting with finding out who knows what, hence resulting in division of labor and finally learning with the additive product, enables a common ground. Cooperation then can be seen as an optional sub-process of collaboration, which takes place if the symmetry of knowledge is not assured. Summed up, social interaction has an enabling role within cooperation: it enables the common ground, by dividing the work and finding out, who knows what.

The knowledge construction though is an individual process, yet the product is additive and gives each individual the ability to again construct knowledge individually in order to generate the common ground needed for collaboration.

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Learning about Team Members' Preferences: Computer-Supported Preference Awareness in the Negotiation Preparation of Teams

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Abstract: Although members of a negotiation team form one joint negotiation party, they often have different preferences within the team. This impairs the team's negotiation performance. Learning about the team members' preferences in order to align them to accurate joint priorities for the negotiation therefore becomes an important part of the negotiation preparation. This experimental study examines, whether computer-supported awareness about the team members' preferences (i.e. Preference Awareness) helps to foster the knowledge about these preferences within the team and thereby leads to accurate team priorities. 150 participants were randomly assigned to teams of three members with different preferences in either a condition with or without Preference Awareness. They had to prepare jointly for an upcoming negotiation via audio conference. In the condition with Preference Awareness, the priorities, which were stated by the team members afterwards, covered the preferences of all team members significantly better than in the condition without awareness.

Keywords: preference awareness, negotiation teams, negotiation preparation, negotiation performance, computer-supported learning

Introduction

Conflicts between groups are widespread. They do not only occur in many situations of everyday life, but also between different organizations, (working-) teams, school classes, political parties and nations (van Kleef, Steinel & Homan, 2012). One of the most common and constructive ways to solve such conflicts is through negotiation. Especially when the situation is very complex and complicated, negotiation teams are used to solve the issues (Brett, Behfar & Friedman 2009). The reason for that is the expected broader range of resources, skills, knowledge and information teams can contribute compared to individuals (Mesmer-Magnus & DeChurch, 2009; van Ginkel, 2007).

Yet, studies that compare the negotiation performances of negotiation teams with those of solo negotiators show no general superiority of teams (Cronin & Weingart, 2007; Morgan & Tindale, 2002; Thompson et al., 1996). The use of negotiation teams is rather associated with particular difficulties due to a higher complexity when several individuals are supposed to cooperate as one negotiation party (Lewicki, Saunders & Barry, 2007).

Behfar, Friedman and Brett (2008) investigated such difficulties by analyzing organizational negotiation teams in the work context. The main problem which was stated out in this analysis lies in the team itself: Although the members of a negotiation team form one joint negotiation party, they often have different preferences for an upcoming negotiation (Behfar et al., 2008). If these aren't exchanged and aligned by the team members *prior* to the negotiation in order to agree on joint priorities, they achieve poorer negotiation results for their team, especially when there is integrative potential (Halevy, 2008). Integrative potential is given, when there are negotiation issues which are differently important for the negotiation parties. This is the case in most negotiation situations (Swaab, Galinsky, Medvec & Diermeier, 2012). Then mutually profitable trade-offs are possible between the negotiation parties. This means, that concessions are made on negotiation issues of low priority for the own party, but high priority for the other party, to get in return concessions on issues of high priority for the own, but low priority for the other party (e.g. Ten Velden, Beersma & De Dreu, 2007).

To be able to make such mutually profitable trade-offs with the other negotiation party in favor of the whole team, the team members need to have knowledge about all team members' preferences and have to agree on what the joint team priorities are. Importantly, this alignment process has to take place prior to the negotiation. The negotiation preparation of the team therefore becomes an essential part of the negotiation process.

But teams often insufficiently prepare for an upcoming negotiation (Brett et al., 2009). Furthermore, there are various collaboration barriers which hinder the proper exchange and alignment of team members' preferences within the team. A number of findings show, that members of teams discuss more about shared information and common preferences during team discussions, whereas unique information or preferences are often neglected (Bowman & Wittenbaum, 2012; Stasser & Titus, 1985). Additionally, complex issues often require the participation of experts from different fields, who are often hindered to meet in person but have to prepare computer-supported in a virtual environment, for example via the telecommunication application software Skype. In such virtual contexts, there is less contextual information than in face-to-face situations and also the social presence is reduced (Martinez-Moreno, Zornoza, Gonzalez-Navarro & Thompson, 2012). This makes it even more difficult to develop a model about the knowledge of others (cf. Engelmann & Hesse, 2010) or about which information and preference backgrounds the other team members have.

Solution approach: Preference Awareness

Hints for a solution to these problems are provided by the Knowledge and Information Awareness approach (Keller, Tergan & Coffey, 2006). Findings show, that group members reach better solutions in computer-supported collaborative problem solving tasks when they are informed about the knowledge and its underlying information of their collaborators (i.e. Knowledge and Information Awareness; Engelmann, Tergan & Hesse, 2010). Additionally the exchange of unshared information is fostered (Engelmann & Hesse, 2011). Based on these findings, the concept of *Preference Awareness* was developed by the first author, defined as being informed about the team members' preferences for an upcoming negotiation. It is expected, that computer-supported Preference Awareness during the negotiation preparation fosters the exchange and alignment of preferences within negotiation teams and thereby leads to a better knowledge about the joint team priorities among the team members.

Method

To examine the postulated effects of Preference Awareness, an experimental study with university students was conducted. One-hundred-fifty participants (119 female, 31 male, M_{age} = 23.33, SD_{age} = 2.97, age range: 18–32) were randomly assigned to a condition with Preference Awareness or a condition without Awareness and then to teams of three members, representing a water-supply corporation. This resulted in 50 teams, with 25 teams per condition.

In this economic scenario, the team members had to prepare jointly for a negotiation with another corporation about the distribution of ten building grounds for water-supply companies in Africa. The negotiation preparation took place computer-supported via audio-conference in three different rooms. Within the team, each team member took over the role of one manager of the corporation with individual preferences for nine different attributes of the building grounds (e.g. water quality, transport possibilities, cultural environment). The values for the preferences ranged from 0 to 100 and were presented in a spreadsheet, graphically supported by different sized bar charts. In the condition with computer-supported Preference Awareness, each member could see the preferences of all team members in the spreadsheet during the audio conference. In contrast, in the condition without awareness, each team member could only see his/her own preferences. So the Preference Awareness-Tool enabled the team members to have direct access to all team members' preferences on the computer screen in a structured way during the audio conference. For better discrimination, different colors were used for the bar charts of each team member. The team members were told that the time to prepare for the upcoming negotiation was limited to 20 minutes and that the presented information would only be available during this audio conference, but no further instructions were given. So it was up to them if and how they used the available information offered by the Preference Awareness on the computer screen during their discussion.

When the audio conference was finished, all team members were individually asked what priorities they would pursue for their team, if they were selected to represent it in the upcoming negotiation. Therefore each team member was asked to rank the nine attributes of the building grounds by importance. In order to represent the whole team, the amount of knowledge about the joint team priorities gained during the audio-conference was crucial. The accurate team priorities resulted, when all team members' preferences were considered equally. So the perfect ranking for the joint team priorities could be achieved by averaging the individual preference values of all team members for each of the nine attributes. It was expected that Preference Awareness during the negotiation preparation would help the team members to learn about the preferences within the team and thereby would lead to priorities for the negotiation, which cover all team members' preferences to a higher extent.

Additionally it was also tested, how well the single team members could judge the importance of five building grounds for the whole team via ranking. The purpose of this task was to test, if the knowledge about team members' preferences could also be transferred to the judgment of concrete issues for the negotiation. For each building ground it was therefore presented how well it covers the nine attributes by stars from one to ten. In order to rank the building grounds accurately, one had to consider the accurate team priorities. The more stars a building ground had in attributes which were important for the whole negotiation team, the more valuable it was. The quality of the ranking of the building grounds serves as an indicator of whether the team members knew which profitable trade-offs could be made for the whole team. This is an important requirement for achieving good negotiation results (e.g. Ten Velden, Beersma & De Dreu, 2007). Therefore the task is a direct indicator for the expected negotiation performance.

Findings

To analyze the data statistically, it was aggregated on group-level because of the interdependence of the team members within a team.

First it was analyzed, if Preference Awareness fosters the knowledge about the accurate joint priorities within the team. Therefore the deviation of the rankings stated by the team members from the accurate ranking based on the averaged preferences was calculated and summed up for each team. The priority rankings of team members with computer-supported Preference Awareness during the negotiation preparation deviated significantly less from the accurate team priorities (M = 12.48, SD = 7.30) than the rankings of team members without awareness (M = 22.64, SD =11.82, $t(48)$ = -3.657, p = .001). So the hypothesis, that Preference Awareness during the negotiation preparation fosters the knowledge about the accurate joint priorities within the team, can be confirmed.

Furthermore the rankings of the building grounds were analyzed in order to find out whether the team members knew which profitable trade-offs could be made for the whole team. Therefore it was calculated, how much the rankings of the members of each team for the five building grounds deviated from the accurate ranking based on the accurate team priorities. The rankings of team members with computer-supported Preference Awareness during the negotiation preparation deviated significantly less from the accurate ranking (M = 7.36, SD = 5.47) than the rankings of team members without Awareness (M = 12.48, SD = 8.65, $t(48)$ = -2.502, p = .016). So members of teams with Preference Awareness during the negotiation preparation were better able to judge the importance of the different negotiation issues for the team accurately in a transfer task. The findings are illustrated in figure 1.

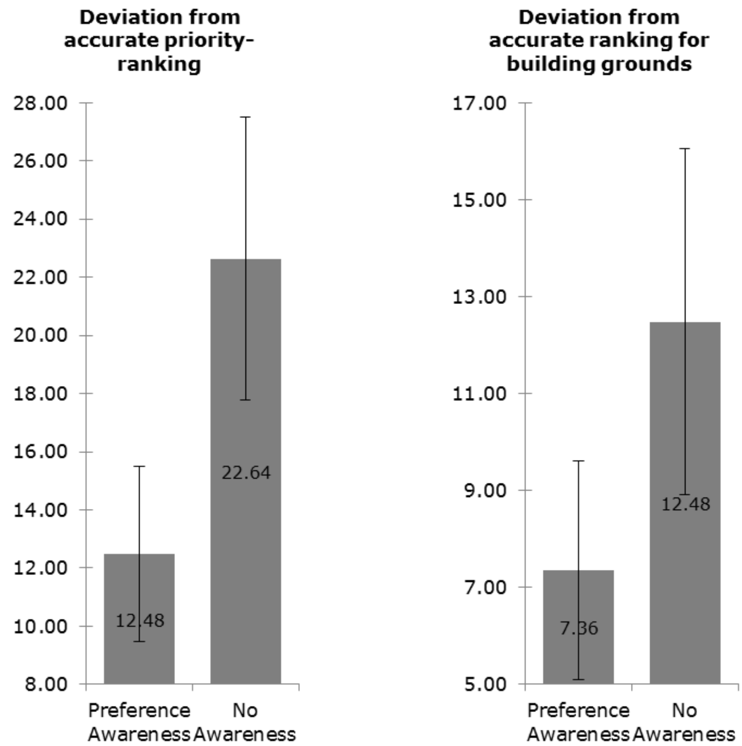

Figure 1. Deviations from accurate priority ranking (left) and accurate ranking for the building grounds (right) on team-level with 95% confidence interval for the experimental condition with Preference Awareness and the control condition without awareness.

Conclusions and implications

The results of this experimental study show that computer-supported Preference Awareness not only fosters the knowledge about the accurate joint priorities within negotiation teams. A further transfer task showed that it also enables the team members to judge the importance of the different negotiation issues for the team accurately. This is an important indicator for the expected negotiation performance: the team members do not only have to know the priorities of the whole team, but also need to be able to transfer this knowledge to an accurate judgment of the negotiation issues. To know the importance of each negotiation issue for the team is crucial in order to act as a unit and claim the demands of the whole team during the negotiation. It is furthermore a necessary requirement for the ability of the team members to know which profitable trade-offs could be made with the other negotiation party in favor of the *whole* team. Otherwise trade-offs are made, which are not beneficial for the team. This impairs the negotiation performance and consequently the negotiation result.

So it can be concluded, that Preference Awareness is a very promising approach to optimize the negotiation preparation of teams, especially when the team cannot meet in person but prepares computer-supported. In this experiment, the concept of Preference Awareness was tested in an economic scenario with a student sample. However, due to the promising results, it is highly recommended to implement this Preference Awareness-Tool in the negotiation preparation of real organizational teams. But this approach also has the potential to be extended to other collaborative situations in which the awareness about the group members' individual preferences could be useful, for example in order to get to a team decision. It could also be very valuable for a learning group in order to help its members to agree on joint learning contents and goals. Further studies should therefore investigate the implementation of Preference Awareness in more settings.

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Internalization of Physics Concepts and Relationships Based on Teacher Modeling of Collaborative Prompts

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Abstract: As students create shared artifacts, individuals and the social system co-evolve through dynamic processes in which individuals and groups shape each other. After collaboration, however, it is not always clear what students internalize from this interaction. Even when students are aware of group-work benefits, effective collaboration does not necessarily occur spontaneously within the group context. To address this potential issue, the teacher can facilitate collaboration by modeling how to foster elaborative group discussions. In this paper, we evaluate how teacher modeling of collaboration prompts may increase the quantity and quality of concepts that students internalize before, during, and after collaboration. We found that students who did not observe modeling increased the quantity of connection on their post concept maps. In contrast, students who did receive modeling increased both the quantity and quality of their connections. This suggests that modeling of prompts before collaboration can deepen the internalization of concepts.

Keywords: shared knowledge, collaboration skills, network analysis

Introduction

What happens to individual learning after working in a group? Building on Vygotsky's (1978) idea of internalization, social interactions shape individual learning and development, as "*interpersonal processes* [are] *transformed into an intrapersonal one*" (p. 57; emphasis in original). We base our study on a sociocultural framework that emphasizes that learning is a dynamic individual and collective practice that highlights the transformative nature of social interactions (Rogoff, 2008). As people create shared artifacts, both the individuals and the social system co-evolve through internalization and externalization (Cress, 2013). The individual shapes the group's understanding, and the group shapes each member's understanding.

While learning may be a social process, the degree of internalization depends on both the individual learner and the social context and interactions of the activity (Smagorinsky, 2012). Internalization, also referred to as appropriation by some researchers (Rogoff, 2008; Grossman, Smagorinsky, & Valencia, 1999), means to transform and take as one's own. One key factor that might affect the degree of internalization is the nature of the collaborative interactions. Research suggests that effective collaboration does not necessarily occur spontaneously within the group context (Barron, 2003). The classroom teacher can facilitate collaboration by modeling how to interact within groups and foster better group discussions (Mercer, 2000).

In this study, we examined how teacher modeling of effective collaboration affected students' understanding and internalization of physics concepts and the relationships between concepts. To examine the extent of internalization of ideas resulting from group discourse, we used concept mapping as a tool to organize and represent knowledge. Concept maps help connect ideas by describing the relationship between two concepts (Novak & Cañas, 2006). When students are working in a group, they "engage and interact with their environment to transform particular objects of activity to achieve an outcome, which is mediated by cognitive and physical artifacts" (Hmelo-Silver, Jordan, Liu, & Chernobilsky, 2011, p. 86). Collaboratively constructed concept maps can be used as an external artifact representing shared knowledge (Cress, 2013; Teasley & Fischer, 2008), and changing conceptual understanding (Roth & Roychoudhury, 1994). Our research question was: How does teacher modeling of collaborative learning through prompts for effective collaboration change students' internalization of physics concepts?

Methods

Students in two eighth grade science classrooms taught by the same teacher participated in this study. Students worked in groups of three to five, comprising 11 groups for a total of 42 students (22 female, 20 male). Students engaged in the CoMPASS design-based curriculum (Puntambekar, Stylianou, & Goldstein, 2007), which is an 8-week curriculum about work and energy using simple machines. Students worked in the same groups throughout the unit and had opportunities to practice developing individual concept maps.

Experimental design and procedure

This study used a 2 x 3 experimental design to examine the effects of teacher modeling of prompts on internalizing ideas from a group concept mapping activity. During the study, students in both conditions created concept maps before, during, and after collaboration for a total of 93 maps. Students either received modeling of prompts (6 groups, 27 students) or received no modeling (5 groups, 15 students). In the intervention, students received a list of four individual and four group prompts to support individual and collaborative thinking during the activity. The teacher then read several prompts to the class and explained what the prompt meant in her own words. An example individual prompt was “Justify your thinking about why the concepts or relationship between concepts you contribute are important,” and a group level prompt “Ask other group members to justify, give evidence, or support their ideas.” Further, the teacher demonstrated a hypothetical situation, such as “How could you help your group if someone says, ‘I think we should start with lever’?” Finally, students practiced enacting these prompts in their small groups.

First, students spent 12 minutes creating an individual concept map about the physics ideas they had learned up until that point in the unit. Students in the teacher modeling condition received an additional seven minutes of instruction in how to support individual and collaborative thinking during the group activity time. Then, the teacher gave the students in both conditions identical directions to make their group maps; students were given 20 minutes to collaboratively create their map. The teacher instructed all students to think about deep connections between concepts and provided ideas for starting words and linking words. While working in their groups, students could access resources from previous activities in this unit. At the start of the next class period, students had fifteen minutes to create a final individual map. The entire activity took less than one hour.

Data sources and analysis

In each of the 93 concept maps, we extracted propositions that consisted of a concept – connection – concept set. For example, if a student connected two nodes, “levers” and “simple machines,” with a line that had the words “type of” on top, then the proposition is “levers – type of – simple machine.” To maintain these connections, the full proposition was chosen as the unit of analysis. We assigned each proposition two codes: a *concept profile* code and a *depth of relationship* code. *Concept profiles* scored the presence (1) or absence (0) of a connection between two concepts. For example, any connection between Friction and Work received a score of one. This isolated what concepts were added or left out of maps over time but did not examine the nature of connection between them. *Concept profile* codes were useful in assessing concept quantity and surface changes.

To extend beyond simply identifying what concepts students connected in their maps, we used a *depth of relationship* code to examine changes in the quality of relationships between concepts over time. Connections between concepts could be assigned a number from zero to four to indicate the depth of relationship between two concepts: absent or incorrect relationships (0), simple relationships (1), equations and definitions (2), simple directional relationships (3), and relationships that elaborate and specify the conditions for the relationship (4). We analyzed concepts as written to preserve the original language during coding, but we later converted concepts into a categorized and reduced format to permit network analysis of key concepts. Two researchers coded the concept maps for depth of relationship and achieved good inter-rater reliability with an overall agreement of 91.5%, weighted $\kappa = 0.885$; all discrepancies were resolved through discussion.

Our analysis explored the quantity and quality of propositions in maps created before, during, and after collaboration to assess internalization. Social network analysis (SNA) provides the opportunity to look at patterns of relationships to provide a more comprehensive picture of student understanding in CSCL contexts (Aviv, Erlich, & Ravid, 2003). In order to quantify the patterns of relationships between concepts while maintaining the networked nature of the maps we used the Epistemic Network Analysis (ENA; Shaffer et al., 2009) tool. This tool, based on SNA, transformed the propositions into co-occurrences and allowed us to build network graphs to study the quantitative relationships between maps. To condense the complexity of each concept map, ENA reduced the number of data dimensions to geometrically reproduce the internal structure of the data and then plotted that reduced map as a node in the space (x, y, z). The resulting dimensions, which explain the greatest variability between the maps, became the axes upon which the mean center (network score) of each map was projected (Shaffer, 2014). Therefore, each concept map became a node in this high-dimensional space and could be analyzed with other nodes from the same condition or time of map creation using a *t*-test. Because we used two separate coding schemes, we compared the concept maps in two loading spaces: one for the concept profiles (*Concept*) and one for the depth of relationships (*Depth*).

Results

Because ENA is a data reduction procedure, each dimension contrasts connections with extremes at each axis end showing primary differences. For each dimension, the first phrase denoted dimension loadings to the negative end of that axis and the second phrase characterized the positive loadings of that axis (see first column in Table 1). A dependent-samples *t*-test was performed to compare the mean network scores between pre and post maps for each ENA dimension for both conditions. This resulted in 12 comparisons that identified what connections accounted for the most difference within the sample, which are also listed in Table 1.

Table 1: Comparing mean network scores by condition over time

	Modeling				**No Modeling**			
Dimension Name and Description	Pre	Post	*t*	*df*	Pre	Post	*t*	*df*
Concept1: Simple Machine VS. Force & Mechanical Advantage	-0.153 (0.274)	0.005 (0.199)	-1.79	25	-0.027 (0.292)	0.135 (0.260)	-2.47*	13
Concept2: Lever Examples; Applied Force VS. Force	0.055 (0.169)	-0.124 (0.24)	3.40**	25	0.183 (0.187)	-0.064 (0.169)	4.10**	13
Concept3: Specific Machines VS. Mechanical Advantage, Work, & Force	-0.055 (0.139)	0.057 (0.237)	-2.12*	25	-0.091 (0.158)	0.063 (0.197)	2.34*	13
Depth1: Core physics concepts & Simple machines VS. Force & Specific machines	-0.152 (0.299)	-0.087 (0.276)	-0.76	25	0.142 (0.411)	0.119 (0.353)	-0.04	13
Depth2: Force & Simple machines VS. Force & Specific Machines	-0.076 (0.331)	0.093 (0.185)	-2.42*	25	-0.099 (0.231)	0.058 (0.170)	-1.92	13
Depth3: Force, Distance, & Work VS. Force & Specific and Simple Machine	0.044 (0.234)	-0.037 (0.208)	1.79	25	-0.061 (0.260)	0.023 (0.094)	-1.04	13

Note: Standard deviation of mean network score is shown in parenthesis; * $p < .05$, ** $p < .01$.

When comparing changes in *Concept1*, the No Modeling group included significantly more connections to Force and Mechanical Advantage after collaboration. While the Modeling group changed in the same direction, this was not significant. For *Concept2,* students in both conditions significantly internalized more concepts about Mechanical Advantage, Work, and Force but created fewer connections to specific machines. Students in both conditions added more concepts to Applied Force and fewer to Force and Simple Machines over time (*Concept3)*.

In comparing relationship depth, there was only one significant comparison among the six. Neither group of students changed over time when contrasting connections from core physics concepts and simple machines versus Force and Simple Machines (*Depth1*). However, for *Depth2* only the Modeling condition showed a significant difference indicating a shift from connecting Force to Simple Machines versus connecting to Specific Machines. Although there was no significant difference in *Depth3*, each group moved the opposite way of the other. The Modeling group shifted toward interconnecting Force, Distance, and Work; the No Modeling group shifted toward connecting to Force, Specific Machines, and Simple Machines.

Discussion

This study examined how individual learning may be affected by collaboration. Analyzing concept map networks using a network based analysis allowed investigation of the commonality and variance in underlying structures of sets of maps from each condition.

A key focus of collaborative learning is to improve students' individual learning outcomes; the extent of what each student learns, or internalizes, is therefore important to examine (Grossman et al., 1999; Smagorinsky, 2012). We found that students produced higher quantity and quality maps after collaboration; however, this finding had different implications across the two conditions. While students in the No Modeling condition seemed to show more evidence of internalization of connections between force and mechanical advantage (*Concept1*), this condition did not show differences when comparing changes in maps based on increasing the depth of their ideas. Though students added more concepts, these relationships failed to establish deeper connections such as directional relationships between concepts. Students in the Modeling condition showed both higher quantity *and* quality of conceptual relationships after working on their group maps. This suggests that the nature of the collaborative discourse that occurred while students worked on their group maps might have had an effect on internalization of the relations between science ideas.

Because individual physics knowledge was discussed and collaboratively combined to produce a group map, students processed ideas and accessed these collective ideas when constructing their final individual maps (Cress, 2013). The goal of collaboration was not just to create longer lists but to create deeper relationships between concepts, which was seen in maps for the Modeling condition but not in the maps for the No Modeling condition. This difference in condition supports the idea that when teachers model how to elaborate ideas and encourage the elaboration of others, students learn to understand when and how to apply these resources (Mercer, 2000). Student and group understanding underwent multiple and varied transformations during this activity, and each student may have internalized a different set of conceptual relationships. This supports Cress's (2013) assertion that the individual and group system co-evolved. Our study also supports identification of multiple levels of internalization or appropriation across individuals and groups (Smagorinsky, 2012).

The next step in this analysis will be to analyze each proposition in the concept maps in detail and to better understand how relationships between force, distance, work and mechanical advantage change over time and across groups. To support this analysis, we will use the discourse data recorded during collaboration to better understand what happened during collaboration to explain the differences in internalization.

This paper identifies ways in which students' ideas and understanding about physics concepts evolved over time and were affected by their group discussions. Only by analyzing concept maps before, during, and after collaboration could we observe the different ways students may have internalized different concepts during this short, one-hour activity. In summary, our results suggest that after receiving collaborative support for their group work, students improved the quantity and quality of internalized concepts.

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Promoting Interaction by Integrating a Question and Answer Forum with a Digital Textbook

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Abstract: As digital textbooks become more common in formal learning environments, there is an opportunity to embed technology that represents our growing understanding of best pedagogical practices into the textbook itself. Integrating collaborative technologies into a textbook platform provides substantial opportunities for facilitating classroom discourse surrounding the textbook content. However, to be successful in a digital textbook, these technologies have to be perceived by students as useful, and must function well on the tablet platform. This paper proposes the integration of Q&A into a digital textbook platform as a way of facilitating productive collaboration, designing for the tablet, and engaging students with the technology. We describe our implementation of an integrated Q&A system and digital textbook, and outline the results of a pilot study that demonstrate how the Q&A system might be effectively used by groups of students.

Keywords: digital textbooks, question and answer forums, tablets, introductory biology

Motivation

Despite decades of technology in classrooms, textbooks remain the primary instructional resource used by teachers and students (Lewin, 2009). They are designed to serve as a grounding tool for classroom instruction, and to facilitate students in forming an intellectual community through the co-construction of knowledge (Zhao & Kuh, 2004). Digital textbooks are gradually replacing physical textbooks in the classroom, and are projected to represent 35% of the total textbook market by 2016 (Uzwyshyn, 2012). Today's digital textbooks, however, are often analogues to their print counterparts, with additional features such as better search, navigation, and annotation (Marmarelli & Ringle, 2011). With the transition from the physical to the digital medium, there is an opportunity to reflect on how textbooks can be reimagined to best scaffold student learning.

Our work investigates how to incorporate collaborative activities directly into the digital textbook platform. Collaboration is already a natural part of textbook use, but it typically occurs externally to the textbook itself, as students use textbook content as a starting point for face-to-face interaction (Rossing, Miller, Cecil, & Stamper, 2012; Li, Pow, Wong, & Fung, 2010). By incorporating collaboration directly into the textbook platform, students can co-construct knowledge asynchronously, from any location, and yet still ground discussion in textbook content. In some cases, researchers have built computer-mediated collaboration into their textbooks by having students share notes or collaboratively annotate the textbook, and have noted that these activities motivate the students to engage more with the course material (Tront, 2007; McFall et al., 2004). These functionalities are also making their way into commercial digital textbooks such as Inkling and Kno. It is important to note that while these textbooks do enable collaboration, they do not scaffold students in engaging in productive collaborative behaviors. Students must engage in particular promotive interactions in order to benefit from collaboration (Johnson & Johnson, 1990), and in the digital textbook context, they receive little guidance on how to do so. Given the growing ubiquity of digital textbooks, facilitating scaffolded collaboration within the textbook platform might have the potential to improve student learning at a large scale.

In this paper, we design a Q&A model of interaction into a digital textbook environment that satisfies the constraints of the particular design problem, principles of collaborative learning, and student perceived needs. In our Q&A system, students ask and answer questions of their classmates while reading a digital text. Thus, there are two constrains of the design problem: (1) the system will be used by a closed group of students (the number depends on class size), and (2) the system will be used on a tablet platform. We chose Q&A because, in properly designed interactions, *answering questions* has several benefits: students attend more to domain material, reflect on what is required to solve problems, and elaborate more on their own knowledge (Roscoe & Chi, 2007). Taking on the role of help-giver can also improve students' academic self-efficacy and attitudes towards school (Robinson, Schofield, & Steers-Wentzell, 2005). In contrast, students see a main benefit of collaboration as a way of getting immediate support from peers on learning content, and thus tend to embrace course-related Q&A systems (Hung, Yang, Wang, & Shih, 2006). The Inquire textbook, which implements automated answers to student generated questions, has received a similar positive response from students, but does not give students the opportunity to construct knowledge by answering their peers' questions (Chaudhri et al., 2013). In the following sections, we describe a prototype we developed to implement key features of a textbook-embedded Q&A, and then a pilot study where we examine how students used and perceived the features.

Textbook-embedded Q&A prototype

We built a prototype that drew from existing Q&A sites, collaborative learning theory, and the constraints of the digital textbook platform to extract and adapt Q&A-style features that may facilitate collaborative learning within the digital textbook. The prototype was developed in Objective-C for the iPad, and loads textbook content encoded using the epub standard. For the Q&A feature we modified the open source project www.question2answer.org to make it suitable for the textbook platform. Our prototype facilitates both anchored and sequential discussion and provides a means for validating and organizing content.

Typical use of our prototype proceeds as follows. Students read the text in landscape mode, and can see two windows: the textbook content on the left, and the Q&A system on the right (see Figure 1). As students turn the page, only questions relevant to that page (i.e., added when a student was on that page) are displayed. To compose a new question students touch the "Ask a question" button, and the compose question window appears on the right half of the screen. Students can fill in the title of the question, information about the question, and any content-related tags they would like to add using hashtags. Their question is then added to the list of questions for that particular page. Each question represents its own discussion thread. To answer the question, students touch the question, and on the right half of the screen can see the question title, additional information on the question, the user who posed the question, all replies to the question, and relevant hashtags. If the student composes a reply to the thread, it is added sequentially to the bottom of the thread. For each reply, students can up-vote it or down-vote it by touching either an up arrow or down arrow located just to the left of each answer. These arrows also show previous votes received by the particular answer, as shown on the right side of Figure 1. Voting on answers does not change the order of the replies in the thread. In general, students have a lot of choice in the way that they view the questions and the text. At any point, in landscape mode, students can view all questions asked or all questions related to a particular content hashtag by clicking on the tag. Turning the tablet to portrait mode allows students to read the text without viewing the Q&A forum.

This prototype design is an implementation of *anchored discussion* (Guzdial & Turns, 2000), where students immediately see which questions are relevant on particular pages and determine whether they can engage in a discussion surrounding those questions. Anchored discussion is the process of creating links between the content space and the discussion space, such that it is very clear which idea from the content is currently under discussion. For a successful anchored discussion, students should be able to access the textbook content and discussion forum in tandem, without losing sight of either, thereby lending focus to the discussion (Alrushiedat & Olfman, 2013). Anchored discussions have been demonstrated to promote effective discussion among individuals on a computer mediated forum, potentially because they help students attend better to key details of the text (Guzdial & Turns, 2000; Van der Pol, 2006). In our prototype, students view the discussion content and text content side by side, with relevant questions linked to relevant pages. This arrangement allows for side by side comparison of the Q&A and the textbook content, and allows students to ask and answer questions that are most relevant to what they are reading. Our prototype is also an implementation of *sequential threaded discussion*. Threaded discussion forums keep track of relationships between posts, and students can easily identify which posts are in response to what, to easily find points of interests and get a sense of the overall discussion. The persistence of the posts in the thread also helps students to return to earlier posts at a later time for reference or to post a reply (Guzdial & Turns, 2000). In our implementation of threaded discussion, each question represents its own thread, replies to the question are added sequentially to the bottom of the thread, and this sequence is preserved throughout the interaction. Our implementation shares both similarities and differences with the model used by typical Q&A forums, which we illustrate in this paragraph using the example of StackOverflow (www.stackoverflow.com), one of the most successful Q&A sites (Mamykina et al., 2011). In StackOverflow, as described by Mamykina and colleagues (2011), students up-vote and down-vote answers, with the best answer presented higher in the thread. While in our prototype students can still vote on the best answers to reward quality contributions, we viewed answers not as individual responses to the question but as components in a sequential discussion. This design decision facilitates students in interacting directly with each other to build on and refine each other's ideas, prioritizing inter-student interaction over the correctness of individual responses. StackOverflow also allows students to reply to individual answers, but because of the small screen real estate of the tablet platform and the nature of the closed system (only users from the same class interact) we chose to consider the question as the unit of discussion for threading purposes.

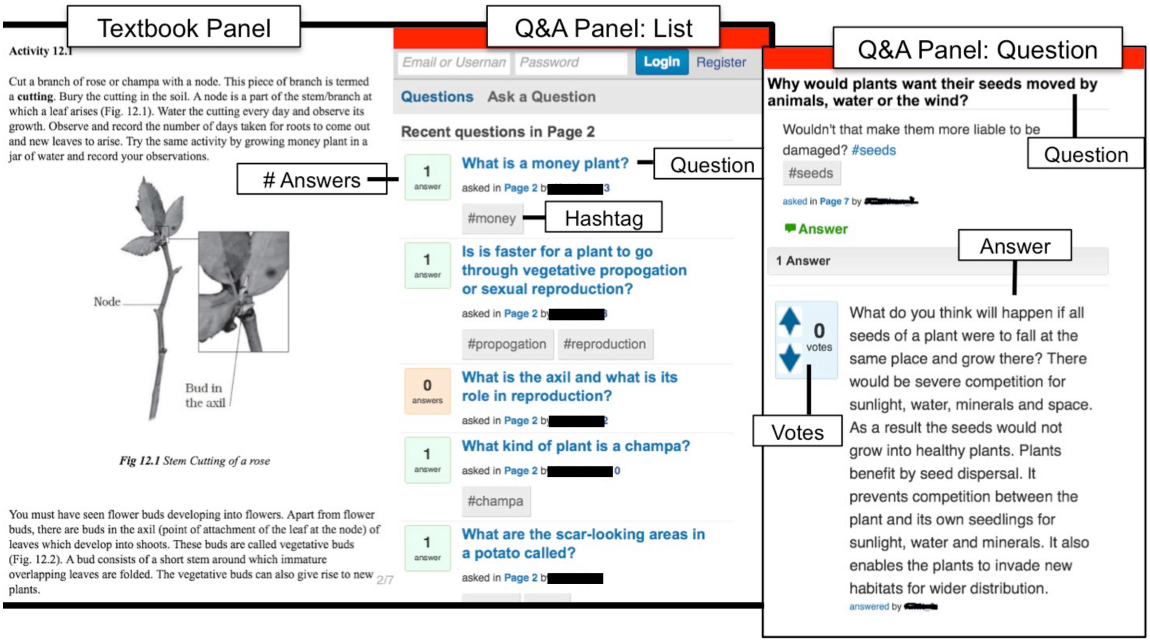

Figure 1. Screenshot of the Q&A prototype. The left side is the "Textbook Panel," with the domain content. The right side is the "Q&A Panel." This figure shows two views of the Q&A Panel, one containing the anchored list of questions, and one containing the interface to a single question.

Pilot sessions

We ran 3 pilot sessions with a total of 9 undergraduate students (6 women) with ages ranging from 19-30 to explore the key features of the Q&A prototype. The domain of the textbook we used was a plant reproduction unit for introductory biology. Students spent 30 minutes reading the text and simultaneously engaging in computer-mediated Q&A with the others in their session. They were instructed to ask and answer at least one question. After they engaged with the prototype, we conducted a focus group where we asked them about their experiences with the textbook. The following results are presented based on student activity in the Q&A forum and their responses to interviewer questions. We use the notation S3P1 to mean session 3, participant 1.

Table 1 presents results related to how students used the prototype. Each student asked an average of 2.89 questions (SD=1.97) and made an average of 2.78 replies (SD=1.99). Most questions asked were factual and received a single answer. For example**,** "*What kind of plants go through vegetative reproduction?*" received the response, "*If a plant has roots, stems, leaves, then it has the necessary vegetative parts to go through vegetative propagation. This is a type of asexual reproduction*". While students asked and answered more questions than instructed to, questions almost exclusively led to a single reply rather than an in-depth discussion. The one question that had more than one reply left room for longer explanation and debate ("*What is the difference between self pollination and cross pollination?*"). Students had general positive comments regarding the Q&A activity (S1P2: *"It's good that you have, like, the ability to ask a question immediately and immediately get an answer while you are...reading or studying"*).

The anchored discussion functionality was heavily used; all students used the prototype in landscape mode for the entirety of the pilot session, even though both orientations were demonstrated. S2P1 said having Q&A embedded in the text helped with understanding, *"I like the feature of being able to read and see what other people's questions are as I read because then I can find the answer to it...Instead of all the chapter and then the questions in the end at once, it is easier to focus on if it is in little bits."* The anchored discussion was also helpful for composing contextually-relevant questions (S2P4: "*I like the landscape feature because if I had to ask a question, I didn't have to go through five different steps*"). S1P1 wanted even more anchoring (*"I'd like it if I could cite a portion of the text when I want to ask or answer a question. I think this helps us reassure if it is the right answer"*). Students appreciated the specific features we adopted from existing Q&A sites. Each student up-voted and down-voted an answer a mean of 1.56 times (SD=1.26). S3P1 said that voting added credibility, saying: *"You could figure out how credible your answer was."* S2P1 requested having a feature where they could explain why they wanted to down-vote an answer: *"If you're going to down-vote it say why... say I'm down-voting this because its wrong this isn't entirely correct, cause then I can learn from that too."* In total, students used six different hashtags (e.g., pollination).

Table 1. Descriptive information about each session.

Session #	# students	# questions	# answers	# votes
1	2	11	11	5
2	4	9	8	4
3	3	6	6	5

Conclusion

In this paper, we described an implementation of Q&A within a digital textbook that facilitated anchored discussion, threaded sequential discussion, voting on answers, and tagging question content. We found the students responded positively to the prototype and, in particular, found the anchored discussion useful. However, our prototype did not prompt as much interaction around questions as we had hoped. Perhaps students were inhibited by the fact that the source material lent itself to factual rather than conceptual questions, or by the challenges of typing on a tablet compared to a keyboard. Future exploration will probe deeper on how our features influence student collaboration and how our features interact with the content being discussed. Overall, we see this as a promising direction for facilitating collaborative knowledge construction and community building while meeting student perceived needs and design constraints related to digital textbooks.

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Collaborative or Individual Learning within Productive Failure: Does the Social Form of Learning Make a Difference?

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Abstract: Productive Failure (PF) – comprising initial problem solving and delayed instruction – has been proven effective for learning when compared to Direct Instruction (DI) in multiple studies with high school and university students. Although the problem-solving phase is usually implemented in a collaborative setting, the role of collaboration for the effectiveness of PF remains unclear. In two quasi-experimental studies we investigated whether collaborative as compared to individual learning in PF leads to more learning. We also tested whether the beneficial PF effect could be replicated with much younger students, namely 4th and 5th graders, than previous studies. Only our first study replicated the PF effect. While the first study did not reveal differences between collaborative and individual learning, in the second study individual learners even outperformed their collaborative counterparts in both PF and DI conditions. Against these findings, we discuss possible prerequisites for PF and propose an agenda for follow-up CSCL research.

Keywords: collaborative learning, productive failure, instructional design

Introduction

Learning approaches in which instruction is delayed, such as Productive Failure (PF; e.g., Kapur, 2012), enable students to explore the underlying concepts and procedures of new learning material on their own before receiving explicit instruction. In the first phase of PF, students try to solve a yet unfamiliar problem, usually in small groups. In the second, so-called instruction phase, the teacher builds upon students' initial solutions to introduce the canonical solution (e.g., Loibl & Rummel, 2014). Multiple studies showed advantages of PF over so-called direct instruction conditions (DI), particularly on the acquisition of conceptual knowledge or transfer (e.g., Kapur, 2012). While the term "direct instruction" is used vaguely in the literature, here we refer to direct instruction as a teacher-lead activity of comparing and contrasting students' erroneous solution attempts with the canonical solution preceding students problem solving (cf. Loibl & Rummel, 2014).

While the effects of delaying instruction are well studied (e.g., Kapur, 2012; Loibl & Rummel, 2014), the role of collaboration within PF has not yet been investigated intensively. As collaborative learning is known to elicit elaborative processes (e.g., Teasley, 1995), it can be hypothesized that collaborating during the problem-solving phase of PF will lead to higher learning outcomes than individual learning. This assumption is also supported by Chi's ICAP-framework (2009) which predicts a superiority of collaborative-interactive learning activities over individual-constructive learning activities. However, research on collaborative learning (e.g., Fischer et al., 2010) has also revealed that collaborating students need to be supported (e.g., by implementing a group goal and/or a role script; cf. Slavin, 1996; King, 2007) in order to ensure fruitful collaborative processes. Against this background, we hypothesized that *supported* collaborative learning leads to higher learning outcomes than individual learning during the problem-solving phase of PF (hypothesis 1).

Our second focus was on replicating the PF effect with younger students: While most PF studies were conducted with high school students (e.g., Kapur 2012; Loibl & Rummel, 2014), we were wondering whether younger students would similarly benefit from PF. This question is of relevance, because the German standards for teaching mathematics highlight the importance of facilitating students' self-determined problem-solving competencies already in primary school (Kultusministerkonferenz, 2004). However, as the findings of Kroneberger and Souvignier (2005) suggest, younger students may be limited in their ability to elaborate deeply on new concepts. Therefore, the beneficial effect of PF found with high school students may not necessarily hold true for younger students. Nevertheless, we hypothesize that the PF effect can be replicated with 4th and 5th graders (hypothesis 2), because so far the beneficial effect of PF was stable across different domains and populations (i.e., students with different ability profiles).

Method

We tested our hypotheses in two quasi-experimental studies. Our initial study (N = 52 4th graders) compared students who worked collaboratively (PF-Coll) or individually (PF-Ind) (cf. hypothesis 1) on an equivalent fraction problem and then received instructions. In order to test hypothesis 2 we additionally implemented a DI-Coll condition, in which students first received instruction and then solved a similar equivalent fraction problem. For our second study, we recruited a larger sample (N=228 5th graders). In this study, we varied the two factors social form of learning (collaborative vs. individual) and the timing of instructions (PF vs. DI) in a 2x2 design, resulting in four experimental conditions (PF-Coll, PF-Ind, DI-Coll, and DI-Ind). Note that across both studies all participants learned during two learning phases: a problem-solving phase and an instruction phase which will be described below.

Problem-solving phase

In the PF conditions, students were challenged with a typical PF problem during the initial problem-solving phase. A PF problem has to address at least two design requirements (cf. Kapur & Bielazcyc, 2012). First, a typical PF problem should allow students to find multiple solution approaches and to elaborate on their (often erroneous) solution ideas. Second, typical PF problems are complex problems which should neither over- nor under challenge the students. The complexity of a problem is based on the interaction between students' prior knowledge and the problem itself. The two requirements were met as follows: The equivalent fraction problem required students to equally divide two "groups" of pizzas for two groups of children (4 pizza Salami ordered for 6 boys and 2 pizza Hawaii ordered for 3 girls) and asks them whether a single boy or girl receives a greater proportion of pizza. This problem can either be solved by calculating a solution, making use of a graphical representation (i.e. circle), drawing various solution ideas or by logical reasoning. Across both our studies, students have not yet been formally introduced into the concept of equivalence nor the procedure to find equivalences (i.e., reducing or expanding fractions) but have already developed a pre-concept of fractional numbers (i.e., numbers smaller than 1). The complexity of the to-be-solved problem was further ensured by including more than a single problem-solving step (i.e., three problem-solving steps): Students had to identify the number and the size of pizza slices each boy or girl receives, and then they had to compare the proportions by expanding or reducing the given fractions.

In the DI condition, students worked on an isomorphic problem during the problem-solving phase. However, as the problem-solving phase only took place after the instruction, they were not expected to generate multiple (erroneous) solutions.

During the problem-solving phase, students either worked alone (PF-Ind and DI-Ind) or in pairs (PF-Coll and DI-Coll). As fruitful collaborative interaction needs to be supported, we introduced a role script and a group goal within the PF-Coll and the DI-Coll condition (cf. Slavin, 1996; King, 2007). The goal of the role script was to support the *collaborative* interaction between learning partners and *not to cognitively* support the problem-solving process (cf. Westermann & Rummel, 2012) The role script consisted of two roles. While the student in the role of the thinker was asked to explain his or her problem-solving ideas to her or his learning partner, the student in the role of the asker was prompted to pose hint-questions and questions of clarification. During collaborative problem solving students were provided with role cards displaying either the role of the thinker or asker and were asked to switch roles (at least once). Thus, students were prompted to collaborate following the role script, but were not forced to do so. We implemented the role script in this way in order to prevent a motivational loss due to over-scripting. By additionally implementing a group goal we aimed to set students a motivational incentive to indeed engage in team work and mutual support. Thus, the experimenter hold out the prospect to win a prize (i.e., chocolate bars) for the dyad who best collaborates.

Instruction phase

The instruction phase was designed as a class discussion and was managed by the experimenter in all conditions. As a starting point students were asked an estimation question whether a single girl or a boy will receive exactly, more or less than an entire pizza (cf. last problem-solving step), because the Rational Number Project (e.g., Cramer, Post & del Mas, 2002) showed that including estimation questions prior to operating with fractions facilitates learning.

In line with the design requirements described in Kapur and Bielaczyc (2012) and with findings of Loibl and Rummel (2014) the instruction built upon "typical" erroneous and incomplete students' solutions which were previously collected in a pilot study (N= 25). By referring to "typical" incomplete students' solutions and not to the very solutions of these students, we ensured to keep the instruction constant across all conditions (of both studies). The experimenter helped students to compare and contrast the typical solutions with the canonical solution for each problem-solving step and explained why the typical solutions are erroneous.

For example, the first problem-solving step implied to identify the number and size of pizza each boy should receive when there are four pizzas but six boys. When equally divided each boy should receive 4/6 (= canonical solution). As one "typical" erroneous student solution was to partition the four pizzas in quarters (instead of sixths) the experimenter can build upon this solution attempt by also dividing four pizzas into quarters, counting the number of slices and dividing the total number of slices by six (16 : 6 = 2 rest 4). According to this solution attempt two boys will receive only two slices of pizza but four boys will receive three slices of pizza. By drawing students' attention to the fact that the pizzas are not yet equally and fairly divided, the experimenter can optimally prepare students for the canonical solution. To further support students understanding about fractions (e.g., Cramer Post & del Mas, 2002) we additionally included working with graphical representations (i.e. circles) as most of students solution attempts also included circles.

Instruments and measures

Across both studies, students were asked to complete a pre- and a posttest. The pretest measured students' mathematical prerequisites such as naming fractions when differently represented and dividing with rest. By measuring students' prerequisites we additionally prevented to prompt *all* students to generate solution ideas about the target concepts and procedures in the pretest as this would reduce the difference between our experimental conditions (i.e. also students from the DI conditions would be prompted to generate solution ideas prior to instruction) (cf. Kapur, 2012; Loibl & Rummel, 2014). To measure students' learning about the concept of equivalence and the procedures for finding equivalence, for the first study we administered a posttest with six items (including a total of 18 subtasks with a maximum total score of 26 points). Based on the results of the first study, we adapted the degree of difficulty of the posttest for the second study. The posttest again included six items (this time including a total of 12 subtasks with a maximum total score of 17 points). In addition to the pre- and posttests in both studies we collected collaborative process data in order to be able to investigate interaction processes. The analysis of the process data is, however, not in the scope of the current paper.

Procedure

In both studies, all participants answered the pretest (circa 10-15 minutes) in the mathematics lesson preceding the respective study. At the beginning of both studies, all students first received a 10-15 minutes introduction about the background and procedure of the study. Students in the PF-Coll and DI-Coll conditions further received explanations about the group goal and a brief role play in order to learn how to make use of the role script. While students in the PF-Coll and PF-Ind conditions started with the problem-solving phase and then received instruction, students of the DI-Coll and DI-Ind conditions first received instruction and then solved an isomorphic problem. The problem-solving phase took 30 minutes and the instruction phase 45 minutes. After both learning phases students had 45 minutes time to work on the posttest.

Results

To assess differences in learning outcomes between the three experimental conditions of the first study, we calculated an ANCOVA with the factor condition, the covariate pretest score, and students' posttest scores as dependent variable. Means and standard deviation of the pretest and posttest scores of the three conditions are displayed in Table 1. We defined two a priori contrasts in line with our hypotheses. One a priori contrast compared PF-Coll and PF-Ind to test the effect of collaboration. Contrary to our first hypothesis, this a priori contrast did not reveal significant differences between PF-Coll and PF-Ind (F[1,48]=0.4, p=.84). In light of the aforementioned literature not finding a difference between collaborative and individual learning within PF was unexpected. The second a priori contrast compared both PF conditions to the DI condition to test if the PF effect could be replicated with young children (hypothesis 2). Indeed, our results revealed a significant advantage of PF over DI on the learning outcome (F[1,48]=4.6, p =.03, η_p^2 = .09).

Table 1: Means and standard deviation of pretest and posttest scores (study 1)

	Pretest		**Posttest**		
	M	**SD**	**M**	**SD**	**N**
PF-Coll	4.5	2.63	7.88	5.43	16
PF-Ind	5.12	1.9	7.71	3.29	17
DI-Coll	5.68	1.29	5.26	3.91	19

For the second study we calculated a two-factorial MANCOVA with the two factors social form of learning (collaborative vs. individual) and the timing of instructions (PF vs. DI), with students' pretest scores as covariate, and students' posttest scores as dependent variable. Means and standard deviations of the second study are displayed in Table 2. We found a significant main effect of the social form of learning (F[1, 223]=3.95, p=.048, η_p^2= .02): overall students learning individually outperformed students learning collaboratively. In testing our second hypothesis we did not find a significant difference between the PF conditions and the DI conditions (F[1,223]=0.74, p=.392,). Also, the interaction between the two factors was not significant (F[1, 223]=0.21, p=.651).

Table 2: Means and standard deviation of pretest and posttest scores (study 2)

		Pretest		**Posttest**		
Timing of instruction	**Social form of learning**	**M**	**SD**	**M**	**SD**	**N**
PF	individual	4.0	2.04	10.80	2.41	49
	collaborative	4.19	2.48	10.31	2.45	74
	total	4.11	2.31	10.51	2.44	123
DI	individual	4.4	2.46	11.28	2.15	48
	collaborative	4.74	2.25	10.50	2.73	57
	total	4.58	2.34	10.86	2.50	105
Total	individual	4.2	2.25	11.04	2.29	97
	collaborative	4.43	2.39	10.40	2.57	131
	total	4.33	2.33	10.67	2.47	228

Conclusion and discussion

In conclusion, our two quasi-experimental studies revealed divergent findings: While we were able to replicate the beneficial effect of PF for a younger age group in the first study, we were not in the second study. In addition, we did not find a superiority of collaborative learning during the problem-solving phase in PF over individual learning on the posttest scores. Against the background of the literature on collaborative learning (e.g., Chi, 2009; Teasley, 1995), this result is surprising. In the following, we discuss three possible explanations.

Quality of collaboration

As mentioned earlier, collaboration does not automatically lead to fruitful interactions between students. Possibly, despite the collaborative setting, students did not collaborate well enough and may for instance have mostly engaged in individual-constructive learning activities (e.g., one partner generating ideas without considering his partner's understanding) in our collaborative conditions. This activity pattern was possible, because the implemented role script was optional. While the role script intended to facilitate collaborative-interactive activities, students could still engage in merely individual-constructive learning activities. This explanation can be investigated by intensive process data analysis and by comparing whether students who acted strictly in their roles reached higher posttest scores than those who did not. In addition, it is also possible that our participants were not sufficiently familiar with applying the role script in particular and with collaborative learning practices in general as such practices are often not well established in German classrooms and mathematics lessons at this young age. However, as the educational standards of mathematical education (Kultusministerkonferenz, 2004) point out that even at this young age students should be able to collaborate and communicate their mathematical reasoning, this finding underlines the need to pay particular attention to this apparent deficit. However, considering that our first study failed to find a superiority of collaborative learning and the second study even showed a superiority of individual learning it may be useful in moving forward to also discuss our results from another possible angle:

Production blocking

To some extent the problem-solving phase of PF resembles a brainstorming activity, as students try to come up with as many solution ideas as possible for a problem they don't know how to solve yet. The brainstorming literature predicts a superiority of individual over collaborative brainstorming (Stroebe & Nijstad, 2004), because during collaborative brainstorming the generation of associated solution ideas is blocked by turn taking: one partner needs to wait until it is his or her turn before being able to propose a solution idea (cf. production blocking). In order to shed more light on the brainstorming hypothesis an intensive analysis and comparison of the quantity and quality of students' solution attempts in both PF-conditions is needed.

Prerequisites. An additional goal of our studies was to investigate whether the beneficial PF effect also holds true for students of a younger age group. While the results of our initial study confirmed this hypothesis, we were not able to replicate the PF effect that has consistently been found in many previous studies (e.g., Kapur, 2012; Loibl & Rummel, 2014) in our second study. Our divergent findings emphasize the need to discuss in more detail the prerequisites for effective PF. In this context, prior knowledge activation has been discussed as one effective learning mechanism underlying PF (e.g., Loibl & Rummel, 2014). Our participants may not have had enough prior domain knowledge to generate different solution ideas on their own, and may in contrast to older students also not have had enough prior knowledge about metacognitive and motivational learning strategies for adapting to the specific challenges of the PF problem-solving phase. Thus, our results support the notion that the delineation of productive and unproductive failure is a narrow line that one must walk carefully.

In order to shed light on the above considerations we intensify our effort to analyze the process data of the collaborative conditions as well as to analyze students' solution attempts in both PF conditions.

Outlook

In parallel to further analyzing the data of the two presented studies, we plan a follow-up study which will be embedded in a CSCL setting. In particular, we propose to introduce an exploratory learning environment (ELE) when students are confronted with an equivalent fraction problem in the problem-solving phase of PF (followed by instructions in a regular classroom setting). Within an ELE students are enabled to explore the target concepts on their own by inspecting and manipulating, for instance, different representations of fractions and their relationships (e.g., Hoyles, 1993). As collaborating students will work simultaneously from two different computers and will interact via a chat tool with each other, we will be able to address the three core issues raised in the discussion: the quality of collaboration, the danger of blocking ideas (cf. brainstorming research), and the potential influence of students' prior knowledge about metacognitive and motivational strategies.

First, we concluded that the collaboration itself and the collaboration support that was provided (i.e., role script and group goal) may not have developed their full potential, because students were not familiar with collaborative practices and the use of a role script. Apart from enabling students to practice good collaboration prior to the problem-solving phase of PF (e.g., by introducing a pre-training), implementing the collaborative problem-solving phase in an ELE allows for a more adaptive approach: based on students' log data and chat data, we can deliver collaboration support prompts when needed. For instance, when students do no chat with each other for a certain amount of time the intelligent component of the ELE could provide students with a prompt encouraging them to think-aloud and exchange their problem-solving ideas or asking them a thought-provoking question (King, 2007). Furthermore, if only one student talks or interacts with the ELE the student can be prompted to help his learning partner and to engage him in the problem-solving process. On a process level, this adaptive support should facilitate interactive learning activities (Chi, 2009) or transactivity (Berkowitz & Gibbs, 1983).

Second, we argued that the problem-solving phase of PF resembles a brainstorming activity. The research on brainstorming suggests that in a collaborative setting the generation of associated solution ideas is blocked by turn takings and waiting time (cf. production blocking, Stroebe & Nijstad, 2004). Thus, collaborative brainstorming as compared to individual brainstorming is less beneficial for developing solution ideas within PF. However, if we can prevent students from production blocking by letting them generate solutions simultaneously instead of waiting for their turns, brainstorming in a collaborative setting may still have beneficial effects on the quantity and quality of solution ideas as learning partners cause mutual cognitive stimulation. In our ELE students should be able type in their solution ideas in the chat tool whenever they want. In consequence, students would not have to wait until it is their turn to bring in their solution ideas without production blocking. Thus, collaborative learning in such a computer-supported setting would also address the line of brainstorming research.

Third, we assumed that our young participants may not have had enough prior knowledge about metacognitive and motivational learning strategies in order to deal with the specific challenges of the PF problem-solving phase. For instance, within the problem-solving phase of PF students are asked to generate as many problem-solving ideas as possible for a problem type they do not know yet. Due to the lack of domain knowledge, they may reach a dead end (of problem-solving) several times and are thus confronted with their own failure. Based on research on self-regulated learning and motivation (e.g., Kuhl, 1987) students need to apply at least four strategies in order to address this failure: control of motivation, control of attention, coping with failure, emotional control. As young learners might still have to improve the application of the aforementioned learning strategies again the intelligent component of the envisioned ELE could help them by delivering prompts facilitating those learning strategies just in time (i.e., when they reach an impasse and stop working on the problem). These prompts may include hints on the aforementioned strategies as well as emotional boosts (cf. Grawemeyer et al., 2015).

In conclusion, transferring the collaborative problem-solving phase of PF from a face-to-face setting to a computer-supported setting (by implementing it in an ELE) will allow to flexibly react and adapt to the young students needs which, in turn, should facilitate the acquisition of conceptual knowledge.

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Fostering Argumentation Skills in Mathematics with Adaptable Collaboration Scripts: Only Viable for Good Self-Regulators?

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Abstract: Argumentation scripts have been proposed as an effective means to structure students' argumentation and to support their acquisition of argumentation skills. Yet, argumentation scripts run the danger of overscripting students' argumentation. A possible solution might be to offer adaptable argumentation scripts that allow students to adjust the script to their own needs. This study compares the effects of three argumentation scripts (high structured vs. low structured vs. adaptable) on students' argumentation skills. Furthermore, we investigate to what extent students' self-regulation skills influence the acquisition of argumentation skills in the three conditions. N = 109 math students were randomized to the three treatment conditions and worked in dyads on mathematical proof tasks in a CSCL environment. Students' argumentation skills increased between pre- and post-tests with comparable gains in all three conditions. Only for students learning with the adaptable argumentation script, self-regulation skills were a significant positive predictor for argumentation skills.

Keywords: collaboration scripts, argumentation, mathematics.

Introduction

To be able to engage in high-level argumentation has often been described as an important precondition to gain knowledge in a given domain ("arguing to learn"; Andriessen, Baker & Suthers, 2003). When situated in a social context, argumentation includes the production and exchange of well-warranted arguments and counterarguments and possibly the construction of a synthesis of different arguments that were previously expressed by different learners (see Leitão, 2000). Even in rather well-structured domains such as mathematics, in which often more systematic instructional methods are suggested (such as worked examples; Atkinson, Derry, Renkl & Wortham, 2000), the potential of putting learners in social contexts in which they engage in collaborative argumentation for knowledge construction has been recognized (e.g., Kollar, et al., 2014; Zemel & Koschmann, 2013).

Nevertheless, by far not all learners are able to engage in high-level argumentation spontaneously (Stegmann, Weinberger, & Fischer, 2007). Particular kinds of scaffolding that can be designed to help students engage in high-level argumentation are argumentation-related collaboration scripts ("argumentation scripts" hereafter). Mostly studied in domains other than mathematics, argumentation scripts structure collaboration by specifiying, sequencing and distributing high-level argumentation activities among the learners of a small group (Kollar, Fischer & Hesse, 2006). For instance, while one learner may be prompted to make a claim and provide evidence for it, his/her learning partner may be asked to provide counterevidence. Empirically, such argumentation scripts have been shown to be effective for the development of students' argumentation skills (e.g. Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013).

Yet, collaboration scripts have in the past been criticized with respect to the high rigidity by which they structure the collaborative learning process. More specifically, scripting argumentation often comes with a restriction of learners' autonomy to apply their own – possibly functional – learning strategies and thus may not always lead to optimal learning outcomes ("over-scripting", Dillenbourg, 2002). As a reaction to this criticism, attempts have been undertaken to design more flexible collaboration scripts by making them adaptive. Often based on intelligent tutoring technology, adaptive scripts continuously assess the quality of the collaborative learning process and fade parts of the collaboration script in or out as needed (Diziol, Walker, Rummel & Koedinger, 2010). An alternative to the often costly development of intelligent tutoring technologies that enable such a continuous assessment of learning processes might however be to make collaboration scripts adaptable, i.e. to grant learners themselves the opportunity to switch parts of the script on and off, based on their self-perceived needs. On the one hand, adaptable scripts offer a valuable opportunity for self-regulated learning, as decisions on how to adapt the script must be made on a thorough analysis of the previous learning episode and an estimation of one's own competence level (Järvelä & Hadwin, 2013). On the other hand, unfortunately, learners who are not able to self-regulate their learning effectively may make wrong decisions when granted the opportunity to adapt their script and thus not benefit from the opportunities offered by adaptable scripts.

Research questions and hypotheses

Overall, this paper addresses two research questions:

RQ 1: To what extent do the structure and the adaptability of an argumentation script (low structured script vs. high structured script vs. adaptable script) affect the learners' acquisition of argumentation skills?

We hypothesized that learners presented with a high structured argumentation script would outperform students from the low structured script condition. Learners from the adaptable script condition should on average reach higher levels than students from the low structured script condition because students from the adaptable script condition have at least the chance to choose a high-structured collaboration script to be displayed to them. With regard to the comparison between students from the high structured and the adaptable script condition, we did not set up a directed hypothesis, as one may either expect the adaptable script to lead to better learning outcomes (because of the opportunity to engage in a more self-regulated form of learning) or to worse learning outcomes (because learners' self-regulation skills may be over-taxed by being granted the opportunity to adapt the script).

RQ 2: To what extent do students' self-regulation skills influence their acquisition of argumentation skills when learning with adaptable and differently structured non-adaptable argumentation scripts?

With respect to RQ2, we hypothesized learners' self-regulation skills to be a significant predictor of their acquisition of argumentation skills in the adaptable script condition, but not in the other two conditions, as in both the low and the high structured script condition, students had no chance (and thus no need to engage in a further reflection of their collaboration) to modify the script.

Methods

Participants were $N = 109$ mathematics students and mathematics teacher students participating in a two weeks preparatory course at university. They were randomly assigned to one of the three treatment conditions: Low structured argumentation script, high structured argumentation script, and adaptable argumentation script. The students learned in three treatment sessions within three consecutive days. For each treatment session, the learners were grouped into new learning dyads to work on a different mathematical proof task. Each learner was equipped with a laptop and a graphical tablet. The two laptops of each dyad were connected via a computer-supported learning environment that displayed the mathematical proof task and a graphical chat environment where the dyads were able to exchange text, formulas and drawings on their ideas to solve the proof task. Beyond that, the dyads could also communicate face-to-face. The computer-supported learning environment also displayed the script prompts which sequenced the discussion and structure of argumentation.

The students were asked to collaboratively discuss their ideas about the proof tasks in all treatment conditions. In the condition with the low structured argumentation script, prompts that were integrated in the chat sequenced the discussion into the steps (1) argument, (2) counterargument and (3) synthesis three times per treatment session. In the condition with the high structured argumentation script students were additionally prompted to formulate sound arguments (e.g. formulating evidence for a claim) in the first and second step. In the condition with the adaptable argumentation script, learners were allowed to choose between the high structured and the low structured argumentation script right before each argument and counterargument step in each treatment session. Overall, an adaptation of the script was thus possible at six points in time per treatment session.

To assess students' argumentation skills, a pre- and a post-test was conducted in which students were asked to describe typical phases and quality features of an argumentative discourse in science. Students' answers were evaluated by two trained coders for the appearance of relevant elements in an argumentative discourse. These were derived from Leitão (2000) for the social discursive phases in an argumentative discourse (relating to the other's arguments when continuing the argumentation, formulating critic against the other's arguments, integrating different arguments). After training, the coders reached sufficient interrater reliability (Cohen's $\kappa = .82$). Self-regulation skills were measured with an eight-items questionnaire (adapted from Fisher, King, & Tague, 2001) in which students rated the extent to which they typically apply certain self-regulation strategies (e.g.; "I prefer to plan my own learning."; "I am systematic in my learning."). The resulting scale proved reliable (Cronbach's $\alpha = .72$).

Results

Results from a repeated measures ANOVA showed that across all conditions, students' argumentation skills increased significantly between pre- and post-test (see table 1; $F(1,106) = 12.83$, $p < .01$, $\eta^2 = .11$). With respect to RQ1, there were no significant differences in students' learning gains between the three conditions ($F(2,106) = 1.49$, $p = .23$, $\eta^2 = .03$).

Table 1: Mean values and standard deviations for students' performance in the pre- and post-test on argumentation skills

	CSCL script		
	low structure (*n* = 32) *m* (*SD*)	high structure (*n* = 41) *m* (*SD*)	adaptable (*n* = 36) *m* (*SD*)
Pre-test argumentation skills	0.84 (0.88)	0.71 (0.81)	0.61 (0.77)
Post-test argumentation skills	0.94 (0.84)	1.10 (0.80)	1.06 (0.86)

With regard to RQ2, subsequent regression analyses for each condition showed that the students' self-regulation skills were neither a significant predictor for the acquisition of argumentation skills in the conditions with the low structured script ($b = 0.14$, $p = .45$, $R^2 = .02$) nor in the condition with the high structured script ($b = 0.05$, $p = .75$, $R^2 < .01$). However, in the condition with the adaptable script, the students' self-regulation skills had a significant positive influence on the acquisition of argumentation skills ($b = 0.40$, $p < .05$, $R^2 = .16$).

Conclusions and implications

We argued that argumentation scripts may be helpful in fostering students' argumentation skills in the domain of mathematics. Yet, such scripts have been criticized for their rigidity that leaves little freedom for learners to apply their own – potentially functional – strategies ("over-scripting"; Dillenbourg, 2002). Our study therefore investigated the potential of making scripts adaptable as a way to grant learners the opportunity to adjust the argumentation script to their self-perceived needs.

Regarding RQ1, our results indicate that there was no general superiority of the adaptable argumentation script on learners' acquisition of argumentation skills, compared to a continuous (low or high structured) argumentation script. Thus, students on average do not seem to be able to take full advantage of opportunities to adapt scripts to their self-perceived needs. This adds to previous literature that has argued for strong instructional guidance when it comes to help learners acquire new skills (e.g., Kirschner, Sweller & Clark, 2006). What however is surprising is that learners from the high structured script condition did not outperform students from the low structured script condition, given that previous research has typically reported positive effects of stronger forms of scripting especially on more domain-general skills and competences (e.g., argumentation skills or online search skills; e.g., Kollar, Wecker, Langer & Fischer, 2011). Though, the present study differs from many previous studies with respect to the fact that related studies often compare their scripts to completely unstructured control conditions in which groups are simply asked to discuss with each other, without being further supported in this process. In our study, in contrast, also the low structured condition received considerable guidance with regard to the different phases of their argumentation. The fact that, in addition, our coding of the post-test mainly focused on exactly this sequential argumentation strategy (and not, for example, the quality of single arguments or counterarguments) may thus have obscured possible differences between the two conditions.

Regarding RQ2, we found that learners' self-assessed self-regulation skills were a significant predictor of argumentation skills as measured in the post test only in the adaptable, but not in the two continuous script conditions. This confirms our hypothesis that only learners with high levels of self-regulation skills are able to benefit from the opportunity of adapting the script. Thus, the opportunity to consciously decide about the structuredness of the argumentation script, which may be regarded as a genuine act of self-regulation (Järvelä & Hadwin, 2013), can obviously only be taken by learners who already possess a certain level of self-regulation skills. This leads of course to the question how argumentation scripts should be designed that also help students with less functional self-regulation skills. Perhaps, for these learners a longer phase of learning with a continuous (high-structured) argumentation script could be effective, before they are granted opportunities for adaptation. Another possibility might be to offer those students additional instructional guidance on how to reflect their past scripted learning experience and their actual learning needs in order to make adequate decisions during adaptation.

In further analyses of our data, we aim at investigating the students' adaptation behavior in more detail. The underlying hypothesis is that a more appropriate adaptation behavior in the adaptable script condition should lead to an improved acquisition of argumentation skills. Such an analysis seems important since our measure of self-regulation skills was based on students' self-assessments. Since students do not always adequately assess their own knowledge and skills (Dochy, Segers & Buehl, 1999), an analysis on the basis of real performance data may yield important insights into the validity of our measure. If such an analysis could be done by aid of intelligent tutoring technology (see Diziol et al., 2010), even a successful combination of adaptability and adaptivity might be achieved.

All in all, our study demonstrates that adding flexibility to argumentation scripts (e.g., through making them adaptable) does not seem to reduce their effectiveness with regard to the acquisition of argumentation skills. Yet, only some learners seem to be able to really benefit from this flexibility, i.e. those who already possess a decent set of effective self-regulation skills. Future research should investigate (a) whether these findings also hold true in other domains and (b) ways to help poor self-regulators in their adaptation process.

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From Lurking to Participatory Spectatorship: Understanding Affordances of the *Dota 2* Noob Stream

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Abstract: From investigations in online learning and virtual communities, peripheral observation or "lurking" has been framed as an active process in which learners align themselves with the practices and discourses of a community. In this paper, we further develop the notion of lurking in informal computer-mediated contexts, focusing on competitive gaming communities, where games are marked for the steep learning curves and players demonstrate an extended commitment toward mastery. In this descriptive case study, we leverage new perspectives on routes to participation in order illustrate *participatory spectatorship* as integral in not only the act of becoming a player but also in learning the discourses and practices of a larger gaming enterprise.

Keywords: lurking, participatory spectatorship, participation

Introduction

The availability of online resources continues toward more open-source and collaborative spaces. As information and communication channels expand and reorganize, "lurkers" have received contradictory assessments of their validity as meaningful participants. Traditionally, lurkers are referred to as passive, participating as readers or observers but rarely – if ever – as active contributors (Edelmann, 2013). Nonetheless, lurkers make up the "silent majority" and account for the lion's share of participants in online spaces (Nonnecke & Preece, 2000). The negative connotation aimed at the vast majority of online participants has led to their re-evaluation. A more comprehensive interpretation of lurkers is as goal-oriented, active, and essential to well-balanced online communities. As Lave and Wenger's (1991) work on legitimate peripheral participation showed, observation on the margins of a learning community can be quite active. With this lens, we can view lurkers as new members of a community searching for established social norms and discursive practices, honing observation skills, and formulating the practices of a community (Lee et al., 2006). From this vantage point, lurking is a valid and practical avenue to negotiate access to a social community.

Lurking as a form of acceptable and worthwhile participation illustrates the need to understand online interaction as a multidimensional and multimodal set of behaviors, purposes, and practices. The prevalence of this phenomenon in online forums is only a small sample of potential routes to full participation in a social space. We have recently seen the rise of the "eSport" in digital gaming communities as worthy of deeper investigation. While competitive games and even professional gaming (Taylor, 2012) have been a staple of the digital gaming world for some time now (e.g., *Quake*, *StarCraft*), the emergence of the multiplayer online battle arena (MOBA) and the related rise of streaming services (e.g., Twitch.tv, YouTube) have introduced these games to millions of new players.

In games and learning research to date, many have focused on the individual's immersion in a game as a model for learning. Scholars have argued that games incorporate sound learning principles and can be used to understand and enhance learning (Gee, 2007; Squire, 2011; Steinkuehler, Squire, & Barab, 2012). This perspective often focuses heavily on engagement through *play* as a means for learning by doing, acting as a vehicle to engage players in problem-solving and consequential decision-making. And yet, with a focus on the informal learning contexts of games, we find that the *players'* perspective is often just as integral to learning in the larger space of computer-mediated activity.

Participatory spectatorship

Participation in competitive games is highly specialized and demanding. Relevant membership within competitive gaming communities requires an understanding of complicated and nuanced discourse, expert execution of play, and high-level strategic understanding. This leads us to the question: Why do players continue to persevere and pursue expertise despite a harsh learning curve and competitive atmosphere? We posit that one factor is engagement with streaming and eSports. We seek to characterize the tools that mediate enculturation in these communities by looking deeply at the structures within eSports.

While the term "participatory spectatorship" has a history in games, theatre, and invasion sports (Douglas, 2002; Jensen, 2011; Ludvigsen & Veerasawmy, 2010) in this study we characterize it as *the active observation of a sport or spectacle in the pursuit knowledge though without requiring a recognized information need*. Traditionally, lurking describes peripheral membership as "readers" but not "writers." Here, the act of "watching" functions as an often overlooked element of participation and may simultaneously serve as entertainment, a means of social engagement, as well as provide opportunities for learning the game and community's discourses.

Discourse analysis

As the primary aim of this study is to understand how a curated process of participatory spectatorship shapes how learners use computer mediated-information channels, we present here a descriptive case study (Stake, 1995) of an eSports stream and provide a discourse analysis of a specific exchange during a live broadcast of a tournament.

For this case, we focus on the *The International's Newcomer's Stream* for the eSport game *Dota 2*. *The International 4's Newcomer's Stream*, informally referred to as the "noob stream" (located at http://www.twitch.tv/dota2ti_noob), caters to brand new and relatively inexperienced players with the explicit educative intent (e.g., teaching the mechanics of the game, strategies, and discourse of *Dota 2* and eSports). At the time of our sampling, the noob stream channel had been viewed over 1.6 million times. For novice players, *Dota 2* is quite difficult to follow. Watching with the support of a *Newcomer's Stream* offers newcomers a basic description of game mechanics and a subtle introduction to the depth of eSports, serving to teach as well as introduce new players to *Dota 2* to its participatory culture (Jenkins, 2006).

We conducted an exploratory Discourse analysis (Gee, 2013) on a sample from game two of *The International 4 Grand Finals*. Of particular interest is an exchange between two noob stream announcers "A" and "B," who utilize the space as a means to overtly instruct new players as to salient elements of the game. In the following analysis, we took several seconds of interaction between the two announcers, transcribed the discussion, and reframed it in Stanza form for analysis.

Stanza 1: Explanation of Actions

1(A): NewBee has smoked up,
2(A): meaning they're invisible to the minimap
3(A): and to the wards and whatnot.
4(A): They are doing this to get a little bit of movement speed at the beginning of the game
5(A): and to place wards.
6(A): Wards.

Stanza 2: Elaboration

1(B): And not just that --
2(B): Come on, it's about trying to get kills.
3(A): Of course, yeah --

Stanza 3: Reframing as Strategy

1(B): They are trying to find the enemy heroes,
2(B): because if you kill somebody right at the…
3(B): the first person that dies gives an extra reward, basically.
4(B): Its called first blood and
5(B): they give away an extra 200 gold.

Stanza 4: Evaluation of Strategy

1(B): So, using a smoke here is usually a little dangerous
2(B): because it means that their supports are less likely to roam later.
3(B): So, they were really hoping to get a kill there

4(B): and they didn't.

Stanza 5: Prediction of Future Play

1(B): So, that means that they are probably not planning to be very roamy this game.

2(B): The only hero that's going to move around is probably going to be the Earthshaker.

3(B): The Ancient Apparition played by SanSheng, or Banana, sorry,

4(B): is mostly going to sit up here and

5(B): cover his safe lane carry.

Stanza 6: Back to Original Framing

1(A): Indeed, let's go over here and

2(A): just go over wards if you don't mind.

3(B): Okay.

In Stanza 1, "Announcer A" described the game first at a *technical level*, focusing on the components and mechanics of the game. This emphasis carried through the theme of Stanza 1. Players' explicit actions were presented through the use of technical terms: "smoked up" and "wards." This represents both game specific lexicon and discourse practices. Announcer A made unambiguous what spectators were observing but may not have fully understood. "Wards" are considered structural components of *Dota* 2, and their reiteration in lines 3, 5, and 6 demonstrates Announcer A's position as to the depth of knowledge appropriate for the noob stream.

In Stanza 2, "Announcer B" stepped in and elaborated on the previous observations. This sets up a shift in the framing of the gameplay from one in which the announcer valued components and mechanics to one where practices and *goals* ("trying to get kills") became important. This negotiation characterized the dialectical relationship and developing tension between Announcer A and Announcer B. Stanza 3 reframed the discussion as about *strategy*, and Announcer B's strategic explanation was an extension of what was explicitly observed, building off of Stanza 1's reflection of the spectator's perspective with additional definitions of in-game content. In all, Stanza 3 moved beyond what is "observed" to strategic discussion.

In Stanza 4, Announcer B further developed an *evaluation* of the strategic merits of the actions described in Stanza 1. Line 1 assessed the risk of using "smoke" at this stage of the game. This evaluation of decision-making was relevant, as team NewBee did not attain the hypothetical goal proposed by Announcer B (see Stanza 4, Line 4). Line 2 indicated a long-term strategic ramification of the actions described in Stanza 1: NewBee had lost ability to "roam" while aided by "smoke" to elude the vision of "wards." Announcer B moved beyond structures and components of "smoke" and "wards" and developed strategic *hypotheticals*.

And so, expanding on these hypotheticals, Stanza 5 elaborated *predictions*. The early "smoke" signals a premeditated strategy to be less "roamy" this game. Line 2 shifted the framework from team level strategy to the approaches of individual players. According to Announcer B, the player-controlled hero "Earthshaker" will likely be the only "roamer." This hypothetical is based on team-level decision-making, the actions (Stanza 1), the ramifications of actions (Stanza 2 and Stanza 3), and observable outcomes (Stanza 3). Line 3 attached cultural significance to "Ancient Apparition" by noting the professional player who is controlling the hero. Moreover, Line 4 and Line 5 continue to process of generating hypotheticals based on situational awareness.

Finally, in Stanza 6, Announcer A prompted a *return* to the description of the observable components and mechanics of "wards." This full-circle approach is perhaps representative of a larger model of participatory spectatorship practices: observable components and mechanics leading to hypotheticals and strategy followed by to a return to observable components and mechanics.

Overall, it seems that participatory spectatorship may provide learners opportunities to assume the *identities and roles* of professional players (Stanza 5, Line B), *embody their actions* (Stanzas 1-3), and understand their *decision-making* (Stanzas 4-5). Moreover, this form of participation hones observation of basic activities and components of a functional game system, as well as the rules and ritual of competitive gaming communities. Participatory spectatorship takes the form of embodied problem-solving narratives, wherein players may develop and analyze hypothetical situations based in observation of play (Stanza 5).

Conclusions and implications

We provide here a provisional analysis of the affordances of the *Dota 2* noob stream, as a means of illustrating the ways that participatory spectatorship may be consequential for enculturation into these informal learning communities and for the collaborative play found within them. Though this is but one verbal exchange within a larger set of announcer conversations, and atop a multimodal and highly interactive game space itself, the discussions here seem to reveal patterns within the conversations that occur in these spaces. That is, spectating the noob stream is not a “simple” viewing of game activity, but is a complex process in which learners interpret the announcers’ interpretations of play, reinterpret this as strategy, and model the prediction of play activity. Spectatorship becomes participatory as observations and interpretations are added to knowledge and later embodied in practice. The predictions of play in Stanza 5 are features of a computer-mediated negotiation between announcers and spectators that may serve to coordinate and guide continued participation.

As we saw in Stanza 1 and Stanza 6, the degree to which “wards” are emphasized develops a tension between the announcers. The dialectic between announcers on the noob stream may afford spectators an opportunity to negotiate and interpret a variety of approaches to understanding the game as player. The lack of a required information need in participatory spectatorship gives viewers the opportunity to actively transform knowledge. Information presented by the announcers is constrained by the actions in the game; however, these constraints also allow for the spectrum of information complexity present in Stanzas 1-6. As lurkers gather discursive tools and the social capital that comes from them, they may work their way toward visible participation within an online community. Similarly, participatory spectatorship can afford enculturation and knowledge construction embedded within a social community. Yet, as games are embodied forms of play, participatory spectatorship may also afford a sense of physical participation in a performance or hypothetical scenario. The present study does not investigate how spectators engage with live streams, nor does it interpret all the possible forms of participation surrounding *Dota 2* as an eSport. It is only the first step in understanding how participatory spectatorship serves participants as they move toward more central membership in a larger gaming enterprise, and will serve as a basis for future work.

This descriptive case study is a way to re-engage with lurking from a new direction by injecting forms of spectatorship that may afford different kinds of participation from those studied in online text-based communities. The expansion of lurking into multimodal spaces opens perspectives to a variety of forms of sociodramatic and pretend play. The lens of participatory spectatorship presents players with opportunities for learning in complex media spaces involving a widely interconnected set of resources and the exemplification of discourse practices that extend beyond the game itself. With the goal of teaching novice players a complex game, the noob stream hones the observation of components and strategy, a level of perception that in other circumstances may require hundreds of hours of practical experience. As participatory spectatorship, play is modeled in real-time and in real-world (albeit digital) situations, allowing players to observe and later enact skills and practice in the form of play. This reinforces that participatory spectatorship, like lurking, is an *active* process of enculturation into complex media spaces.

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Assessing Young Children's Cognition through Multi-Modal Interviews

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Abstract: Designs that leverage embodiment argue that embodiment supports students' cognition and learning. However, it is unclear how we might assess the role of embodiment in supporting student learning as compared to other modes of expression, such as verbal or visual. Furthermore, computer-supported learning activities that rely upon embodiment may be best evaluated with measures that allow students to continue to embody their knowledge during assessments. Our study presents early efforts to understand how embodiment might support or hinder 2nd graders' expressions of states of matter (N=18). Results indicate that when students are less familiar with content or provided fewer details in other modes of communication, embodiment provides an alternative way to express their understanding. Moreover, the intervention familiarized students with how to use embodiment to express themselves which led students to yield responses which were just as nuanced as other modes of communication.

Keywords: embodiment, assessments, multi-modality, young children, interviews

Introduction and background

Embodiment, including both gesture and whole-body activity, plays a critical role in cognition and learning (Goldin-Meadow, 2004; Smith & Gasser, 2005). It is particularly valuable when students are less familiar with a topic (Radford, 2009) and in early elementary classroom contexts where a high level of physical activity is already commonplace. As a result of these findings and ongoing technical innovation that support embodied interfaces, educational technologies are increasingly incorporating embodiment as a central component of their designs (Lindgren & Johnson-Glenberg, 2013). However, it is not yet clear how we might effectively use these different modes of communication in evaluating young children's understanding of science content such as states of matter, where assessment is typically based on students' drawings and/or talk (cf., Paik, Kim, Cho & Park, 2004; Smith et al, 2006).

This paper reports on initial efforts to explore the different ways that 2nd graders expressed their understanding during semi-structured interviews both before and after an intervention, which centered on how embodied modeling with motion-capture technology supports the learning of states of matter (Danish et al, 2015). We analyzed how different multimodal opportunities may encourage or hinder students' articulations and examined the extent to which embodiment as a mode of communication can support students' early articulations of unfamiliar concepts. Given that students were embodying particles in different states of matter, we expect that students will be better able to ground their ideas or knowledge in the physical space by using their bodies (Alibali & Nathan, 2012). Moreover, given that gestures reflect a child's readiness to learn and consequently improve learning (Cook, Mitchell, & Goldin-Meadow, 2008), we expect that whole-body activity can encourage students who are less familiar with the content to better able to express their ideas and consequently increase their use of embodiment to demonstrate their understanding in the post-interviews.

Methods

Participants and data sources

Four groups of students aged seven to eight (12 males and 6 females) from a mid-western public school participated in this study. Using motion capture technology, these students worked with two teachers and learned about the particulate nature of matter and the role of energy as a causal mechanism in state changes (Danish et al, 2015). Over the course of three days, students engaged in role-play involving a narrative centered on water in various states, embodied particles and modeled how energy would impact these particles (for further details, please see Danish et al, 2015). These activities leveraged embodiment and dramatic play; encouraging students to use their positions and motions in the physical space to depict themselves as particles, which are then displayed on-screen. Pre-post interview analysis for conceptual understanding indicated that all of the students developed a more robust conception of states of matter (ibid). This paper reports on a secondary analysis of the pre-post semi-structured interview video data to understand how different modalities supported students' articulation of the particulate nature of matter and changes of state.

Assessing student understanding

To examine student understanding, we analyzed students' verbal and non-verbal responses, and developed a coding scheme structured around particle behavior and the relationship among energy, particle behavior and state changes. We began with a priori codes focusing on the underlying principles behind students' characterization of boiling and melting (both state changes) from Paik, Kim, Cho, and Park (2004). After several iterations of applying our initial codes, two sets of ordered codes were finalized and applied to all pre-post interviews (see tables 1 and 2). We targeted increasingly nuanced descriptions of matter (from observable properties to particle behavior) and types of causal mechanisms involved in change of states (from simple descriptions to articulating the relationship among energy, particles and state changes). Students' propensity to use embodiment was not assessed, although the teachers commented that students were used to physical and role play in both in class and out of class activities.

Table 1: Summary of the matter-type codes for conceptions of matter

Codes	**Illustrative examples**
MT1: Observable characteristics of matter	It's just stacked up, ice is hard, water can just sinks down to the bottom but ice has to stack.
MT2: Understand that matter is conserved	Really it's the same amount as this picture from that picture, cause it melts.
MT3: Initial discussion of particles (includes incorrect articulations)	The particles are frozen... on a hot day it melts the particles can't handle that much coldness.
MT4: Accurate discussion of particles (no incorrect articulations)	They [water] move a lot, medium fast, not like (makes whizzing-like noise), that would be gas.

Table 2: Summary of the change-type codes for causal mechanisms in changes of state

Codes	**Illustrative examples**
CT1: Superficial description of state change	Water changes into ice.
CT2: Some mechanism involved	It [The glass shaking] sorta rocks me around.
CT3: Energy or temperature as mechanism	Energy made me [particle] move faster.
CT4: Particle behavior as mechanism	Gas [particles] coming together a little bit more [to make liquid].
CT5: Relates energy to particle behavior and state change	Well, there has to be snow or something like that to get it cooler, and get the energy not flowing as much, so they [particles] move a little.

Examining student responses to different modalities

The interview protocol included a series of questions, which differed in the modality of response that they requested. This sequence of questions focused on how students explained the behavior of particles in various states of matter. Students were first asked a) what particles look like; then b) were asked to embody a particle in a liquid state, and c) directed the interviewer as the interviewer embodied a state transition. The first two questions were coded using as matter-types while the last question was coded as a change-type. Given that the content was not coded similarly, we inspected the codes to select cases where students initially responded with "I don't know", or were not codable in the verbal question, but later provided a more nuanced description when asked to embody or direct the interviewer. Selecting these cases allowed us to explore how students who do not appear to have initial ideas about the content or seem less familiar with it, respond in the subsequent questions. We also supplemented the analysis of interview data with videos of the intervention to determine how specific embodied activity might have carried over into the post-test. After examining these initial cases, we analyzed the remaining cases to explore how all the students responded to the three questions.

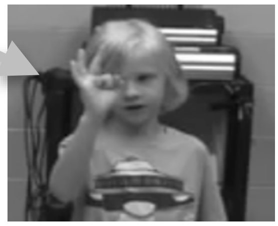
Findings

Using embodiment to share nascent ideas

Findings indicate that when students are less familiar with the content, embodiment allowed them to demonstrate their understanding. We present an example of a pre-interview with Jonah who initially responded that "it (water particles) would turn to ice" when asked about how particles would behave in a liquid state.

Excerpt 1: Student's embodied response to query on how particles behave in liquid state in pre-interview

	Transcript	**Embodiment**
1	The little specks of water	[makes specks with right hand]
2	would turn into…	[joins both hands together]
3	they would um…	[drops left hand down, and then brought it back up again]
4	they would like	[forms hands together again]
5	turn into ice	[moves hands apart from one another in a straight line]
6	and make the water still	[moves hands together and then apart]



Jonah continued to add that the sun played a role in the change from solid to liquid, all the time gesturing while articulating his thinking. When asked to embody what he meant, Jonah's response was richer and more detailed. At first, he used his right hand to represent particles (line 1), later using both hands to depict more than one particle (lines 2-4) and then further illustrating how these particles might arrange themselves in a straight line to form ice (lines 5-6). In Jonah's case, gesturing appears to allow him the time to gather his thoughts and facilitated his attempts to share his ideas. Jonah's gestures indicate some awareness that particles arrange themselves in a particular way to form ice, although he may not have the disciplinary sophistication to illuminate his idea further. In his post-interview, Jonah was able to articulate and embody an initial conceptualization of particle movement in a liquid state. He correctly moved around to embody particle movement and explained that "they (particles) move around pretty fast". Even though Jonah's characterization of particle movement in water is inaccurate (particles move around faster than in solid, but slower than in gaseous state), his gestures were not as hesitant, and more immediate and direct.

However, not all students chose to use embodiment to articulate their thinking. Seven students across both pre and post-interviews (four in pre, three in post) opted not to embody when asked to by the interviewer. Out of these, two made initial attempts but then expressed that they did not know how to embody, whereas the others declined to embody when asked by the interviewer. We contend that this could be due to students' lack of familiarity with both content as well as embodied ways of explaining their ideas prior to the intervention. Instead, some students opted to visually represent their ideas when we provided them with this opportunity in the interview (e.g., drawing a picture), demonstrating that students will default to familiar modes of expression. However, in the post-interviews, students readily used embodiment to explain themselves. 75% of the students embodied responses that were just as detailed as their verbal answers, with one student providing all details in his embodiment since his actions activated his thinking about the movement of particles. In the case of this student, the fact that the intervention supported embodiment as means of expressing one's understanding was critical in ensuring that he was able to access what he had previously learned.

The value of directing embodiment

In the seven instances where students opted to not embody, they were still willing to direct the interviewer, which then provided more insight into their thinking. Take for instance, Nigel, who initially declined to embody his explanation. He had explained that "they (particles) liquefy", paused and then added "I don't know" when asked about how particles behaved in a liquid state. Subsequently, when asked to embody, Nigel shook his head and said no. When the interviewer asked him to direct her actions, Nigel both demonstrated and verbally provided instructions to the interviewer on how to act like particles behaving in a liquid state (lines 1 and 5).

The changes in the particle movement were both demonstrated by Nigel first (e.g., lines 1, 9) and these utterances were mimicked or clarified by the interviewer. Nigel presented how he imagined particles act when they liquefy, demonstrating his assumption that particle movement mirrors the macro descriptions of matter (lines 5 and 9). Thus, his conception of particle movement is further nuanced in this sequence. In the post-interview, Nigel began to embody particles with no hesitation, moving around in a circle slowly to indicate particle movement, indicating that the implementation offered embodiment as more salient means of expressing understanding. This example also illustrates that asking students to direct embodiment could be more useful to illustrate student thinking than asking students how to embody when students are less familiar with not only this type of expression, but also the content.

Excerpt 2: Student directing interviewer as particle behaving in liquid to solid in pre-interview

	Speaker	**Transcript**	**Embodiment**
1	Nigel:	Um, you should go like this	[moves from his chair and squats on the floor facing the interviewer]
2	Interviewer:	Like this?	[mimics student and squats on the floor]
3	Nigel:	Yeah.	
4	Interviewer:	Uh huh.	
5	Nigel:	And then sorta move your arms around you because water is wavy.	[sit back down in his chair]
6	Interviewer:	Ok.	[waves arms around]
7	Nigel:	And then you'll change slowly to get less wavy	[gets up, hunches over and hangs his hands]
8	Interviewer:	Yeah, less wavy?	
9	Nigel:	Less wavy and start slowing down.	[droops over]
10	Interviewer:	Slowing down.	[mimics drooping over]

Conclusions and implications

Our findings suggest that interviews that incorporate embodiment can offer an alternative way for students to articulate their thinking, above and beyond what is originally offered in more traditional-interview formats. This is especially so when students do not include sufficient details in one mode of expression, are unfamiliar with how to express new content, and unfamiliar with using embodiment to express understanding. Furthermore, our results suggest that experience with embodiment as a form of representation leads to increased use of embodiment in post-test interviews. This suggests that there is value in teasing out when and how learning with embodied technologies supports transfer into more traditional assessment contexts.

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Symposia

Artefacts Mediating Practices across Time and Space: Sociocultural Studies of Material Conditions for Learning and Remembering

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Abstract: The theme of this symposium is to explore the material conditions of learning and remembering from a sociocultural perspective. We do this in four different empirical contexts. Learning and remembering are understood as meaning-making processes that are dependent on and co-constituted by mediating tools that enable practices to extend across time and space. Our interests are precisely in what ways the "tools" people employ in these studies mediate activities of learning and remembering, and how they contribute to the organization of collective forms of knowing. We also address how we analyze the specific material features of tools that co-determine the unfolding of the activities.

Overall focus and issues addressed

The overall focus of this symposium is to explore the material conditions of learning and remembering from a sociocultural perspective. It is nowadays not uncommon to think of learning and remembering in terms of socio-materially entangled and distributed practices, but this idea, in fact, has been around for quite some time. The basic notion in sociocultural studies of the material basis of learning and remembering is mediation, initially introduced by Vygotsky (1997). Vygotsky argued for situated studies of how humans interact with artefacts – technical as well as "psychological" – as they engage in activities and practices. To make his idea of mediation salient, he used an analogy and argued that psychological tools restructure the capacities of the human mind (i.e. learning, remembering, coordination of actions and perceptions) in ways that are similar to how "technical tools" transform physical activities. This is the essence of the idea of tool-mediated action.

The inclusion of a tool in the behavioral process, thus, reorganizes what Vygotsky (1997, p. 87) refers to as the "instrumental act". First, it "sets to work a number of new functions connected with the use and control of the given tool; second, abolishes and makes unnecessary a number of natural processes, whose work is [now] done by the tool; third, it modifies the course and the various aspects (intensity, duration, order, etc.) of all mental processes included in the instrumental act, replacing some functions with others, i.e., it recreates, reconstructs the whole structure of behavior just like a technical tool recreates the entire system of labor operations." (Vygotsky, 1997, p. 87)

As many scholars have pointed out, the distinction between psychological and technical tools must be understood as an analogy, since in a sociocultural tradition the distinction between the material and the ideal/conceptual is not accepted. Cultural tools "are simultaneously ideal (conceptual) and material" as Cole argues (1996, p. 117).

Based on these ideas as a shared premise, this symposium will first present four empirical studies conducted in diverse settings. Then the contributors will discuss the situated processes of meaning-making that are salient in the activities studied, and they will explore how these are contingent on material and conceptual features of tools:

1. Precisely in what ways are the “tools” people employ in these studies mediating activities of learning, remembering, and how do they contribute to the organization of collective forms of knowing?
2. What are the specific material features inherent to those activities?

Collective contribution to the discussion of these issues

As a collective enterprise we will explore and discuss the different ways that the notion of mediation is relevant in our studies in order to make salient what could be referred to as the materiality of learning and remembering in situated activities. It should also be noted that mediating tools may extend or restrict people’s participation, they may serve to support or challenge people’s co-ordination and interaction, they may black-box certain processes people engage in, they may function as prosthetic devices that extend people’s agency or as vehicles for entering into domains and practices that are entirely new.

Significance of each contribution

The contributions to this symposium accordingly share specific interests but they also differ with regard to empirical contexts and the kind of artefacts included in the activity. This will be fruitful for the discussion we wish to promote. In the first paper, by Ritella, Ligorio and Hakkarainen, design students’ collaborative activity (as they engage in creating artefacts in their design project), and their meaning-making process are analyzed through the Bakhtinian concept of chronotope. A similar, and yet different, case is presented in the paper by Arnseth, Jornet and Krange. The study reported concerns student work on sustainable energy use in the context of science education. As the authors follow how students engage in meaning-making with discursive and non-discursive artefacts in multi-modal learning environments, they use the analytical notion of a functional system (John-Steiner, Meehan, & Mahn, 1998). The third contribution, by Fauville, Lantz-Andersson and Säljö, explores students’ meaning-making as they engage with a mediating tool, a so-called carbon footprint calculator. This tool has been designed for people to conceptualize and understand the complexities of climate change, and, more specifically, the environmental consequences of their daily activities (travel, shopping, food intake etc.). Here the notion of psychological tool is drawn on to elaborate on the reflexive nature of engaging with personal behaviors through the lens of a powerful artifact. The final contribution, by Lundin and Mäkitalo, shares important elements of the third contribution with respect to how the self-generated data from people’s everyday life are visualized to facilitate learning to manage one’s own life situation. The tool in this case is used in hypertension care (a common but invisible condition). The study explores the tensions that this mediating tool creates in the clinical encounter as patients draw on their own documentation and experience to frame and understand their health status.

Building space-time frames and shared understanding in a media design task

Giuseppe Ritella, Beatrice Ligorio and Kai Hakkarainen

This study is aimed at investigating if and how the building of space-time frames is intertwined with the construction of a shared understanding of the task to be accomplished during a media design project course. The literature suggests that building a shared understanding of the task is crucial for CSCL (Dillenbourg *et al*., 2010; Rochelle & Teasley, 1995). Moreover, design tasks are considered as ill-structured or wicked, which require additional interpretative efforts for the building of a shared understanding. Nevertheless, we argue that a comprehensive understanding of the relationship between two crucial processes is missing: (a) building a shared understanding of the task and (b) framing the context of learning in space and time. In particular, we analyze students’ interaction when the link between negotiation of space-time relations (chronotope) and shared interpretation of the collaborative task is explicitly articulated in students’ activity. By looking at such moments, we shed light on the collective interpretation of the task as a holistic sense-making process regarding what the task is about (including subtasks), and the space-time organization (chronotope) of the activity, as it is mediated by multiple artifacts created and updated by students throughout the course. We conducted participant observation at a media design course where students worked in groups of 4-5 to develop a project, held at Metropolia University of Applied Sciences in Helsinki. Students worked in teams of 4-5 participants to develop a project. Students had to build a product or a service based on a problem presented by a representative of a company, who acted as their customer. The course lasted 16 weeks and the students worked together for ten hours per week. Many technological tools such as smart-boards, tablets, and notebooks, were available for them. Groups were free to negotiate and select the tools they considered appropriate at the different stages of the course, which gave them a relatively high degree of autonomy in the management of the collaboration. In this paper we will present the analysis of one group, composed by five students coming from different master programs. The principal method of data collection of this study was participant observation, involving also collection of audio and video records, which allowed documenting multi-level activity processes taking place while participants are engaged in technology-mediated learning (Goodwin, 2000). Six weeks were selected for participant observation: two weeks at the beginning of the course, two weeks in the middle and two weeks at end of the course. The rationale of this sampling was to follow the development of space-time management in the different phases of the course. Moreover, the collection of video records was complemented with screen records of computer-mediated activity whenever students used a smart board. Furthermore, we had access to most of the artifacts that students shared during the course. Artifacts and field notes were used as secondary data. The qualitative methods employed allowed triangulating various aspects of the emergent chronotopes and their development. The data analysis was organized in three steps:1) exploration of the data and preliminary interpretation; 2) selection and transcription of the data for in-depth qualitative analysis: we selected the clips in which (a) students were explicitly discussing their interpretation of the task; (2) the students were referring to space-time coordinates in their speech; (3) the students were taking decisions implicitly framing the task or the chronotope;3) qualitative video analysis of the 52 selected clips.

Finally, two stimulated recall group interviews were conducted in order to gather students´ perspective on the investigated phenomena. The interviews were used as secondary data set and analyzed using discourse analysis (Gee, 2000). The analysis shows that students´ interpretation of the task is a developmental process, interdependent with students' perception of the space-time relations of the ongoing activity. At the beginning of the course, when the task is defined in abstract terms, space-time frames were marginal in students´ discourse. However, already at the third week of the course the time-space frames, become relevant for building a shared interpretation of the task. Often students discussed – and changed – their interpretation of the collaborative task in association with the discussion of the space-time organization of the activity. For example, while discussing the task and defining subtasks, students referred to time constraints, to the organization of the workspaces, to the tools and resources available in the context. Therefore, both the task and the chronotope appeared to be emergent (and interdependent) features of the learning process. When collaboratively building a shared understanding of the task the chronotope was negotiated as well. Multiple artifacts and tools were used by students in this process: a concept map tool was relevant especially in the beginning of the course to create a preliminary shared understanding of the task; a shared dropbox folder was used to collect artifacts that were created and updated every week by students and contributed to create shared understanding and coordinate efforts; the slides for the final presentation, which became relevant for creating a shared understanding of the task in the end of the course. These results show that interpreting the task and organizing the activity in space and time are integrated layers of activity strongly "grounded" in the artefacts created and updated by students throughout the course. During the presentation some excerpts of students' discourse will be illustrated to exemplify how these processes are interrelated.

Learning in a material world: Reflection in science education as embodied practice

Hans Christian Arnseth, Alfredo Jornet Gil and Ingeborg Krange

Learning about sustainable energy use is a very important topic in science education. There exists a range of educational resources that support such learning in both formal and informal settings, but these resources are seldom systematically connected to other resources or embedded into curricular trajectories designed for knowledge integration and reflection. As part of a research program concerned with understanding how to better connect learning experiences across formal and informal settings, we implemented a technology-rich curriculum that was designed to facilitate the emergence of coherent conceptual trajectories across activities. In this paper, we analyze video recordings of classroom interaction in an upper-secondary school, and examine how a teacher and a group of 1st year students engage with material objects and digital resources to learn about energy transformation. We are concerned with how interactions between students and their teacher and their perceptually available world are organized through their exchange of semiotic means (Streeck, Goodwin & LeBaron, 2011). Our analyses focus on how participants orientations to the different material objects and digital resources, become occasions to reflect on prior experiences and to connect those experiences with the overall topic of energy. Attending to the embodied nature of these reflection practices, we examine how students and teachers together structure and perceive the world in certain contextually relevant ways.

The use of curricular resources such as still pictures or interactive, dynamic visualizations, have always been part of education in general, and of science education in particular. Educators can use these kinds of resources to make abstract concepts and relations between these more coherent and accessible (Edelson, Gordin,

& Pea, 1999; Lee, Linn, Varma, & Liu, 2010). Despite being carefully designed, resources are ambiguous and inference rich. This ambiguity, rather than problematic, can constitute a basis for the emergence and development of conceptual discussions in collaborative activities (Roschelle, 1992). In the learning sciences focus has shifted towards investigating the ways in which resources enable joint activities. For instance, Schwartz (1995) reported that dyads working with graphical representations of scientific issues outperformed individuals in conceptual performance, and theorized this advantage to be based on the need to build a common ground for mutual understanding. More recently, literature on computer-supported collaborative learning has taken interest in understanding how interaction is organized so as to lead to *uptake* sequences, that is, sequences in which participants take aspects of prior events as having relevance for ongoing activity (Suthers *et al*., 2010). Such uptakes often involve the enactment of teacher-led reflective practices by means of which conceptual links across events are an outcome (Scott, Mortimer, & Ametller, 2011). Although achieving such conceptual links is often regarded as relying on the participants' intellectual competences, and on how the latter are mediated by dialogue, recent research taking a semiotic and cultural-historical approach has shown that bodily and perceptual aspects of the organization of interaction also plays an important role (Jornet & Roth, in press). However, research has not yet fully scrutinized the embodied nature of joint reflective practices. In the paper we address the following research question:

How do students perceive and translate between discursive and non-discursive artefacts in multi-representational learning environments?

We extend the unit of analysis beyond the individual and see learning and sense making as emerging features of social interaction. This extended unit is captured in the notion of a functional system (John-Steiner, Meehan, & Mahn, 1998). According to Luria there are two distinguishing features of functional systems. The first is the presence of a task that is performed by variable mechanisms. The second is the complex composition of the system itself (Luria, 1932). The teacher provides the directionality for the development of the system, but there is a mutually constitutive relationship between the changing participation of the students and the changing system as a whole. The data were collected as part of a larger project where 24 first year upper secondary students worked on concepts of energy transformation using both physical and digital resources. We designed a curricular trajectory distributed over 7 days and spread across a four-week period. Emerging findings suggest that the teacher is crucial in contextualizing material objects and digital resources that students make use of while solving curricular tasks. The students have problems to see the resource in relevant ways. In this way, the teacher plays a decisive role to help them make significant interpretations of the curricular topic of energy transfer.

"I was shocked and embarrassed by the results": Carbon footprint calculators as mediators of tangible information and as resources for knowing and reasoning about emissions

Géraldine Fauville, Annika Lantz-Andersson and Roger Säljö

Human activities over the past century have resulted in a rapid accumulation of carbon dioxide (CO_2) in the atmosphere, resulting in changes in the global climate. To deal with the issue of climate change, citizens need to gain understanding of their own CO_2 emission, also referred to as their carbon footprint (CF) – linked to their lifestyle activities. However, one of the major difficulties to grasp the abstract concept of CF is that such emissions are invisible to the human eye. Recently, the emergence of digital technologies has extended the range of concepts we can visualize and manipulate. Representational devices such as carbon footprint calculators (CFCs) present questions concerning the user's lifestyle, and by answering the questions, the users receive their total CO_2 output in kilograms. This raises interesting questions about how CFC mediates understanding and enables altered ways of reasoning about CF.

The few studies that have investigated the impact of learning about the personal emission through CFCs and then analyzed environmental behaviors, display divergent results. On the one hand, for example Mallett and colleagues (2013) suggest that adult self-confrontation via a CFC promotes guilt, which partially mediates willingness to support actions for existing pro-environmental groups. On the other hand, Brook (2011) describes how some adults might be less likely to engage in pro-environmental action after receiving negative feedback from the CFC. Even if the implications of the use of the CFC in instructional settings have not been thoroughly studied, the results so far cautiously point to the positive impact that use of CFC has in how the students are able to link their lifestyle to climate change (e.g. Cordero, Todd & Abellera, 2008). The present study aims at contributing to this field of research by scrutinizing how the visualization of the CFC relates to the students' understanding of their CF and their reasoning about ways to decrease it.

By grounding the study in a sociocultural perspective on learning (Vygotsky, 1978; Wertsch, 1998; Säljö, 2005), we regard the CFC as a material and psychological tool, which mediates the idea of CF and its determinants in manners that offer possibilities to understand and learn about climate change and about how one's personal behaviors contribute to carbon emissions. Our empirical study focuses on learning activities implemented to scaffold high school students around the world to understand their CF and to envision local and global solutions. Students first calculate their CF by using a specific CFC (http://footprint.stanford.edu/footprint.html), and then they discuss different aspects of the climate change issue using a social media platform (muut.com). Data were collected from the September 2014 session, involving 45 classes from 15 countries. In the analysis, we scanned the discussions for comments where students clearly addressed potential CF decrease.

Preliminary results show that the CFC as an artefact makes discussions possible and the metric system used offers concrete reference points for understanding emissions both at the personal level and more generally. Thus, this digital tool supports meaning-making by creating new access points to tangible reasoning practices that concern CF and environmental impact. These results imply that the use of CFC's gives the students opportunities to enhance their understanding of, and involvement in, the climate change issue.

Documentary practices in transformation: Follow-up consultations with patients and health care staff in hypertension care

Mona Lundin and Åsa Mäkitalo

In current health care reforms, for instance those building on person centred care, new relations between health care institutions and their patients have been articulated. It has been argued that patients need to be more actively involved in managing their own health and take on more responsibilities for their own well-being and treatment. In recent policy discourse, 'patients' are accordingly being reinvented as 'partners' in the delivery of health care services (Candlin, 2000; Dunston *et al*, 2009). This implies that responsibility and agency need to be both renegotiated and shared between the parties, and trust needs to be established in the new relation. Technologies are suggested as potential solutions to several problems identified when it comes to establishing new relations and supporting individuals in self-management and treatment. Digital tools are seen as useful and handy devices for entering and sharing information on a daily basis (on blood pressure, pulse, medical treatment, symptoms, physical activity etcetera). The information that is entered may also be stored in databases that can be made available for the parties. This implies a new basis for medical consultations and allows for new patterns of following up treatment. In addition, the information may be aggregated over time and displayed in web-based graphs (bar, line, pie, area charts etcetera), allowing for visual *re*-presentation of the individual's health status. As such, technologies in person-centred care provide the person with a *technologically mediated version* of him- or herself. Such representations of one's own health status, allow individuals to distance themselves and provide a reflexive element in daily life. From a sociocultural and dialogical perspective we study the reflexive element that mediational means (Wertsch, 2007) like technologies of this kind may provide in practices of self-documentation and *re*-presentation. Engaging with such mediational means on an everyday basis may have profound implications for identity formation and learning (Vygotsky, 1997) as well as for moral accountability and responsivity to 'the other' (Linell, 2009). At the same time technologies of this kind may create tensions for both parties – as clinical practices are extended into peoples' homes (Winthereik & Langstrup, 2010), responsibilities and obligations will be re-negotiated.

Our empirical material consists of 20 follow-up consultations (10 videorecorded, 10 audiorecorded) with hypertension patients and health care staff. Our preliminary analysis of the material features of this system, shows that the way the patients' data are visualized and displayed graphically on the computer screen during the consultation provides support for remembering and discussing their everyday life and related health issues. It is also evident that the consultations were embedded in multiple documentary practices that created tensions in the organisation of the face-to-face encounter. We will thus highlight how a material-semiotic tool in the form of a mobile phone-based system anticipates new relations between patients and health care staff.

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Researching and Designing for the Orchestration of Learning in the CSCL Classroom

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Abstract: Designing tools for teachers to orchestrate computer supported collaborative learning activities in their classrooms requires that attention be paid to the range of roles and activities a teacher must take throughout the process. Drawing on the Implementing Collaborative Learning in the Classroom framework proposed by Kaendler, Wiedmann, Rummel and Spada (2014), the contributors to this symposium will speak to the way their designs address the various parts of this framework, allowing us to draw conclusions about what has been successful for different parts of this process, and identifying future directions for development and research.

Keywords: teachers, design issues, classroom technology, collaborative learning

Focus of the symposium

As the field of computer-supported collaborative learning embraces an ever-widening set of technologies, the opportunities to implement CSCL activities into classrooms increases, and the role of the teacher in orchestrating the learning experiences becomes a central concern. Moving away from standard personal computer and online activities, in favor of handheld devices, immersive simulations, large interactive surfaces, and device ecologies in classrooms allows for more face-to-face CSCL interactions in classrooms. These tools provide new opportunities to use the students' interactions with the technology to provide insight into the collaboration and learning processes, through the use of learning analytics. Thus, there is both the potential and the need to design tools for teachers to use when orchestrating CSCL activities in their classroom (Dillenbourg & Jermann, 2010).

The teacher's role in supporting collaborative learning has received limited attention in the research literature (Webb, 2009), however, in a recent paper, Kaendler, Wiedmann, Rummel and Spada, (2014) propose a framework for teacher competencies in the implementation of collaborative learning in classrooms. Building on the premise that effective collaborative learning is largely dependent on the quality of student interactions, the framework focuses on teachers' competencies in planning for, monitoring, supporting, consolidating and reflecting on these interactions. Three phases of activity are identified in the Implementing Collaborative Learning in the Classroom (ICLC) framework. In the first phase, the pre-active phase, the teacher is involved in planning the collaborative activity. In the second, the inter-active phase, the teacher focuses on monitoring, supporting and consolidating the collaboration, while students engage in collaborative, cognitive and meta-cognitive activities. During the final, post-active phase, teachers focus on reflecting on the activity and evaluating the student interactions in order to inform future activities. They propose that teachers draw on their professional knowledge and beliefs to develop these competencies. This framework provides a useful starting place for those involved in designing computer-supported collaborative learning activities for classrooms, as it highlights the ways in which the teacher participates in these activities. This allows researchers to consider the range of opportunities for teacher engagement with collaborative activities, and design tools that support teachers during the different stages or activities in this process.

The major issues addressed and contribution of each presentation

The goal of this symposium is to bring together researchers who focus on computer-supported collaborative learning in classrooms. Using their research and design work as it relates to the role of the teacher they will elaborate on the ICLC framework, identify areas for further development of the framework, and suggest how it can be used to guide the design of orchestration tools. Two of the contributions focus directly on the design of tools to support teacher engagement during the inter-active phase of CSCL activities, providing initial examples of the integration of technology into the orchestration process. Two focus on the actions of teachers during CSCL activities in classrooms, developing our understanding of when and how teachers intervene at the small group or whole class level, to inform future design decisions. The final three contributions focus on different aspects of what teachers need in order to engage in the CSCL process, providing different lenses through which to examine and extend the ICLC framework (fostering student interactions and teacher competencies with technology and collaborative learning pedagogy).

In the first contribution, Martinez-Maldonado draws on research from the University of Sydney that examines how visual indicators can be used to help inform teachers about how students are interacting during collaborative tasks on multi-touch tables during the interactive phase of the ICLC framework. In a similar vein, Mercier's contribution examines how providing teachers with updates about the content being created by group members can be used by teachers to identify which groups or students need their attention.

The contributions from both Fong and colleagues, and Joyce-Gibbons, pay attention to the way in which teachers orchestrate the whole-class interaction activities, during computer-supported collaborative learning tasks. From these we draw a deeper understanding of the inter-active phases of the framework, and in particular the informational needs of the teacher to help make decisions about when and how to intervene at the small group or whole class level.

The final three contributions ask what the teacher needs in order to 1) support the students' interaction behaviors, 2) use technology effectively and 3) use collaborative learning effectively. The contribution from Israel looks at two important aspects of supporting CSCL – the preparation of students to participate in collaboration, and on-going interactions of teachers to align students with the expected collaborative interaction behaviors. Using a framework to teach students about positive collaborative interactions developed by teachers in the research site, Israel reports on how it provides a basis for teachers to monitor and support students during collaborative processes. Forssell focuses on how to support teachers using technology – a key aspect of implementation. Drawing on survey data of practicing teachers, she identifies the prerequisite teacher beliefs and knowledge for adoption or adaptation of technology in the classroom. Finally, Shehab's contribution draws on survey data from teachers who actively use collaborative learning, focusing on the key issues that they identify, in an effort to further elaborate the design requirements for tools to support orchestration of CSCL.

Significance

This session will be organized as a structured poster session. Each contributor will take five minutes to describe their work at the beginning of the session. The rest of the time will be equally divided between audience engagement with the posters and an audience-wide discussion of future directions for this work. Rummel, an author of the ICLC framework, will provide commentary about the contributions and their relation to the framework at the beginning of the audience-wide discussion.

The significance of this symposium will be in drawing out the specific design issues related to the ICLC framework, informed by research that is actively addressing the role of teachers in CSCL classrooms. It will allow future development work to build on this framework, providing common terminology and a shared understanding of the issues to facilitate comparisons or joint development work.

Learning analytics and teachers' awareness in the CSCL classroom

Roberto Martinez-Maldonado

Parts of the model addressed: Inter-active phase (monitoring and supporting).

A particular recent strand of research carried out at The University of Sydney has focused on enhancing teacher's awareness in a multi-tabletop CSCL Classroom: the MTClassroom (Martinez-Maldonado, 2014), by developing and evaluating a series of awareness tools. By awareness tools we refer to those that provide a user (e.g. the instructor) with an enhanced level of awareness of what other actors (e.g. students) are doing in the learning space. This research has explored different ways to exploit student's data that can be pervasively captured through enriched multi-touch interactive tabletops to provide teachers with group indicators that cannot be easily evaluated by teachers in the limited classroom time. This provision of visual indicators is strongly linked to the field of *Learning Analytics* (LA) which has emerged in recent years as a multidisciplinary research area with the aim to improve the overall learning experience for instructors and students. This suggests the potential value of the overlap between CSCL and the LA fields to provide novel and practical support in the classroom.

Part of the research studies in this project has included the exploration of real-time visualizations and notifications that can suggest (or more directly alert) teachers about groups that may be facing problems (Martinez-Maldonado et al., 2014). Additionally, a number of data mining techniques has been applied to detect student's behaviours that may not be collaborative and to identify the frequent patterns that are mostly associated with high or low achieving groups (Martinez-Maldonado, 2014). However, the most significant contribution and recent contribution of the project is a proposed workflow to help other designers or researchers to more effectively design and deploy awareness tools for technology-enabled learning settings by following an UX-based iterative approach.

Even though most of the work in this strand of research has addressed the inter-active phase of the ICLC framework, work in progress is looking at the support that can be provided in design-time to teachers (pre-active phase) to design and re-design the learning tasks to be deployed in the classroom. Alternatively, further work is analyzing the ways in which similar learning analytics tools can be used by teachers to promote reflection after the classes have been enacted in the multi-tabletop classroom in order to drive re-design (post-active phase).

Live content updates and teacher intervention in collaborative groups

Emma Mercier

Parts of the model addressed: Inter-active (monitoring and supporting)

The SynergyNet classroom was designed to allow teachers to manage the networked multi-touch tables from a number of devices, including the shared display and a tablet. The teachers could send content to the tables, move content between the tables and shared display, freeze and clear the tables as necessary and, in some instances, view the work being conducted on the tables and change the parameters of the task. In this contribution, we focus on the use of live updates to the teacher's tablet during a collaborative math activity and ability to change the task demands. This tool was developed in order to allow teachers to more easily assess the contributions of each individual student during the task.

Building on a traditional classroom activity the tool NumberNet was designed to foster the development of mathematical adaptive expertise (Mercier & Higgins, 2013). During this activity, each group receives a target number, and each student works on their own number-pad to create expressions for that number. The number-pad does not allow students to send duplicates to the table, but it does not reject incorrect expressions. Groups work cooperatively or collaboratively to come up with as many correct expressions as they can during a time limit. The teacher's tablet receives live updates from the students, allowing her to see the correct (in green text) and incorrect (in red text) expressions each group or student is creating. In our studies with this tool, the teachers used the live updates to 1) identify a student who was making the same mistake repeatedly and intervene at the individual level; 2) identify groups who were relying on simple expressions and remove certain keys from the number-pad (e.g. the addition sign, the number 5) to make the task harder for the group; 3) identify a group who were struggling and pause the whole activity, using the shared display to conduct a whole class discussion to help prompt the struggling group with new ideas.

These tools allowed the teachers to make informed decisions about intervention at the student, group or whole class level, altering the tasks and providing support as necessary. Although not explored in our studies, the tools also have the potential of being used in the post-active phase of the ICLC framework, where the teacher could use the information gathered during the task to prompt her reflections on the task and adapt the task for future use. Additionally, when paired with tools that support the creation of tasks and allow teachers to monitor the interaction of students, there is the potential to provide teachers with much needed insight into when to intervene at the various levels of learning that occur in the collaborative classroom.

The 3R orchestration cycle: Fostering inquiry discourse in a CSCL classroom

Cresencia Fong, Rebecca Cober, Richard Messina, Tom Moher, Julia Murray, Ben Peebles and James D. Slotta

Parts of the model addressed: Inter-active (monitoring, supporting, consolidating)

We observed exemplary inquiry teachers and found that they employed an orchestration "cycle" of Reflect-Refocus-Release (3R) as a means of managing their CSCL classroom, over a 9-week astronomy unit for 2 classes of grade 5/6 students. To support their inquiry, students used Common Knowledge (CK) – a note-sharing tool that allows for "blended" (online and face-to-face) discourse (Fong, 2014). CK scaffolded students through 3 phases of collaborative astronomy inquiry: Brainstorm, Propose, and Investigate (Fong et al., 2013). Using tablets, students contributed to a community knowledge base that was represented in a public view on the interactive whiteboard (IWB), which persistently and publicly visualized the community's idea flow. Large displays were also created for student groups, on the side walls of the classroom, providing a visual mapping of the spatial distribution of inquiry topic specializations during the Investigate phase. Such public displays enabled learners to sort ideas along socially negotiated categories. Inquiry work done in the CK environment was seen to influence the discourse in teacher-guided classroom discussions, and vice versa (Fong et al., 2014).

Throughout the inter-active phase of the ICLC framework, teachers used these public knowledge visualizations as formative assessment of the community's knowledge state, to inform their monitoring of collaborative, cognitive, and metacognitive activity in the classroom. Students' CK notes displayed on the IWB were used by teachers to ground and spur face-to-face rounds of *reflective* classroom discourse, by which teachers supported and guided their knowledge communities' cognitive and metacognitive activity towards knowledge consolidation, which often led to further inquiry trajectories. Such discourse usually culminated in teachers' instructions that *refocused* the community's subsequent inquiry and cognitive activity, scaffolding students towards productive trajectories; at which point, students were *released* to pursue their inquiry collaboratively – resulting in further note contributions to the community knowledge base. This "3R" cycle figured prominently in teachers' orchestration of their enactments. Formative assessment of the community's publicly displayed knowledge state informed teachers' small-group interactions with students during Release, enabling them to provide timely support to students whom they deemed were in need. Reflective community discourse was pivotal in helping students develop awareness of their community's state of knowledge, achieve knowledge convergence, and receive teacher guidance towards productive inquiry.

Content analysis of students' CK notes examined their congruity with ideas that had emerged in previous inquiry phases. The primary goal of such analyses was to determine if the collective inquiry was progressing, by uncovering the extent to which teachers' Refocus statements were indeed driving students' inquiry progress, and to determine if CK was able to support the carriage and application of knowledge from one inquiry phase to the next. Average scores for both classes were above 1.6 (out of maximum score of 3.0), suggesting that proposals (i.e. from the Propose phase) were somewhat inspired by direct reference to Brainstorm notes (i.e. from the Brainstorm phase), and Reports (i.e. from the Investigate phase) were influenced by the corresponding proposals to which they were linked.

CK technology was designed to guide knowledge communities through a phased inquiry progression while enabling students to drive their own inquiry trajectories. Its technology and script design assumed an important role for the teacher, in the orchestration of the technology and inquiry activity. Future CK design will aim to decrease this teacher orchestration load – especially the monitoring of students' collaborative and cognitive activity (i.e., during Release phase) in the inter-active phase of the ICLC, so that teachers could devote more of their attention to supporting and consolidating students' cognitive and metacognitive activity (during Release and Reflect). To this end, using technology to increase teachers' awareness of the community's ongoing state of knowledge, in terms of "where they are" and "where they are going", can better equip teachers in their scaffolding of the community inquiry (i.e. Refocus).

Exploring teacher behaviour prior to the initiation of mini-plenaries during collaborative group work

Andrew Joyce-Gibbons

Parts of the model addressed: Inter-active (monitoring, supporting, consolidating)

Classroom orchestration requires that teachers resolve a number of inherently contradictory imperatives (Dillenbourg, 2013). They must balance the need to maintain disciplinary norms, keep to time and manage classroom resources, with the need to stimulate dialogue (Perrotta & Evans, 2013). This study looked at teachers' use of transitions from group-level interaction to whole-class interaction returning to group-level interaction in the context of these contradictory imperatives. Whilst such transitions are a common feature of a teacher's repertoire, the orchestration tools developed by the SynergyNet project enabled a more rapid shift in register, giving teachers the ability to freeze and unfreeze all tables simultaneously (Mercier et al. 2012).

Two teachers working with 10 and 11 year-old children were observed prior to the initiation of nine transitions. Each showed distinct behaviours in the minute prior to initiation of a transition. One teacher interacted with a single group and then called the whole class together after observing issues that that group was encountering, using the whole class discussion as a time to identify the issue and prevent all groups from going down the incorrect path. The other observed all groups silently for an extended period and then started a classroom conversation based on a group who appeared to be working well, using their correct moves to model the appropriate problem solving activities to the class. These behaviours indicate the processes of reflexive judgment by teachers that take place in the interaction phase of the ICLC framework.

The teacher's task as orchestrator of a CSCL activity is to continually balance progress being made by their students towards task completion, while engaging in deep collaborative discussion and knowledge convergence. Maintaining both sufficient progress for all groups in a classroom, and supporting all groups in collaborative knowledge building may represent a mini-ICLC cycle of pre- inter- and post-active phases within the lesson. Further research is needed to study this cyclical process by observing the impact of the transition on groups of students once they resume their tasks.

Further research is also needed to explore the collaboration management cycle and identify and evaluate the indicators that lead teachers to conclude that groups have deviated from the desired model of interaction sufficiently to warrant an intervention. A challenge for future CSCL classroom design is to provide teachers with a set of real-time indicators that enable them to make better-informed judgments as to the necessity or direction of intervention.

Supporting collaborative interactions during computing in K-5 classrooms

Maya Israel

Parts of the model addressed: Inter-active phase (monitoring and supporting).

Computing education is spreading quickly with initiatives such as Code.org's Hour of Code emerging. One of the advantages of computing technologies has been the focus on student collaboration and problem solving with peers. In this way, students can engage in computational *thinking* and computational *participation* that results in a connected learning community (Kafai & Burke, 2014). Computing environments such as Scratch rely on highly social processes in which students are encouraged to share their work with peers during the creation process. However, Good (2011) explained that despite the social aspects of these programming environments, we have yet to fully understand the types of collaboration that exist between learners and the types of benefits that students gain through these collaborative computing experiences.

This contribution will highlight findings from a school-wide computing study that examined the use of the Collaborative Discussion Framework (Lash, Park, & Pitcher, 2014) for encouraging collaborative computing. The Collaborative Discussion Framework was created to help teachers facilitate collaborative problem solving during the computing process because although collaboration is widely discussed within the computing literature (Kafai & Burke, 2014), students often did not naturally collaborate effectively. Research questions included: (a) How do teachers promote collaboration within the context of computing instruction? And (b) How does teaching students how to collaborate influence their interactions and behaviors during collaborative problem solving? Data was collected through the Collaborative Computing Observation Instrument (C-COI), in which students' computing experiences were captured using Screencastify (an open source screen capture software that also records audio). In this way, we could observe the on-screen behaviors of the students as well as the conversations that they had while they completed computing tasks. The aim of using the C-COI was to measure how teachers promoted collaborative computing as well as the process of collaborative problem solving during difficult computing tasks. The C-COI was used to measure how teachers monitored interactions among their students and facilitated collaborative problem solving, persistence, and positive help seeking. The ICLC framework identifies the importance of students' collaborative interactions, and the teacher's role in supporting these interactions throughout the three phases of the framework. This study provides insight into how teachers can prompt students to engage in particular forms of interaction and discussion and highlights the importance of proactive planning for collaborative discussions within the context of CSCL instructional practices.

Ready, Able, and Willing to Adopt CSCL Practices

Karin S. Forssell

Parts of the model addressed: Professional knowledge and teacher beliefs

Designing and implementing computer-supported collaborative learning activities requires teachers to learn new tools, new techniques, and new tasks. It requires both a pedagogical facility with collaborative activities, and an understanding of the technological tools that support them. In many studies of CSCL, the availability of the technologies, the teacher's pedagogical competencies, and the willingness of teachers to engage in these tasks are taken as a given. This contribution seeks to 1) position the competencies identified in the ICLC framework in the broader context of the prerequisites for successful implementation of CSCL, and 2) explore what it might mean to be willing and prepared to engage in CSCL activities.

This study draws on data from a survey of accomplished secondary teachers in the US to examine the role of teacher competence in the adoption of new technologies and practices in classrooms. We make a distinction between being ready, able, and willing to use new tools. We define *ready* as self-perceived competence. *Able* is represented by access to the required external resources. *Willing* is operationalized as a belief in the value of using computers with students. We explore these three constructs in relation to two outcome variables: exploration of new computer-based activities with students, and frequent use of computers in the classroom. Results suggest that the teacher's self-perception of competence is the largest predictor of both exploration and repeated use of new technologies. The external resources available, in this study represented by computers available in the classroom, play a large role in frequent use of technology, but are not a significant contributor to exploration of new activities. Finally, beliefs about the value of technology in teaching and in the discipline contribute to both frequent use and to exploration.

We use these findings to explore what it would mean to prepare teachers to be ready, able, and willing to implement CSCL in their own classrooms. Specifically, we explore the important educational beliefs that motivate teachers' use of CSCL (Pajares, 1992). In our study, beliefs about the impact of technology in the classroom are explored based on key elements of Pedagogical Content Knowledge (Magnusson, Krajcik, & Borko, 1999): knowledge and beliefs about curriculum, about students' understanding of specific topics, about assessment, and about instructional strategies. For this contribution we explore beliefs inherent in the ICLC framework, and how they relate to the identified competencies. After exploring the application of these findings to the ICLC framework, we suggest areas in which the framework provides important insights, and areas in which it could be extended.

Teachers' reflections on implementing collaborative learning in classrooms

Saadeddine Shehab

Parts of the model addressed: Issues identified in Implementing Collaborative Learning in Classrooms

One of the key features of the ICLC framework is an emphasis on the capacities that teachers bring to the classroom when they orchestrate collaborative learning experiences. Understanding more about these capacities, and the issues that teachers encounter across the three phases of collaborative learning is essential to our understanding of how to develop tools to support teachers during CSCL activities. Prior research has indicated that teachers identify issues related to time management and preparation of students to engage in collaboration (Gillies & Boyle, 2010) and issues relating to institutional norms, pedagogical practices and contextual constraints of school systems (Ruys, Van Keer, & Aelterman, 2014). To further extend our understanding of the issues encountered by teachers who are actively using collaborative learning in their classrooms, we designed a survey to explore the experiences of middle and high school science teachers using collaborative learning in one US state. The survey was completed by 69 middle and high school science teachers. For the purpose of this symposium, we will report on teachers' responses of three open-ended questions that aimed at exploring their definitions of collaborative learning, their reasons for not using it, and their comments on its implementation. The open-ended answers were coded using an emergent coding scheme to identify the different themes that emerged in the answers.

When asked to define collaborative learning, teachers' responses were coded into the categories: describing the purpose of collaboration, the interaction process, the outcome of collaboration, their roles as teachers, and the influence of the task. The majority of definitions included the first three codes but reflected understandings of collaborative learning that was coded as naïve, moderate, or robust. Only one response was coded as referencing the role of the teacher and the influence of the task. In response to a question asking for reasons that they did not use collaborative learning the teachers listed reasons that are coded as related to students such as age and disciplinary problems and related to teachers such as stress, health, and lack of resources. Other factors that were identified included time constraints and unequal participation of students when working on collaborative tasks. In response to the open-ended item asking for any other comments about collaboration, most responses were general positive or negative reactions to using collaborative learning or specific issues that the teachers had encountered. A small number of responses were coded as relating to a need for professional development, the role of technology in fostering collaborative learning, and a need to explicitly address collaborative learning skills before, during, and after implementing it with students.

These findings shed light on teachers' understandings of collaborative learning, and the real or perceived barriers to the use of collaborative learning in classrooms. These provide an important understanding of real teachers, their experiences and competencies in implementing collaborative learning and possible areas for intervention and development. The responses identified the issues such as time management, resources and outcomes or assessment issues, as well as needing to prepare students to engage in collaboration and participate equally. Drawing on the ICLC framework, there are a number of design opportunities at each phase that could be implemented to allow teachers to more easily design, monitor and assess collaborative learning and CSCL activities in their classrooms. In the design of CSCL tools, identifying the problems encountered by teachers ensures that the tools created provide useful solutions that ease the issues related to orchestrating collaborative learning in classrooms.

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CSCL and Learning Analytics: Opportunities to Support Social Interaction, Self-Regulation and Socially Shared Regulation

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Abstract: Research has generated deep insights into computer-supported collaborative learning (CSCL), but the cycle of impact on practice is relatively lengthy and slow. In contrast, work in learning analytics attempts to leverage the collection and analysis of data to improve learning processes and outcomes in-situ. Developing learning analytics to support CSCL thus offers the opportunity to make our research actionable in an immediate way by using data collected on collaborative processes in-progress to inform their future trajectories. Efforts in this direction are specifically promising in support of students' self- and socially shared- regulation of their learning. Data on collaborative and metacognitive activities can inform collaborating groups and help them to improve future joint efforts. In this symposium we bring together a collection of five papers that are exploring the space of connection between CSCL, learning analytics and self-regulation to advance thinking around these issues.

Keywords: learning analytics, socially shared regulation of learning, prompting, scaffolding

Introduction

Research in CSCL has a recognized tradition of generating insights about how to support collaborative learning with both hard and soft technologies (Tang et al., 2014); yet the cycle of impact on practice is relatively lengthy and slow. Findings from research studies are disseminated through conferences and journals and may eventually be taken up by teachers or designers to productively inform the experience of future students in classrooms. But for those with whom the initial data was collected, the opportunity has passed. In some cases, advances are reified into technological artifacts that can be sent out into the world, but technologies too can be co-opted and still the change and adoption process is slow.

Against this backdrop, the recent emergence of learning analytics as the collection and analysis of data traces used to inform learning activities while they are still in process, offers a special opportunity to "close the loop" (Clow, 2012, p.134) and make CSCL research actionable in a new, more immediate, way. Importantly, moving from CSCL-as-research to CSCL-as-learning-analytics is different from a simple application of previous findings. Rather it requires the generation of previously unexplored kinds of insights into CSCL processes and offers a way to simultaneously achieve high practical impact and new theoretical advances in the field. Specifically, there is an opportunity to unite work in CSCL with emerging research in the area of self-regulated learning (SRL).

Contemporary research on SRL focuses on the collection and analysis of complex, temporally-unfolding data using various interdisciplinary methods. Researchers use a variety of multi-channel SRL data such as log-files, eye-tracking, physiological sensors, facial expressions, utterances, etc. to examine the role of cognitive, metacognitive, affective, motivational, and social processes engaged in by individuals both together and on their own, at times in conjunction with advanced learning technologies. These methods and techniques challenge current conceptions of SRL as a purely individual process while simultaneously addressing emerging conceptualizations, such as socially shared regulated learning (Molenaar & Järvelä, 2014; Hadwin & Järvelä, 2013). Such data on collaborative, metacognitive and other learning-related processes can inform student groups and help them to improve their future joint activity. This process of data-informed reflection and change can also be thought of as a form of socially shared regulation itself.

In this symposium we bring together a collection of five papers that are exploring the space of connections between CSCL, learning analytics and self-regulation. The researchers will each present their work, articulating the central conceptual, theoretical, methodological, and analytical issues that have arisen. The discussant will address how the papers collectively advance thinking around CSCL, SRL and learning analytics.

Collective and individual discussion analytics: Connecting learning intentions, discourse patterns and responsive action

Alyssa Friend Wise

While advances in the availability of data and methods for processing it present exciting opportunities to provide real-time feedback to students on their collaborative processes, translating a CSCL research program into learning analytics is non-trivial. An additional novel knowledge base is needed to leverage CSCL methods and models to be useful in this context. This paper focuses on a critical set of sociotechnical issues related to the use of CSCL analytics by students and teachers. First, analyses of collaborative learning that are meaningful to researchers are often complex, deeply theoretical and involve epistemological entailments. Thus we need to carefully consider what kinds of analyses are appropriate to share with learners, in what form to present them, and how to support their interpretation. Second, the use of learning analytics is fundamentally a process of sense-making, decision-taking, and action; thus another key area for development and research is into interventions that support metacognitive and self-regulatory processes around collaboration. Such interventions are important to help learners and teachers ask useful, relevant and actionable questions of the data (Verbert et al., 2013) as well as to effectively incorporate the use of the analytics into the flow of collaborative activities. Specifically, pedagogical interventions to support student use of collaborative learning analytics can be framed around the principles of integration, agency, reference frame and dialogue and the processes of grounding, goal-setting, monitoring and reflection (Wise, 2014). The issues of what analytics to share with learners and how to do so are explored in more concrete form below in the context of the E-Listening Project (Wise et al., 2014).

One foundational issue in generating learning analytics for CSCL is to be clear about the epistemological unit of analysis and action. A core feature of CSCL is a focus on the process of interaction and negotiation among the collective *group* (Stahl et al., 2006). In contrast, the field of learning analytics has largely focused on the *individual* (at times within a group) as the "target" for analytic insight and resultant action. This tension can be addressed in several ways. First, analytics can be conducted at the level of the group and then presented back to the group *collectively* to inform their future collaborative activities. In the E-Listening Project a graphical representation of the collective discussion is presented as a "Starburst" that the group can use to monitor whether contributions are receiving replies and if threads are being abandoned or ignored (Wise et al., 2013). Of course, the sense of collective responsibility for the discussion that engenders such activity is something that must be deliberately fostered in the community (Scardamalia & Bereiter, 2006). Second, analytics can be conducted at the level of the group, but used to make claims about particular individuals with respect to the group. A classic example of this is social network learning analytics (Shum & Ferguson, 2012) when one takes an ego-centric rather than whole-network view to make inferences about an individual's position in the network (Haythornthwaite & De Laat, 2010). Finally there may be aspects of CSCL environments that can reasonably be analyzed from an individual perspective. Learners' online listening behaviors (the ways in which they attend to existing comments in asynchronous discussion) are one such construct. Various indices of the depth and breadth of individuals' online listening can be calculated, shown back to individuals, and used to inform the subsequent behaviors. We now move from the question of what analytics to how they can be used.

For learning analytics of CSCL processes to help facilitate productive changes in the ways learners interact, they need to have their use framed as an integral part of the collaborative learning activity tied to goals, expectations and a reflective cycle. *Integration* of analytics refers to creating a clear thread between the goals of collaborative activity, the patterns of interaction that support these goals, and the ways in which the analytics reflect such patterns. This can be done through a process of *grounding* in which the parameters of the collaborative activity are established with students a priori. In the E-Listening project this is done through the presentation of guidelines that describe the purpose of collaborative online discussions and what is expected in terms of broad, deep, integrated and reflective attention to the posts of others (Wise et al., 2013). *Agency* in analytics use refers to getting learners (individually or collectively) to be proactively engaged in managing their own collaborative learning process. From a self-regulated learning perspective students can be supported through cycles of *setting proximate goals* (in the contexts of the larger activity goals described earlier) and then monitoring and evaluating progress towards them through *reflective activity* (Winne & Hadwin, 2010). In the E-Listening project this is done via individual goal-setting/reflection journals and collective meta-discussion about the discussions (Wise et al., 2013). Finally in making sense of and taking action based on analytic information, it is also important to consider the *reference frame* for evaluating discourse patterns (e.g. a theoretical ideal, other individuals / groups, changes from the start of the activity) and create a space for *negotiation* in which decisions about changes to the collaborative interactions become objects of attention themselves.

A script theory of guidance perspective on learning analytics for CSCL

Karsten Stegmann, Carolyn Penstein Rosé, and Jin Mu

Approaches to computer-supported collaborative learning (CSCL) are mainly based on a triad of assumptions: (1) Collaborative learning outperforms (under particular circumstances, e.g. with specific support) other methods when it comes to learning outcomes. Collaborative activities like argumentation (e.g. Clark, D'Angelo, & Menekse, 2009), reciprocal teaching or transactive co-construction (e.g. Molinari et al., 2013) are regarded as effective learning mechanisms. (2) Computer support enables both certain learning activities (e.g. simulation-based inquiry learning; de Jong & van Joolingen, 1998) and more direct support for certain activities (e.g. scaffolds as an inherent, but adaptive, component of the learning environment; cf. Koschmann, 1994). (3) The combination of collaborative learning and technology can have positive interaction effects that go beyond the simple combination of main effects. On the one hand, the quality of collaborative learning processes is lifted through adaptive scaffolds that positively moderate the positive effects of collaborative learning. On the other hand, the effects of technology functions (like access to various resources) on learning outcomes are boosted through collaborative learning (cf. Weinberger et al. 2010).

The Script Theory of Guidance (SToG; Fischer et al., 2013) provides a theoretical account to instructional support of collaborative learning activities. A principle of the SToG is that internal scripts, which are comprised of the four components play, scene, role, and scriptlet, guide collaborative learning behaviors. In CSCL research, the internal scripts (including their components) are usually measured using discourse analysis (e.g., Mu et al. 2013). A further important principle is the *optimal external scripting level principle*. According to the theory, external scripts can guide collaborative activities similar to internal scripts. These external scripts work best, according to the principle, if the external script has an optimal fit with the internal script.

Learning analytics may be used to measure internal scripts to enable adaptive collaboration scripts. The measurement of internal scripts usually requires, however, a sophisticated analysis of collaborative processes. To adapt, for example, an external collaboration script that scaffolds argumentative knowledge construction, the actual quality of single arguments and argumentation sequences might be assessed. Using methods of natural language processing, it is possible to measure internal scripts automatically (cf. Rosé, et al., 2008). The quality of argumentation is, however, highly task and context depended. Therefore, methods of natural language processing struggle if task and/or context of collaborative learning changes.

The ACODEA framework (Mu, et al., 2012) showed that this problem could be overcome in part by using a multi-layer procedure that first pre-processes and normalizes data from discussions with different tasks and contexts. In a first step, meaningful attributes are extracted against the background of a certain task and/or context. To assess the quality of argumentation, for example, theoretical concepts important in this specific discussion need to be identified to extract warrants. All utterances with theoretical concepts will be translated into an unified term (e.g. "concept"). In the second layer, the pre-processed data is segmented. In the third layer, coding of the segments is performed using the pre-processed data instead of raw data. While layer two and three are the regular procedure of analysis discourse data, the main difference proposed in the ACODEA framework is a translation of context and task specific raw data into a general common "language" that partials out the concrete content of discussion. There is some evidence that this proposed procedure works across different contents of discussions (Mu, et al., 2012) as well as for different types of text-based communication (Mu et al., 2014), although adaptation to such contextual differences remains an active area of machine learning research. Against this background, the SToG can be used as theoretical foundation of learning analytics that aim to measure internal scripts of collaborative learners. The ACODEA framework, in addition, provides an approach how internal scripts could be measured using natural language processing despite the fact that discussions take place in different contexts and with different tasks.

Do collaborative groups benefit from a shared regulation tool? Sequential analysis of actualized regulation in social interaction

Jonna Malmberg, Hanna Järvenoja, and Sanna Järvelä

The field of self- and socially shared regulation of learning (SSRL) is increasingly interested in how temporal sequences of events (e.g., activating prior knowledge; constructing task perceptions and goals; using and adapting strategies) emerge in different stages of the learning process (Azevedo, 2014; Bannert & Sonnenberg, 2014; Volet et al. 2011; Molenaar & Chiu, 2014). Examining temporal sequences of events that incorporate phases of regulated learning can increase our understanding of the process in which students engage when learning alone or in groups. Earlier research considering sequential and temporal aspects of regulated learning focused on individual learning, but there is not much research focusing on capturing temporal sequences of regulation in collaborative groups in terms of how group members establish socially shared regulation in authentic group learning situations.

The problem is that group members often fail to recognize the target for SSRL and tend to use superficial strategies (Malmberg et al., 2014). A vast body of technological tools has been developed to support awareness of SSRL, but mostly this has happened at group level in on-line learning settings without giving guidelines of what SSRL strategy to use (Järvelä et al., 2015). Currently, there are no technological tools aiming to explicitly prompt SSRL in face-to-face collaborative learning. This study aims to capture patterns of social interaction through which collaborative groups actualize socially shared regulation. Furthermore, it aims to investigate whether groups benefit from the use of a tool designed to promote strategies for socially shared regulation of learning in face to face collaboration.

Second-year teacher-education students (N = 44, 36 females, 8 males, mean age 25 years) participated in a mathematics didactics course that lasted for two months. The math course comprised seven lectures, each involving a small collaborative group task, and one extensive collaborative course assignment where the groups were supposed to create a midterm plan for primary school dealing with a specific math topic. Both parts of the course were carried out simultaneously during two months in a class-like laboratory space, which made it possible to record all of the collaborative group work with a 360 degree video camera system. The students collaborated in groups of four students resulting in 11 groups. All together the data collection produced 88 hours of video recordings representing 41 videotaped collaborative group work situations. At the beginning of each collaborative learning session, the students used S-REG tool. S-REG is a visual iPad application focusing on group members' awareness of their cognitive, motivational and emotional states. Specifically S-REG promoted a) awareness of SSRL b) explication of SSRL and c) prompting strategies for SSRL.

The analysis of the video recordings proceeded by first identifying segments that included traceable task-focused cognitive and socio-emotional interaction (cf. Rogat & Linnenbrink Garcia, 2011). Second, these social interaction segments were classified to indicate situations that potentially call for individual and social level regulation. That is, the social interaction segments that included cognitive expressions such as disagreement, argumentation and agreement, or emotional or motivational expressions such as irritation, anxiety or lack of motivation were considered to have a possibility to include socially shared regulation of cognition, motivation or emotion. Finally, these selected segments were analyzed in more detail to capture patterns of social interaction through which collaborative groups actualize socially shared regulation.

The analysis of the S-REG tool was conducted in three phases. First, the duration of groups' discussion when using the S-REG tool was measured from each session. Second, the depth of the groups' discussion was rated on a scale from 0 to 1. The group scored 0 if prompts for SSRL were not elaborated and 1 if the prompts of SSRL were elaborated in the group's discussion. A Spearman's correlation coefficient was used to determine whether there is a relationship between the segments including SSRL and the duration and depth of discussion while using the S-REG tool. To capture social interaction patterns through which collaborative groups actualize socially shared regulation State Lag Sequential Analysis (LSA) was conducted. Since the ways groups collaborate is affected by previous experiences, the LSA was conducted only for those segments of the data that involved socially shared regulation of learning. Thus, from those segments each individual turn was coded until the socially shared regulation of learning was actualized.

The results of this study indicate that even though the situation is calling for socially shared regulation, the groups do not always engage in any type of regulation even when it can be considered as a prerequisite for successful collaboration and learning. Also former research has shown evidence indicating that learners do not always optimally regulate their learning process when opportunities arise. There is a clear need to create ways to support groups in their efforts to regulate the learning process together. Former research has shown promising results, when individuals' regulation processes are supported with various technological applications (Johnson et al., 2011). Yet when groups are supported with their SSRL, high performing groups tend to benefit from the support the most (Malmberg et al., 2014). Therefore, it is important to identify whether the S-REG tool can be beneficial for SSRL. It is also important to identify social interaction patterns that have potential to support SSRL and improve the quality and depth of collaborative learning. By recognising such interaction patterns, it is possible not only to promote SSRL via technological tools, but also the interaction patterns that make it happen.

Do learners benefit from socially-regulated learning provided by artificial pedagogical agents? Implications for data analytics in supporting social interactions during complex learning

Roger Azevedo, Nicholas Mudrick, Michelle Taub, Seth A. Martin, and Jesse Farnsworth

Social interactions between humans and artificial pedagogical agents involve a multitude of temporally unfolding self- and other- cognitive, affective, metacognitive, and motivational (CAMM) regulatory processes during learning with advanced learning technologies (Azevedo et al., 2013). However, contemporary trace methodologies and analytical approaches to measuring SRL processes, capturing the real-time deployment of SRL processes (Azevedo & Aleven, 2013; Molenaar & Järvelä, 2014), still pose several challenges that somewhat impede our understanding of the social processes of learning. These challenges include the conceptualization of SRL versus other types of externally-regulated learning (e.g., CoRL, SSRL), embodiment of these different conceptualizations in artificial agents, the temporal alignment of multi-channel data (e.g., affective responses to the artificial agents' prompting and scaffolding, increased arousal based on the complexity of science diagrams, misconceptions revealed during human-artificial agent dialogue, the impact of the external regulation on learners' monitoring of cognitive and affective processes), accuracy of inferences about the impact of artificial agents' social processes on human learning and self-regulatory skills, and determining which multi-channel data (e.g., dialogue moves, utterances, log-files, eye-tracking, physiological indices) should serve as the basis for data analytics to determine the qualitative and quantitative nature of self- and socially shared regulated learning (SSRL). These challenges are fundamental to our community as interdisciplinary researchers in the field of CSCL grapple with (1) the burgeoning landscape of learning theories and models of instruction that focus on social interactions in different authentic contexts (e.g., human–artificial agents and SRL), (2) massive amounts of rich, multi-modal data for data analytics, and (3) the accuracy of inferences about complex social processes stemming from (2). By addressing them, we can make advanced learning technologies more CAMM-sensitive using externally regulating artificial social agents.

Recent advances in the study of self-regulated learning processes as *events* that temporally unfold in real time during learning and problem solving are transforming the fields of metacognition and self-regulated learning. New methods for detecting, tracking, collecting, and analyzing SRL data as events that have specific non-static attributes, such as frequency of use, duration, time-dependent patterns of use, and dynamics, including feedback mechanisms, offer novel ways to examine and understand the role of these processes across learning contexts, age groups, tasks, learning activities, etc. (Azevedo et al. 2010; 2013). These novel methods can reveal important patterns of SRL events, based on the use of various types of multi-modal data (e.g., eye-tracking, facial expression, utterances, conversational turns, log-files), that can significantly enhance our current understanding of the sequential and temporal nature of self- and socially-regulated learning (Azevedo, 2014; Hadwin & Järvelä, 2013; Molenaar & Järvelä, 2014). Therefore, these new methods, despite being exploratory in nature, have the potential to transform current conceptions of SRL by augmenting our models and theories of SRL by delineating micro-level processes (e.g., specific metacognitive processes, such as judgments of learning [JOL]) and contributing to existing theories and models that are either too abstract or focus on macro-level processes (e.g., monitoring), and by generating testable hypotheses based on the types of process data used and the evidenced results (Winne & Azevedo 2014; Zimmerman 2008). The focus of our paper is to present the issues and challenges associated with capturing, analyzing, and inferring CAMM SRL processes during learner-artificial pedagogical agent dialogue during learning with an intelligent tutoring system and the challenges they pose for learning analytics.

A study was conducted using 150 college students who took part in a 2-day experiment with MetaTutor to learn about the human circulatory system. Participants were randomly assigned to either the adaptive or non-adaptive condition. In the adaptive condition, participants were prompted to use several key SRL processes during their learning (e.g., activating relevant prior knowledge, assessing their emerging understanding [JOL], using effective learning strategies) by the pedagogical agents (PAs) embedded in MetaTutor. While those in the non-adaptive condition had the opportunity to engage in these processes, they were not instructed to do so by the PAs. During the 2-hour lesson session with MetaTutor, we collected the following data from each participant:

eye-tracking, video recording of the face (for affect detection and classification), log-files (e.g., quiz results, summaries and metacognitive judgments, learn-agent dialogue), notes and drawings, and physiological data (e.g., electro-dermal activity). We also collected pretest and posttest data and several self-report measures on emotions, motivation, agent likeability and metacognitive knowledge about specific SRL processes. Our results will focus on describing, using multiple-level trace (process) data, participants' self-regulatory behaviors and how they are related to learning outcomes. For example, *micro-level data* provides information on: (1) fluctuations in affective states (e.g., frequencies, duration, and transitions of basic and learning-centered emotions), (2) eye-tracking processes (e.g., fixations and gaze behaviors on specific areas of interest [AOIs] such as the pedagogical agents, SRL palette, multimedia content, learning goals), and (3) log-file data, which details the duration and sequencing of specific behaviors (e.g., frequency and time spent on relevant vs. irrelevant pages and diagrams). *Mid-level data* (1) represents learners' accuracy in making metacognitive judgments (related to calibration and overconfidence in mastery of multimedia content related to a particular learning goal); (2) provides information on the deployment of cognitive and metacognitive processes based on the frequency use of the SRL palette (embedded in the system interface); (3) illustrates their emotion generation and regulation during different sub-goals; (4) provides information on their regulatory processes associated with adaptive (and non-adaptive) changes during the learning session; (5) reveals their knowledge integration across representations of information; (6) exemplifies changes in their self-regulatory processes based on learner-agent dialogue moves; and, (7) provides evidence of how the deployment of CAMM processes is associated with knowledge construction activities (e.g., taking notes, summarizing) and is predictive of quiz scores. *Macro-level data* provides information on changes in students' learning based on their pretest-posttest scores. Data sources and analyses presented in this paper will provide evidence that has the potential to address challenges in learning analytics (e.g., which data, timing of inferences, within- and between- channel aids to understanding SSRL).

Discourse analytics to support persistent participation in MOOCs

Carolyn Penstein Rosé, Miaomiao Wen, and Diyi Yang

Recent research in the field of CSCL has produced technology for automating analysis of collaborative processes in real time (Rosé et al., 2008; Gweon et al., 2013) and using this analysis to trigger in-process support that increased the effectiveness of collaboration and student learning (Kumar & Rosé, 2011; Dyke et al., 2013; Adamson et al., 2014). The time is now ripe address a more challenging problem. With the rise of massive open online courses (MOOCs), we have an opportunity to extend this technology for the purpose of supporting collaborative interactions that could create thriving online learning communities to create a learning experience that increases learner autonomy (Cotteral, 2000), motivation and goal-setting (Pintrich, 2000), as well as self-regulation (Zimmerman, 2008). We are exploring a new form of automated, just-in-time support for effective online learning, powered through analytics applied to data from discussion forum posts.

One great overarching challenge is to create a form of MOOC environment that effectively fosters community connections that provide the type of socially supportive environment to sustain the motivation of students to persist with instruction (Yang et al., 2014a). Even case studies of particularly dedicated MOOC instructors who work hard to keep up with needs as they emerge during the threaded discussions in MOOC environments ultimately discover that support needs far outnumber resources instructors are able to offer (Rosé et al., 2015). In our recent work, machine learning has been used in a MOOC context to identify factors displayed through linguistic choices encoded in MOOC discussion forum posts as a way of identifying students during times when they are particularly vulnerable to dropout. In this way, the hope is that scarce human resources could be channeled to where they are most needed, or augmented with automated forms of just-in-time support, that might enable students to persist in the course through times of elevated vulnerability. In all of this work, we have started with observations of attitudes, orientations, and dispositions that are visible in discussion forum posts and that are associated with learning or persistence in prior literature. We validated hypotheses about what factors would ultimately flag students at risk by utilizing a statistical analysis technique referred to as survival analysis, which has been used to gauge the impact of time variant factors on dropout in other types of online communities (Wang et al., 2013). Survival models are able to quantify the extent to which fluctuations in time variant factors predict relative probability of dropout at specific time points within a user's participation trajectory. Factors we have had success modeling through discourse analytics, which have been validated as significant predictors of dropout using survival modeling include confusion and disinterest (Yang et al., 2014a), motivation and cognitive engagement (Wen et al., 2014a), student attitudes towards course affordances and tools (Wen et al., 2014b), satisfaction with help received, and relationship formation and loss (Yang et al., 2014b). Of all of the factors explored so far, the most dramatic impact on attrition was related to relationship formation and relationship loss in the MOOC discussion forums, even though the students who participate in those forums are known to be among the most highly committed to the course to begin with. In these results we find support for the importance of community, and evidence of the potential positive impact of work towards greater integration in the community, and engagement in joint meaning making towards deeper engagement with the course materials.

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Technology-Enhanced Learning Communities on a Continuum between Ambient to Designed: What Can We Learn by Synthesizing Multiple Research Perspectives?

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Abstract: This symposium brings together the theoretical and practical tools of scientists in both the social and educational sciences in order to examine the types of interaction, knowledge construction, social organization and power structures that: (a) occur spontaneously in technology-enhanced learning communities or (b) can be created by design. We refer to these, respectively, as the study of *ambient*, naturally occurring, environments, and of *designed* environments. We present a set of seven studies that demonstrate the strong potential for the cross-fostering of ideas between educational scientists, who focus on the interventionist design-based study of learning, and social scientists, who focus on the analytic study of ambient social interaction and knowledge construction. Each study demonstrates specific insights regarding lessons that can be learned from the ambient to the designed arena, and vice versa, using lenses that integrate our various disciplinary research perspectives.

Keywords: Technology-enhanced learning, Learning communities, Networked society, Design

The overall focus of this symposium

One of the most significant developments in contemporary education is the shift of research and practice away from the focus on the individual learner to the view that knowing and understanding are anchored in cultural practices within communities. This shift coincides with technological advancements, such as the introduction of the World Wide Web and subsequently Web 2.0 technologies, which reoriented end-user computer interaction from individual work to communication, participation and collaboration. However, while daily interactions are increasingly engulfed in mobile and networked Information and Communication Technologies (ICT), in-school learning interactions are, in comparison, technologically impoverished, creating the phenomenon known as the school-society digital disconnect (Selwyn, 2006).

We can no longer consider “schooling” and “society” as separate entities. Rather, we must bring together the theoretical and practical tools of scientists in both the social and educational sciences in order to examine what types of interaction, knowledge construction, social organization and power structures: (a) occur spontaneously in technology-enhanced learning (TEL) communities or (b) can be created by design of TEL. We refer to these, respectively, as the study of *ambient*, naturally occurring, environments, and of *designed* environments. By adopting a definition of learning as the co-creation of knowledge in TEL communities, and by bringing together a cohort of expertise within the fields of education and the social sciences (i.e., education, learning sciences, communication, health and social welfare, knowledge management, information sciences, law, and instructional design), the Learning in a NetworKed Society (LINKS) Center seeks to study the continuum between the ambient and the designed arenas (LINKS, 2013).

In this symposium, we present a set of seven studies that are conducted as part the LINKS Center, which explore learning in various settings on the continuum between ambient and designed technology-enhanced environments (Figure 1). Each study demonstrates a particular aspect of learning and highlights a specific insight regarding what can be learned from the ambient to the designed arenas, and vice versa, using lenses that integrate various disciplinary research perspectives.

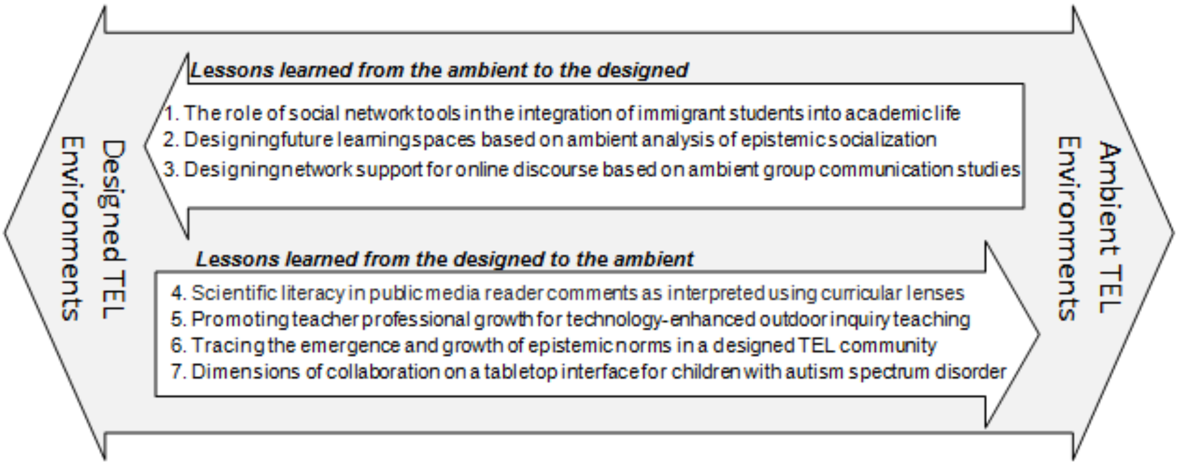

Figure 1. The studies of this symposium on an ambient-designed TEL communities continuum

The symposium will be carried out as a structured poster session, starting with a rationale and background presented by the organizers (10 minutes), then brief introductions from each of the poster presenters (15 minutes), followed by concurrent poster interactions (30 minutes), remarks from the discussant, Christopher Hoadley (15 minutes), and finally, a discussion with the audience facilitated and summarized by the chair, Paul Kirschner (20 minutes).

Theoretical background

The turn to community and communication in education and technology

Several sociocultural theoretical frameworks have been developed to describe learning as active participation in a community. Communities of practice (Wenger, 1998), communities of learners (Rogoff, 1994), and knowledge-building communities (Scardamalia & Bereiter, 1994) are three frameworks that have considerably influenced the learning sciences research and educational practice. Though they have some nuanced distinctions, they share three fundamental tenets: Activity, Participation and Enculturation. The active nature of learning is embodied in students' participation in negotiating meanings, developing understanding, evaluating, and orchestrating their own learning in collaborative environments. These forms of participation are, in turn, viewed as processes of enculturation: students assume increasingly central roles in the community, and immerse themselves within a culture of learning through which they acquire competence in language, social practices, rituals, and values.

Interestingly, this shift in education coincides with technological advancements, such as the introduction of the World Wide Web and subsequently Web 2.0 technologies, which reoriented end-user computer interaction from individual work to communication, contribution and collaboration. Thus, there appear to be concomitant and complementary changes in pedagogy and technology. Several technological innovations have been designed to enhance learning processes in communities to streamline particular activities and function as partners in thinking and as agents of enculturation. For example, dynamic visualization tools (Kali, Linn & Roseman, 2008) provide participants with a shared focal point for the explicit external visual display of information, enabling them to visually inspect, comment on, and modify each other's ideas vis-à-vis these representations. Furthermore, some of these tools reflect the ways in which experts conceptualize, visualize and represent knowledge in their disciplines. These specialized tools can guide learners' interactions in accordance with the norms of the discipline (Tabak & Reiser, 2008), and serve as agents of enculturation.

Blurring school-society boundaries to overcome disconnects and divides

Despite the strong educational potential, and the increasing presence of ICT in formal and non-formal educational environments, there is little evidence of an overall positive effect of the use of ICT on the quality of learning. Technologies in education tend to sustain rather than challenge traditional pedagogical approaches. A number of methods have been adopted to address this limitation, including studies devoted to scaling-up of educational innovations (Roschelle, Tatar, & Kaput, 2008), engaging in participatory design with schools (e.g., Penuel, Roschelle, & Shechtman, 2007), and in forming research-practice partnerships (Kali et al., 2008). At the risk of oversimplification, we suggest that these approaches share a focus on disseminating learning environments that were designed from a school-centered approach.

We are proposing a new tack—partnership between scientists in the field of the social sciences and in education to create a productive synergy between the study of ambient and designed technology-enhanced communities. Educational science has much to offer on the ways in which representations and participant structures can effectively advance specific learning goals. However, this understanding is mostly applicable to the existing structures of schooling with rather rigid, hierarchical definitions of student and teacher roles.

In contrast, social scientists examine the ways in which people adopt these technologies in their daily lives. They primarily take an analytic stance and study, without explicit intervention, the numerous virtual communities that interact using social networking platforms (e.g., Facebook, Twitter), or Web 2.0 platforms (e.g., Wikis, Blogs) without any overt educational intention. In this way, social scientists can offer important insights into the means by which "crowds" can self-organize in pursuit of shared information-based goals, building on ideas such as Schelling's (1978) classical notion that micro-motives of individuals create macro-behaviors in a society. Network analysis techniques enable characterization of the structure of communities in technology-enhanced endeavors such as Wikipedia or YouTube. Other advances in the study of social networks have uncovered how these entities are characterized by power law distributions (Barabasi & Albert, 1999), rather than the more familiar normal distributions. This, in turn, raises questions about the nature of expertise, access and equality, and about whether there is room for more intervention in order to address these new sources of potential inequity. Studies of online communities in the social sciences can further help us understand the inherent motivation to engage in social media, and the impact that this has on identity and social well-being (Elias & Lemish, 2009).

The understanding that the social scientists glean from the study of ambient technology-enhanced communities is a powerful force in directing our attention to learning that may occur incidentally within online communities, offering new interpretations of learner interactions, and inspiring new ways of conceiving of designed learning environments. At the same time, educational research offers important new directions for social science research. In particular, it provides theoretical frameworks and methodological approaches for fine-grained analysis of the development of specific knowledge structures. In addition, social scientists may be motivated to a more interventionist stance to enhance the study of equality and digital divides. Despite the strong potential for the cross fostering of ideas between the educational and social sciences, a key question is whether educational scientists, who focus on the interventionist design-based study of learning, and social scientists, who focus on the analytic study of ambient social interaction and knowledge construction, can engage in a productive collaboration. We believe that the answer lies in adopting a shared focal point for our collaborative research lens.

Co-creation of knowledge: Bridging school-society, educational-social sciences

We focus our collaborative investigative lens on the notion of co-creation of knowledge (Lewis, Pea, & Rosen, 2010). This reconceptualizes learning from a school-based, individual acquisition of knowledge and skills to an ongoing process of the production of knowledge through joint activity. This also repositions the study of ICT from a dichotomy of "educational" versus "generic" tools, to a streamlined study of the role of technology in the co-creation of knowledge across the various contexts that comprise an information-based networked society.

In adopting co-creation of knowledge as our focus, rather than the conventional view of learning as an activity accomplished in schools (and other intentional, circumscribed environments), we view it as an endeavor that occurs throughout the day and across the lifespan; people continually engage in collaborative activities within different communities and for a variety of purposes. In some cases, knowledge goals may be more clearly specified and directed, and in other cases they may be more loosely defined and emergent. For example, in a secondary mathematics classroom, students and teachers annotating a digital textbook may have the specific, institutionally-specified goal of achieving a basic understanding of the nature of mathematical functions; but these same students, later in the day, while communicating with other youths and adults throughout the world about methods for determining the top achieving players on a Massively Multiplayer Online Role-Playing Game (MMORPG), may derive shared insights concerning statistical analysis techniques, without having this as a pre-specified, intentional educational goal.

Adopting the same lens to understand the processes in both education and social sciences highlights the research prospects that lie beyond the artificial pitfalls and blind spots that may have constrained past studies of ambient and designed learning environments. More importantly, it diminishes the boundaries between schooling and society, opening the door for extended conceptual frameworks that can help minimize the school-society digital divide, and better equip citizens for lifelong learning in an information-based networked society. In the following sections we describe seven LINKS studies that illustrate how education and social sciences complement each other, and how the ambient-designed continuum can contribute to our understanding of learning in technology-enhanced communities.

The role of social network tools in the integration of immigrant students into academic life

Meital Amzalag, Nelly Elias, and Yael Kali

Students of Ethiopian origin belong to one of the weakest and poorest groups in the Jewish population of Israel. These students face social and cultural gaps in addition to economic hardships and racist stereotypes. The present study seeks to examine whether social media, and specifically social network groups, used by students to communicate course issues, could provide social, cultural and educational resources for their integration in the Israeli higher education system.

This poster represents part of a larger research project, which will gradually progress from no intervention at all, i.e., examining spontaneous processes in the *ambient* arena, through a series of minimal intervention stages *designed* to take advantage of the social media to support these students' integration processes. As such, the first stage of the research consisted of observation of the learning processes as they occurred spontaneously, while in the second stage students were told about other courses where students have established their own social network group to communicate course issues. Through this second stage, we examined (a) who were the students who became members of the Facebook study group; and (b) how students of Ethiopian origin have participated in that group, as compared to students from the majority group. The findings are based on a survey of 136 students from the majority group and 36 students of Ethiopian origin, and an analysis of 28 posts from the Facebook study group opened by students.

A significant digital divide was found in the spontaneous stage between students of Ethiopian origin and students from the majority group, which was reflected in their lower usage of internet in general, and of study groups in particular. Students of Ethiopian origin were not aware of the advantages of internet resources for advancing their academic goals and social integration. Findings from the second stage indicate that these students' pattern of participation in the study group was peripheral and limited to passive observation.

Lessons learned from the ambient to the designed arena: The minimal progression from the totally spontaneous setting towards the designed study enabled the examination of patterns of participation by students of Ethiopian origin in online social media. Next stages will use a design-based research methodology to explore means for supporting the integration of students of Ethiopian origin in the Israeli higher education system.

Designing future learning spaces based on ambient analysis of epistemic socialization

Uzi Brami and Iris Tabak

In this poster, we draw on an ambient setting analysis to present an initial design framework for the support of epistemic socialization in history in a future learning space (FLS). Epistemic socialization is the process through which classroom interactions influence learners' views about knowledge in the domain of study (Tabak & Weinstock, 2008). A case study of the epistemic socialization in a university introductory history course (Brami, in preparation) revealed continuities and discontinuities between views of historical knowledge and classroom practices. We use these to identify practices that advance or hinder mature views of historical knowledge.

One example is the continuity between views of history and note taking practices. Nascent views consider written accounts of the past to be certain, while mature views consider these historiographies as possible justified versions of the past (Wineburg, 1991). Students in the course used shared "master notes" of a classmate. Students with nascent views perceived these notes as an account of the class lectures as well as an account of the past, and considered their accurate transfer to the exam a formula for success. It seems that nascent learners view the past, historiographies, the lecture and "master notes" as versions of the same canonical text. Thus, reframing the class notes from a canonical to a contestable text could pave the way to viewing historiographies as such. Changing note taking practices from an exclusively learner activity to a joint teacher-learner activity can create a third space where note taking is guided, subject to debate, and is part of the formal script of the classroom. Note taking and other practices of learners who held more mature views, and literature on learning in history, inform the design of tools that structure and support the process of analysis, critique and corroboration. The shared notes will be displayed on the FLS wall mounted computer screens. We will study the role of features such as the prominence and omnipresence of these displays in epistemic socialization. The poster presents the main findings from the case study and an initial design framework for an FLS-based curriculum in history.

Lessons learned from the ambient to the designed arena: This poster draws on an *ambient* setting analysis to present a *design* framework for supporting epistemic socialization in FLS-based history curriculum.

Designing network support for online discourse based on ambient group communication studies

Carmel Kent, Esther Laslo, Sheizaf Rafaeli, and Ayelet Baram-Tsabari

Asynchronous online discussions are commonly used to support collaborative learning in both fully online and blended higher education courses. While online discussion holds a promise for learning and collaborative knowledge building, there remains a challenge. The opportunity to share ideas, learn from peers, and build knowledge collectively in virtual settings is the promise. Yet, in practice, online discussions often do not meet engagement expectations. Contributions are frequently disjointed or not responsive, and discussions may become shallow and incoherent.

This poster represents a synergistic study that combines educational psychology and learning sciences theoretical roots of socio-constructivism and collaborative knowledge building, with theories and frameworks from the field of knowledge management and information sciences, such as perceptions on group communication and interactivity (Rafaeli, 1988). With this joint research lens, we propose a focus on shared and dynamic construction of knowledge during a discussion, using semantic network structures for the discussion instead of the classic thread-based discussion structure. For this purpose we developed Ligilo, a peer learning online platform for networked based discussions. Ligilo enables learning communities to create collective concept maps through discussions. Ligilo provides a hyperlinked learning environment, where the relations between content items are generated collaboratively and connections are made explicit.

The system was used during 2014-15 in several academic institutions and study groups in different settings. Field studies were conducted to evaluate the learning afforded by the semantic networked online discussion forums. Initial research insights shed light on the process of collaborative knowledge building, and the new roles of learners and teachers in learning communities. For instance, initial evidence shows that interactivity level was directly affected by the structure of the discussion, the request to relate new contributions to other students' contributions, and to explicitly tag those relations. Additionally, teachers used Ligilo's tools to manage (or delegate management of) the discussion towards their instructional goals, thus shifting their pedagogies into more learner-centered, rather than teacher-centered approaches.

Lessons learned from the ambient to the designed arena: Building on a theoretical framework that was developed by studying *ambient* computer mediated communication (Rafaeli, 1988), this research developed an innovative TEL environment to support online discourse in a *designed* setting. The lessons learned from the ambient to the designed arena include qualitative insights regarding interest, argumentation and knowledge types, as well as quantitative measurement of metrics regarding outcomes, learning behavior, sharing and interactivity at the community and individual levels of learning.

Scientific literacy in public media reader comments as interpreted using curricular lenses

Esther Laslo and Ayelet Baram-Tsabari

Education for informed citizenship, knowledge-based decision-making, and application of scientific ways of thinking to everyday life are the main goals of the science literacy movement (Ryder, 2001). In today's networked society the internet is the public's primary source of science and technology related information. Social media is ever more prominent in this landscape as a provider of both science-related information and opinions, and as enabler of bottom-up engagement with and deliberation on science-related issues.

This poster presents a study in which expressions of scientific literacy in reader comments in a leading online news site (Ynet.co.il) were sought. Specifically, over a thousand reader comments to articles on animal experimentation and on climate change were analyzed. Based on the definitions above, we view this online reader comments infrastructure as an ambient TEL environment. The contents of the items in this ambient environment were studied using an analytical framework based on a designed learning context - the school science curriculum. The curriculum was chosen as an analytical lens in order to describe how the aims of school science (embodied by the curriculum) are echoed in an authentic public engagement with science setting and its real-world suitability as a provider of scientific literacy. For this reason, the formal Israeli biology curriculum's definition of scientific literacy was adopted, encompassing scientific knowledge, perceptions of the nature of science, scientific skills and structuring an informed position.

Our findings show that over half of the scientific concepts used by the commentators are at the high school or academic level, in which science is elective. This means that even if all the people taking part in the discussion took elective science (an unlikely assumption considering the percentage of those choosing to study science) than in order to take part in the discussion or follow it passively as readers, members of the public need to learn many new science concepts independently—probably from the media. We also found that expressions of scientific literacy do not necessarily go hand-in-hand with the scientific consensus. Many times scientific knowledge is used to support different individual beliefs which are at opposition with the scientific consensus.

Lessons learned from the designed to the ambient arena: The environment investigated is an authentic example of lifelong learning and the application of science literacy to everyday lives of the wide public. Methodologically, it demonstrates how lessons learned from the *designed* arena (the conceptualization and operalization of science literacy in formal science curricula) may be used to explore authentic processes in an *ambient* environment such as reader comments in public online media.

Promoting teacher professional growth for technology-enhanced outdoor inquiry teaching

Keren S. Levy, Yael Kali and Tali Tal

Inquiry in the outdoors may promote cognitive, emotional, and social aspects of science learning, however, teachers face various challenges while implementing this approach. Mobile technologies may provide some solutions, yet teachers need support in developing the knowledge and skills required to successfully integrate these technologies in their teaching.

This poster presents a unique professional development (PD) program that applies a "Teachers-as-Designers" (TaD) approach (Voogt, McKenney & Kali 2014), in which teachers are engaged in collaborative design of learning materials. Our intervention involved 24 teachers of environmental sciences, who used a TEL environment we designed, which integrates mobile applications to support outdoor inquiry. As part of the program, teachers worked in collaborative teams to design a similar learning environment for their students, by customizing a replica of the environment they used as learners. The study examined the potential of the TaD approach to contribute to teacher professional growth, with a specific focus on the integration of technology in outdoor inquiry teaching. Data sources included: observations in the PD program, quantitative measures regarding teachers' activity in the team websites, and interviews with nine teachers.

In order to follow teacher professional growth, data were analyzed using the Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002). Findings indicate that all teachers developed their knowledge and ways of thinking regarding the integration of technology in their teaching, and some demonstrated professional growth as reflected in long-term changes in their classroom practice (referred to as growth networks in Clarke and Hollingsworth framework). For instance, changes in teachers' practice (reflected in the design of the websites during the PD), led to changes in their personal domain (e.g., higher self-confidence), which further led to long-term changes in their school practice (integration of collaborative documents to enhance collaborative learning) months after the PD ended.

Lessons learned from the designed to the ambient arena: This poster demonstrates how the use of a theoretical framework of professional growth can track the change sequences in teachers' learning from their experiences in the *designed* environment (during the PD) to their continued learning and practice in the *ambient* environment (in their school practice, long after the intervention was over).

Tracing the emergence and growth of epistemic norms in a designed TEL community

Sarit Barzilai, Dani Ben-Zvi, and Oshra Duek

Epistemic cognition research has highlighted the importance of epistemic standards for evaluating achievement of epistemic ends (Chinn et al., 2014). This poster illustrates how two different research perspectives – epistemic cognition and learning community research – can jointly contribute to the conceptualization and examination of the ways epistemic norms emerge and grow in a learning community. With this dual perspective, we define epistemic norms as socially negotiated standards of what counts as knowledge within the community and of acceptable epistemic practices of constructing, justifying, and communicating knowledge. We argue that emergence and growth of epistemic norms is an essential part of the formation of learning communities and is critical for achievement of their aims. The specific objectives that guide the current project are: (1) to identify and characterize the epistemic norms; and (2) to trace the emergence and growth of these norms.

This research is set within an innovative, graduate level course that is designed as a technology-enhanced classroom learning community. The characteristics of this learning community include emergent-design, process-content integration, reflective discourse, dialogic-humanistic approach, and use of a Wiki collaborative editing environment. Thus this learning community has an overall design, yet, within this design, both members and moderators take part in shaping emergent epistemic norms as well as shaping the technological and social infrastructures which support these norms. These emergent practices are viewed as ambient within the designed environment. To provide multiple perspectives on the epistemic norms within this setting, this research traces the micro-development of both individuals and the group throughout a semester of study over several years.

To illustrate our approach we report on one epistemic norm identified in our data. This norm maintains that the knowledge created by community members, individually and collaboratively, has a tentative and evolving nature and hence community products can be continually developed. The norm was first introduced in the community by the moderators by explicitly stating that course products can be shared in draft form and repeatedly reworked and was supported by the Wiki technology which enables co-editing of the community website. However, the uptake, re-interpretation, and negotiation of the norm, originally introduced by the moderators, continued throughout the semester as community members struggled with accepting the change in knowledge construction and sharing standards and strove to define and communicate the new norm.

Lessons learned from the designed to the ambient arena: This study examines how both the designed and ambient practices of a learning community jointly contribute to the negotiation and formation of epistemic norms. Examination of epistemic standards through a learning community lens sheds light on the social processes by which epistemic standards arise and attain a normative status, and also elucidates a key component in the development of learning communities.

Dimensions of collaboration on a tabletop interface for children with autism spectrum disorder

Patrice L. (Tamar) Weiss *(Joint work with M. Zancanaro, E. Gal, N. Bauminger and S. Eden)*

Autism spectrum disorder (ASD) is a pervasive developmental disorder which involves deficits in social relationships, communication impairments, repetitive behaviors and restricted interests. Recently, intervention studies to treat the social deficit of children with high functioning ASD (mainly without the use of technology) have adapted techniques of cognitive behavioral therapy (CBT) to help these children engage in more effective interactions with peers as well as to enhance their socio-cognitive understanding of social constructs and processes (e.g., Beaumont & Sofronoff, 2008).

This poster represents a combination of two very different fields of research, namely CBT and CSCL. Specifically, CBT principles and techniques (e.g., problem solving, concept clarification, role play and feedback and behavioral rehearsals), were translated into a CSCL environment -- computer-mediated games to teach the understanding of collaboration through actions and conversation as well as to facilitate children's social engagement with peers while implementing collaborative behaviors during shared actions and conversations. The Join-In Suite, a 3-user touch-based application was implemented via the DiamondTouch mutli-user touch table (Weiss, et al., 2011). The Join-In Suite uses the multi-user capabilities of this device to foster collaboration between pairs of children and to provide ways for a teacher or a therapist to control the pace and process of the educational or therapeutic interaction. The design of the application explored different types of collaborative interaction patterns in a multi-user context: Joint Performance where collaboration is the performance of an action together; Sharing: where collaboration is the sharing of personal resources to achieve a common objective; and Mutual Planning where collaboration is the elaboration and performance of a joint plan. The capability of a multi-user device to recognize the actions of different users allows actualization of these dimensions by embedding them in the operations of the interface. For example, if a play piece is assigned to one child, the other child cannot move it; in order to obtain a successful result they have to play in a collaborative way (in this case, via the sharing dimension).

Lessons learned from the designed to the ambient arena: Field testing has demonstrated that the Join-In Suite appears to have found a delicate balance between the world of gaming (e.g., motivation, excitement, feedback) and the world of therapeutic intervention (e.g., control, empowerment). This balance in the *designed* environment, can assist children with high functioning ASD to develop the cognitive understanding of the social constructs, and ultimately, to more adaptive interpersonal functioning in the real (*ambient*) world.

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A Multimodal Approach to the Analysis of Complex Collaborative Learning Environments: Using Complementary Methods of Analysis to Synthesize New Trends in Scaffolding Research

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Abstract: Synthesis research is a method utilized in the field of ecology, and involves bringing together experts in different areas to address a research question that cannot be entirely answered by a single perspective. This symposium explores the application of this model to the learning sciences, specifically to scaffolding of computer supported collaborative learning. The symposium brings together expert researchers (working on different, related perspectives of scaffolding) to discuss their analysis of processes of learning in relation to discursive psychology and gesture analysis; conversation analysis; and multimodal interaction analysis. Each presenter will analyze and discuss the same corpus of data. These streams of data analysis are then brought together in the fourth presentation, with a discussion of visualizing and synthesizing the findings, piecing together an elaborated understanding of scaffolding. The final presentation includes the whole panel and addresses some of the challenges of conducting research this way in the learning sciences.

Introduction

As CSCL interventions become more integrated, and the availability, and sharing, of 'big data' more commonplace, the need for frameworks to make sense of the data from complex collaborative learning environments is evident. The overall focus of the symposium is to contribute to the discussion about the design of methods for analyzing and assessing collaborative learning. Synthesis research has been adopted in ecology in response to similar circumstances to those facing the learning sciences: (1) a sudden increase in available data, (2) a search for coherence, (3) an interest in applying the data for management of resources, (4) the complexity of the challenges faced, and (5) the need to train new scientists to solve these problems (Kemp & Boynton, 2011). Used for almost twenty years, synthesis research has contributed to some of the most influential studies in areas such as climate change and river ecology and management (Kemp & Boynton, 2011). Synthesis research is inherently interdisciplinary, as experts from different fields come together, bringing their data and perspective, to develop a new explanatory model that accounts for how diverse observations work together (Kemp & Boynton, 2011). The synthesis approach is aligned with the multidisciplinary perspective of the CSCL paradigm (see Stahl, Koschmann & Suthers, 2013; Koschmann, 2008), as well as other studies adopting multi-perspective data analysis (e.g. Stahl, 2014; Stahl, Jeong, Ludvigsen, Sawyer & Suthers, 2013). It is this focus on developing a new model to explain observed patterns, developed from the analysis of multiple data sets, that distinguishes synthesis from other approaches that attempt to align findings. Synthesis can be seen as both a challenge and an opportunity to create new understandings of existing problems (Kemp & Boynton, 2011).

Scaffolding was identified as an area in the CSCL community with a long history of work, and one in which many perspectives have been considered, but usually not coordinated. One issue with research on the processes of learning is the lack of a framework in which to place the results of the research (Goodyear, Jones & Thompson, 2013). This is particularly important given our focus on the application of the synthesis approach. Carvalho & Goodyear's (2014) framework for the analysis of complex learning environments formed the basis for our study in two principal ways. First, the framework provides the structure for the design of the study, where different scaffolds are offered to three groups of learners, as they complete the same educational design task. Second, the framework provides the basis for synthesizing the multiple streams of data collected and analyses conducted. The framework suggests that in complex learning environments, there are elements that can be designed (set, epistemic, social, discussed in more detail below) and some that cannot (the learners' activity).

Three groups of postgraduate students were brought together to discuss the design of an educational resource about a socio-environmental issue. Learning by design has been used previously as an example of a complex learning scenario in which multiple scaffolds would be needed (Tabak, 2004). Participants were asked to design an educational blog about a complex socio-environmental system in Australia. They were expected to access multiple websites (resources) to explore the given problem and design a potential solution (e.g. education resources to address the large number of stakeholder groups). After 60 minutes participants were expected to produce a short statement with ideas for their design concept, and after a further 30 minutes, they were expected to produce a sketch or brief outline of their design solution, which they then presented to two of the researchers.

A group of twelve researchers (from Australia, Spain, Indonesia, Germany, France and USA) have adopted six different perspectives to analyse a complex dataset, which included video, audio, transcripts, and the physical artifacts produced by participants. The group collaborated on the design of the project, and collection and extraction of the data. Each sub-group analysed the data according to their methodological perspective (orchestration, multimodal interaction analysis, conversational turns, process mining, conversation analysis and discursive psychology and gesture), and then the synthesis step was performed as a group. Previous work, particularly in the field of multivocality (Suthers, et al., 2011) has been at the forefront of the application of combinations of methods of analysis. This symposium is the first to explicitly take the synthesis model, apply it to multiple streams of data collected specifically to examine the interplay of task, technology and social interactions, and use the tools developed for the field of multivocality, with experts in a variety of fields. In this symposium, presenters will apply frameworks for Discursive Psychology and Gestures (Hepburn & Wiggins, 2005), Conversation Analysis (Sacks, 1992) and Multimodal Interaction Analysis (Norris, 2004) to describe the co-configuration and co-creation behaviour of learners. The first presentation (Thompson & Carvalho) provides detailed background to the theoretical and analytical underpinnings of the project. Presentations 2 (Evans), 3 (Khoserhonejad, Reimann & Aditomo), and 4 (Wardak, Thompson, Carvalho & Goodyear) focus on individual perspectives. They discuss existing work that has led them to form particular assumptions about the role of scaffolding in their area of expertise, as it relates to the behaviour of learners. Each then outlines the methods used to analyse the dataset collected as part of this study. The fifth presentation (Thompson, Carvalho & Dyke) will include visualizations of the multiple streams of data using Tatiana, as well as a conceptual analysis of the combination of three methods and perspectives of analysis. The final presentation will include the whole project team to discuss the implications of doing research using the synthesis approach. While these presentations are all related, this symposium is of interest beyond the immediate reporting of results. As datasets become more complex, and more easily shared, a framework with which to understand the results is necessary. A discussion of the practical realities of team science in relation to the demonstration of real, theoretical findings, should be of interest to the CSCL community.

Background and framework

Kate Thompson and Lucila Carvalho

Scaffolding is an issue that is of particular importance in computer supported collaborative learning, and one that is in constant discussion in conferences and journals. Most current research agrees that students need to be scaffolded in their collaborative activities (Maloney & Simon, 2006; Hmelo-Silver, 2013; Nivala, Saljo, Rystedt, Knronqvist & Lehtinen, 2012). The concept of scaffolding involves providing support to learners in various ways, as these learners undertake complex or difficult learning tasks (Wood, Burner & Ross, 1976). Many studies have focused on scaffolding, and these could be classified under one or more of the three areas of Carvalho & Goodyear's (2014) framework: set design, epistemic design or social design. Technology scaffolding (set design) can include information about how to use a tool for the learning activity (see Davis & Linn, 2000). The context in which the learning experience occurs is of relevance when considering scaffolding. The Ecology of Resources Approach (Luckin, 2010) emerged in recent years as a learner-centred framework for the use of technology to scaffold learning. Collaboration scripts have often been used to scaffold the social processes of collaborative learning, such as Hogan & Pressley, 1997. Recent work on scaffolding has focused on combining scaffolds, and identifying scaffolding synergy such as technology- and social-focused in language learning in Singapore (Chen, Looi, & Wen, 2011), or social- and epistemic-focused collaboration scripts (El-Rifai, Kollar & Fischer, 2011). By using complementary scaffolds, multiple potential blocks to student learning were overcome. Tabak (2004) was the first to refer to 'scaffolding synergy' while exploring the notion that multiple scaffolds that address the same learning need, in different ways, produce a robust support for learners.

What is lacking in the field of scaffolding is an examination of differences in the *processes* of learning as a result of specific scaffolds, and in the field of process analysis, a framework in which to place methods and analysis. The synthesis approach to analyzing complex collaborative environments presented in this symposium achieves these, and in doing so, will contribute to a deeper understanding of the processes of learning in complex learning environments. Kemp & Boynton (2011) identify five steps in synthesis research: problem identification; data assembly; data integration; explanatory model development; and testing model validity.

The authors purposefully designed a study in order to explore the application of a synthesis model of research to the topic of scaffolding in computer supported collaborative learning, underpinned by an analytical framework proposed by Carvalho and Goodyear (2014). The framework is concerned with how the relationships between the different elements in what has been designed/set in place in a given learning environment, combine to support the activity that ensues, the focus here being on how structure supports function. The framework proposes the examination of complex learning environments under four analytical dimensions: *set design*, *social design, epistemic design* and *co-creation and co-configuration activities*. Set design relates to the material and/or digital elements - the tools, resources, artefacts and affordances of place - that compose the setting for the activity of learners. Epistemic design relates to the proposed learning tasks, for example, their structuring, sequencing, pacing and the way tasks are planned to happen. The social design relates to social arrangements and roles, divisions of labour or who is expected to do what. The fourth dimension, the co-creation and co-configuration activities, relates the above components to learners' activities, acknowledging that learners re-arrange and reconfigure the designed learning space, proposed tasks and social roles.

The data collection was carried out in the Design Studio at the University of Sydney. This dedicated space for researching the processes of design gives participants access to tools (digital and physical) to aid in the process of design. The space is also equipped with multiple video and digital cameras, audio recorders, and the ability to capture log files of computer-based interaction. Three groups of three postgraduate students completed the task: Group 1 (Tools) - scaffold tool use; Group 2 (Design Process) – scaffold the design process; and Group 3 (Social) – scaffold (multidisciplinary design team (roles). We recorded the actions (physical and digital), conversation, and collected artefacts produced during the study. The data collected has been analysed from six perspectives: orchestration; multimodal interaction analysis (MIA) of the role of inscriptions; analysis of collaborative design behavior through conversational turns; conversation analysis (CA) and the impact of positioning in social interactions; process mining – decision-making and the design process; and discursive psychology and gesture. Three will be presented in the symposium: DP and gesture; CA and the impact of positioning in social interactions; and MIA of the role of inscriptions. These three were chosen because of the potential overlaps that will be examined – both DP and MIA examine the role of gesture, and CA and MIA examine key moments of negotiation, but with different focus and purpose to the analysis. In addition, these three approaches address the three designable elements – the tool use, epistemic and social interactions. Examining how they come together, and discovering what this tells us about the way we understand the role of scaffolding of complex collaborative learning environments, will lead us to develop a new explanatory model.

Analysis of scaffolding using a discursive psychology approach

Michael A. Evans and Lixiao Huang

In this presentation, we describe and characterize scaffolding through interactions among participants, analyzing video data from collaborative learning efforts. We are interested not only in learning outcomes from collaborative activity, but also in how the approaches used by learners influenced the ways in which collaborators made meaning of the project and engaged in the design process. To understand the role that talk plays in guiding learning, we employ a discursive psychology (DP) approach (Hepburn & Wiggins, 2005). DP is deemed a valuable framework as it assists us to understand how elicitation strategies of scaffolding influence the ways participants discursively construct understandings guided by the design process.

DP differs from other psychological analyses in that the focus is not centrally on psychological processes in a decontextualized form, but more on the ways that those processes are represented contextually in social interactions. DP explores socially situated and embodied forms of talk to understand psychological constructs like emotion (Hepburn, 2004) cognition (Molder & Potter, 2005) and beliefs (Barwell, 2005). As a primary advocate, Potter (2004) defines four ways in which DP can be used: 1) it assists analysts to better understand institutional practices; 2) it assists us to uncover the construction and meaning of "facts"; 3) it allows for the re-specification of cognitive constructs; and 4) it allows for the exploration of ideology and assumptions. DP frameworks identify discourse as "a type of action or work through which the social field of interaction itself is constituted" (Freisen, 2009, p.133). Discourse is action-oriented, socially constructed, and situated, such that cognitive constructs are embedded in and expressed through talk and action (Potter, 2005). In using a DP perspective we see social interactions as a means of taking "discourse and its pragmatic realization for the purpose at hand as topics rather than language and linguistic structure per se" (Roth, 2008, p 46.). That is, discourse is viewed as a form of social action, rather than simply a means of sharing or outputting information.

While cognitive science has for many years recognized thinking as situated within a social environment (Lave, 1988), and as culturally mediated (Vygotsky, 1978), thinking and learning are still often described in terms of extrapolating mental processes. Rather than "assuming an underlying explanation for why people say or think as they do, DP assumes that mental states, motives, and thoughts are all features that are situated in and made visible through interaction (e.g., verbal and nonverbal communication)" (Lester, 2011, p.4). We used DP as a lens for understanding how scaffolding influences talk and helps to construct ideas about design. Our challenge is to characterize indicators of engagement through the talk and actions of participants, and to understand how the prompts provided by tools, context, and social support influence that engagement. Hsu & Roth (2008) explore science conceptions and motivation through a DP framework. They analyze interviews to understand youth's future career interests, but rather than analyzing what jobs are talked about, they focus on how language is used in the interview. In doing so, they discern how participants make consensus, revise their perspectives, and differentiate cognitive and affective processes. In a separate study, Roth (2007) outlines the ways that scientific conceptions are formed through talk, rather than simply being expressed by talk. He notes that the formulation of conceptions is filled with "mumbles, stumbles, malapropisms, pauses, stupidities, and solecisms" (p 36), all of which are important components of the discourse that are often overlooked. In addition to the verbal interactions, we applied a scheme for describing gesture and physical position of objects to capture the interactions among tools, scaffolds, and social support. Notation for physical interactions includes position of learners (who is in physical contact with it and for what duration) position and movement. Gestures included movements that indicate a directive (e.g. pointing), or describing a concept (e.g. lifting hands to show air flow).

Conversation analysis and the impact of position on social interactions

Maryam Khosronejad, Peter Reimann, and Anindito Aditomo

In this presentation we apply conversation analysis (CA), informed by positioning theory, in order to take an in-depth look at the interactional talk during the design session. Conversation analysis was developed by Harvey Sacks, Emanuel Schegloff, and Gail Jefferson (1974; Sacks, 1992) as a method for the study of conversation, focusing on understanding the regularities of talk-in-interaction applied by participants in conversations. We applied these ideas in the analysis of design group work, seeing such work as the interactional accomplishment of collective action. In our analysis, we focus on solution development of a design process, as a communicative activity and as an ongoing joint interactional achievement of the participants involved (Heritage, 1984). Conversation analysis allows us to investigate how transitions between different phases of solution development are accomplished at the micro level of talk. Our analysis focuses on different phases of solution development, such as solution analysis, solution suggestion, elaboration, evaluation, confirmation/disagreement and implementation (as suggested by the Decision Function Coding Scheme or DFCS, Poole & Holmes, 1995). In addition, we studied how alternative solutions were introduced and followed up through conversational patterns.

Conducting CA through the lenses of positioning theory, we also investigated participants' positioning of one another during conversation (Harré & Van Langenhove, 1999). Positioning theory looks at how people position themselves and others in a conversation by analysing conversation as consisting of tri-polar storylines, speech acts, and positioning (Harré & Van Langenhove, 1999). We investigated if and how positioning practices influenced patterns of conversation and transitions between stages of solution development, exploring whether these help to establish and preserve mutual agreement during design group work.

Our analysis suggests that three main categories of positioning were practiced by participants, each having consequences on the sequence of talk in conversation. These include positioning of oneself in relation to the task as an outsider or insider, positioning of oneself in relation to the researchers of the study, and positioning of oneself in relation to other group members. The first two categories of positioning happened at the beginning of the collaboration and as the group moved towards different phases of solution development, positioning practices were limited to the third category. Our analysis shows how one type of positioning led to rejecting, at least during the collaboration analysed, the scaffolds in the environment and as such contributes to an understanding of the difference between the collaboration environment as designed and as used.

Multimodal interaction analysis (MIA) of the role of inscriptions in design

Dewa Wardak, Kate Thompson, Lucila Carvalho, and Peter Goodyear

Ehrenstrasser and Spreicer (2012) state that “when designing technologies with tangible user interface, we need to enhance our understanding of modalities. We need to better scrutinize how space is used and organized, and furthermore, how users interact with different types of objects” (p. 1), including inscriptions. In order to inform the design of scaffolds for collaborative learning, a rich description of the activities of the learners is necessary. The role of inscriptions and representations has been researched in other studies of learning (e.g. Zhang, 1997; Medina & Suthers, 2013) however, not with a focus on collaborative *design*, instead in specific subject areas such as mathematics or science. Multimodal Interaction Analysis (MIA) takes the action rather than utterance as the unit of analysis (Norris, 2004). Creating and attending to the way in which visual marks, images, sketches and drawings embody a particular type of communicative practice requires a multimodal analytic framework. Spontaneously created visual representations can facilitate, bridge, or anchor communication. Visual communication plays a unique role providing opportunities for a person to employ certain modes of communicative practices (Snyder, 2013). Snyder (2013) illustrates how multimodal interaction analysis techniques can enable the researcher to investigate the role of drawing in face-to-face conversation. The transcriptions of MIA move beyond the focus on discourse, and depend on the analytical categories defined by the researcher. Based on these categories, the researcher defines the communicative modes to be included in the transcription of specific events. In this study certain communicative modes were transcribed because they were deemed important for describing the specific events and actions in the presence of inscriptions. The multimodal system of analysis in this study has at its centre the sketching and drawing practices of the participants. The participants' interaction is transcribed so that it illuminates the inscription-related interaction of the participants. Gestures are included when they are relevant to the analysis. That means, when gestures are produced in relation to the inscriptions and when the gesture is part of the meaning-making process of the participants.

Participants' use of both verbal and nonverbal interaction in relation to visual representations was considered. Inscriptions drawn during the design sessions by the participants in order to communicate and explain their ideas to their team members were analyzed in relation to the context in which they were used. For example, when a team was discussing an issue using indexical terms such as “this”, “that”, “here”, “there”, or “this one” and “that one”, the inscriptions provided the essential context to understand what was being discussed. As such, the inscriptions serve as the background against which verbal and non-verbal communication can make sense (Roth & McGinn, 1998). The multimodal perspective will illuminate how participants were drawing and using the inscriptions they drew, as well as how they were interacting with each other in the presence of inscriptions.

Synthesis

Kate Thompson, Lucila Carvalho, Gregory Dyke, Michael A. Evans, Lixiao Huang, Maryam Khosronejad, Peter Reimann, Anindito Aditomo, Dewa Wardak, and Peter Goodyear

In this presentation we piece together the analytical contributions of each symposium participant, to compose our understanding of the scaffolding of learners and its influence on the learners' behaviour. First, we discuss the structure of our study, which allowed our exploration of part-whole relationships; we then show ways of visualizing how these different elements come together to explain the unique insights the synthesis analysis adds to our understanding of scaffolding in CSCL. As previously stated, the structure of the study follows the analytical dimensions in Carvalho and Goodyear's (2014) framework. We will discuss the results of the three analytical presentations in the context of the framework.

We used Tatiana (Trace Analysis Tool for Interaction ANAlysts) (Dyke et al., 2009) to provide a visual representation of the data and analyses considered. Tatiana is an environment (and an underlying conceptual framework) designed for manipulating various kinds of analytic representations, in particular those that present a view on event-based data, be it the original data or subsequent analyses thereof. We call these representations replayables, because they can be replayed in a similar fashion to a video. Tatiana replayables comprise a sequence of events and benefit from Tatiana's four core functionalities: transformation, enrichment, visualization and synchronization. Replayables can be *transformed* to create new replayables whose events might be a subset, an abstraction or a combination of events from other replayables. Adding annotations and categories is called *enrichment*, and Tatiana also provides a graph enrichment allowing researchers to annotate relationships between events. All replayables within Tatiana can be visualized in different viewers, such as a table with rows and columns, and several forms of graphical timelines, including a sliding window visualization (Dyke, Kumar, Ai, & Rosé, 2012), which affords the visualization of how indicators change over time and at different granularities. Finally, all visualizations of replayables in Tatiana can be synchronized with each other. This functionality allows data to be examined simultaneously from different angles. Because of Tatiana's extensibility, and its ability to manipulate multiple analytic representations it is ideally suited both to accommodating analyses from the multiple perspectives addressed in this symposium, and to allow new insights to emerge when combining these multiple analytic perspectives. It has been successfully used in the past to highlight the agreements and disagreements of analyses from different epistemological positions (interaction analysis, content analysis, and cognitive analysis), not only allowing researchers to achieve common ground in their analysis, but also highlighting how different analytic traditions can achieve productive multivocality.

Recent research has focused on the interplay between social interactions, the design process, and the use of tools in the Design Studio (Thompson, Ashe, Carvalho, Goodyear, Kelly & Parisio, 2013; Thompson, Ashe, Wardak, Yeoman, & Parisio, 2013). Multiple streams of data are collected, processed, and presented to researchers to combine video, audio and image files. Initial studies have shown that the use of Carvalho & Goodyear's framework to structure the analysis of complex data results in rich descriptions of the context as well as the processes of learning. In these studies, we have also combined methods of analysis, such as video, conversation and sketch analysis, and process analysis and conversation analysis. Examining the interplay between the social, tools and epistemic processes can show patterns otherwise unable to be detected.

The analysis of the processes of learning using DP and gestures focused on the epistemic and the social. DP and gestures were used to understand scaffolding in relation to the development of talk and helped to construct ideas about design. Emphasis was given to understanding how the prompts provided by tools, context and social support influenced engagement and the group's trajectory was contextualized in relation to the scaffold. The use of CA and positioning theory also highlighted epistemic elements in a different way that includes social negotiations between participants. MIA of inscriptions offered insights related to the role of artefacts as resources for the participants in achieving a shared understanding of the problem at hand. Thus, in terms of Carvalho and Goodyear's framework, the focus is on how participants use the resources at hand and the role of their inscriptions and the artefacts produced so as to facilitate the groups' social interactions and communication. When these analyses were combined in Tatiana, we gained insight into the complexity of interacting processes of learning.

Reflections on the process

Entire panel

The purpose of this symposium is to demonstrate the results and processes of a synthetic approach to research of a computer supported collaborative learning task. In order to carry out the project, a team of twelve researchers in the learning sciences has come together to synthesize their perspectives in terms of methods of analysis as well as theoretical perspectives. This presentation will give all the participants the opportunity to discuss the challenges and solutions involved in conducting research of this type including: sharing data; managing the social; shared objectives; and future directions. Throughout this process, the research team has had to address the challenges of shared data in the social sciences. The files were made available to all, however the data extracted was unique to each participating researcher. There were three main challenges the team faced: what data was to be extracted, to what purpose; how would this data be visualized so that patterns and overlap could be noticed by researchers; and how would we present the findings coherently. Maintaining regular contact with the project team was important, and making time for virtual meetings was valued. We also held presentation meetings, during which initial results were discussed. Another important social aspect was the mix of established scholars, mid and early-career researchers as well as research students in the team. The students grounded the ongoing progress of the group, as they had specific deadlines for the development of their own work. Early-career and research students both had opportunities to have their emergent research ideas recognized as part of a larger group of researchers, and established and mid-career scholars gained insights into these new ideas. The development of shared objectives, particularly around research output has been crucial, offering concrete short-term goals for the ongoing progress. They helped to guide our work, and maintained the engagement and interest of the group. We have produced symposium proposals, a journal article (Thompson et al., in progress), and a data paper (Thompson et al., submitted). We hope that the discussion of the challenges presented in this symposium will aid in the application of this method to other areas of the learning sciences research, helping scholars in the field to gain richer insights in issues related to complex learning environments.

Even using a subset for this proof of concept, we will demonstrate findings in key areas associated with the processes of learning as well as the role of the design process scaffold. The use of the tools of synthesis – the framework as well as the visualization – are key in bringing these findings together. Without the analysis tool Tatiana, understanding and describing the interactions between perspectives in relation to processes of learning over time would have been far more challenging. The analytic framework was essential for making sense of the multimodal data collected, as well as contextualizing the findings. In future work we plan to incorporate all the perspectives, and present these analyses in full. Other work has already been done synthesising three perspectives (Thompson et al., in progress). While the conclusions are preliminary, the initial findings show that there are identifiable moments of the interplay of tools, task and social interactions, after which shifts occur in patterns of tool use, social interaction or the design process. It appears that there are some key moments of intersecting processes that can affect the trajectory of a group's behaviour. The addition of further perspectives are expected to identify further moments of intersection, as well as other changes to the behaviour of the group.

The ultimate aim of this synthesis research, as opposed to other multidisciplinary research, is to develop a new model to understand the interplay of tools, task and social interaction in response to scaffolds in a complex collaborative learning environment. Unlike ecology, there is not an existing model against which to test the model. This research is focused on model development, and because of this, we are interested in opening up the research to more perspectives, to incorporate them into the model we are developing. To that end, we have submitted a data paper to a special issue of the *British Journal of Educational Technology,* and we are open to sharing the data further. As learning scientists we aim to understand how and why students learn in particular learning environments, given specific tools, tasks, and social interactions. These are complex scenarios that have yet to be fully explained with the current set of analytic and methodological tools. Borrowing methods from other fields, more suited to dealing with large datasets and complexity, and describing the complexity with a tool adapted from educational design, shows promise for unpacking some of this complexity, to begin to make sense of the interactions between the design, the processes of learning, and their effects on learning outcomes.

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Knowledge Construction in the Instrumented Classroom: Supporting Student Investigations of Their Physical Learning Environment

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Abstract: In this symposium we consider the physical space of the classroom in order to understand how location can be used as an input or information source for knowledge-building activities. Five posters encapsulate several projects, addressing the role of *physical or locational elements* within our work, including their role in the pedagogical design, the specific measures collected, and representations employed. The first two projects instrument the classroom with location-specific technologies (e.g., RFID tags), enabling learners to explore location-dependent phenomena (e.g., an earthquake zone, squirrel food patches). The third project maps classroom inquiry discourse (i.e., digital notes) to spatially meaningful locations though out the classroom for collective knowledge mapping. The fourth and fifth projects require learners to consider the physical properties of their learning environment in order to make decisions concerning where they will place motion-activated cameras for wildlife field investigations, allowing learners to instrument the learning environment themselves.

Keywords: physical location, location-tracking technologies, instrumented learning environments

Introduction

There is a long tradition amongst educators to situate learning within a physical orientation in the classroom, through the use of stations (e.g., in elementary classrooms), value lines (i.e., where students are asked to stand in a location that corresponds to their opinion or other value), or even small groups working on specific themes at different table locations. While most classroom instruction remains in the form of lecture (Tapscott, 1998), where location is largely (but not totally!) irrelevant, these longstanding examples have served as a persistent reminder that the physical space of the classroom can be used in pedagogically meaningful ways. A new genre of networked technologies is emerging that can track location and identity, or capture a variety of sensor information. These have opened the doors to new ways of leveraging the physical environment for purposes of learning, creating a new set of interactions with which learners can engage. For example, in BeeSim, students wear a "ForagerBee" glove – a sensor-embedded wearable – to step into the role of a bee and contribute to the health of a "hive" through location-specific actions within the environment (Peppler et al., 2010). Students aim to make optimal foraging choices, such as moving to flowers (fitted with unique resistors) that have the greatest nectar yield and returning to the hive before their "bee" is (virtually) exhausted.

This session will present a set of coherent projects that have pushed the boundaries of such applications, instrumenting students such that the physical environment can tailor its response to their presence at different locations, *or* allowing students to instrument their own physical environment. This set of projects has been conducted across a three-year time span, at several different school settings, with research groups from two universities. It represents a collaboration of theoretical perspectives and technology frameworks to achieve a unique set of curricular interactions. We have instrumented our classrooms to capture and distribute student ideas, to identify and respond to individual students, or to simulate data collection within a scientific community. The emphasis of our work is on science inquiry, with a particular interest in collective forms of progress, where students work autonomously within a larger “whole class” context, aggregating their observations or evidence to advance the understanding or progress within the overall community.

We organize our session as a structured poster set in order to accommodate five projects, giving each project a short presentation, but allowing the audience considerable time to interact with the authors. Each poster will address the role of physical or locational elements within its work, including the role of such elements in the pedagogical design, the specific measures collected, and representations employed. Our discussant Kylie Peppler from Indiana University will serve as discussant, offering comments during the final fifteen minutes of the symposium.

Location matters: The use of classroom space in RoomQuake

Tom Moher, Alessandro Gnoli, and Brenda López Silva

RoomQuake is a multi-week seismology unit designed for enactment in grade 5 and 6 classrooms. The unit problematizes the issue of how scientists are able to determine the properties of remote events—in this case, earthquakes. In RoomQuake, the classroom is imagined to be a miniature version of an earthquake-rich geographic area, and classroom computers situated around the room serve as imitation seismographs (Figure 1, left). During the first few weeks of the unit, earthquakes can be invoked "on demand" as students explore the relationships between the properties of earthquakes (time, location, and magnitude) and the representation of local ground vibration on seismograms. Over the final few weeks of the unit, students apply these understandings to determine the properties of a series of "roomquakes" occurring in their classroom.

In RoomQuake, location matters. When roomquakes occur, they occur at a particular location in the room. The energy transmitted through the ground (the floor of the classroom) travels to the seismographs at a constant speed. Seismograms of the same earthquake will look differently, if they were produced at different distances from the event. Students engage in activities such as (1) estimating the relative distances of different seismographs from an earthquake (based on arrival times or seismogram amplitudes) and using those estimates to qualitatively estimate the epicenter of an earthquake, (2) determining the speed of an earthquake wave front using tape measures and stopwatches, and (3) enacting a room-size version of the mathematical process of trilateration by finding the common point of intersection among multiple circles using tape measures anchored at each seismograph. In each of these, the floor of the classroom becomes a two-dimensional stage for the representation of the phenomenon and the enactment of activities (estimation, measurement, trilateration) common to the practice of seismology.

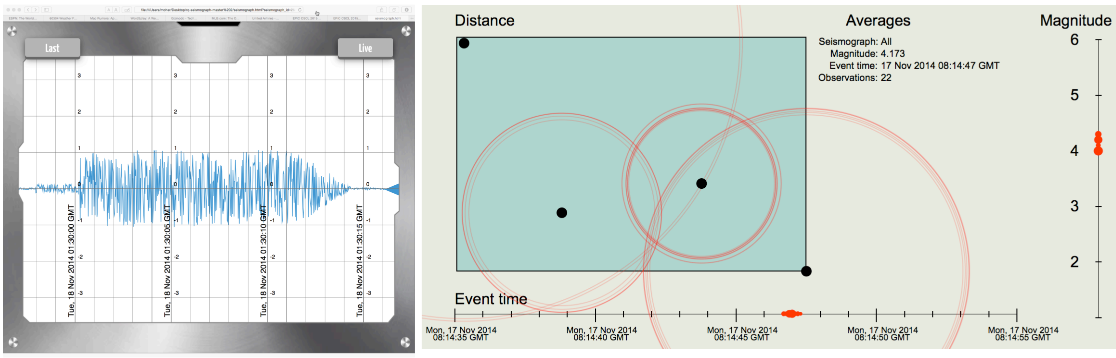

Figure 1. *Left:* Simulated seismograph. *Right:* Aggregate public display of seismogram readings.

In prior quasi-experimental research, we found that students who enacted RoomQuake activities on the classroom floor evidenced more improvement in both practice skills and conceptual understandings than students who performed analogous activities using maps (Moher et al., 2010). We expect that the benefits of physical enactment might derive from a variety of sources, including novelty, increased opportunities for social interaction, greater play value, salience at larger scale, or cognitive benefits associated with pairing action and thought.

Prior versions of RoomQuake included only the latter part of the current unit. Students were taught to interpret seismograms and extract earthquake parameters, but did not develop strong understandings of the capabilities and limitations of seismographs or their dependence on the generation of multiple waves of different constant speeds during an earthquake. The new design introduces a knowledge-building progression in the form of a series of challenges to learners to determine characteristics of earthquakes and waves using a variety of tools: seismographs, tape measures, and stop watches. The classroom floor becomes an experimental space, and "control" of the simulation technology is inverted; in this phase, roomquakes come at the discretion of the teacher (or even student), not according to a schedule, and the earthquake parameters—time, location, and magnitude—are specified by the user, not the goal of inquiry.

We also changed the activity structure of the second phase of the unit. In prior versions, students were typically organized as teams responsible for reporting a consensus reading from specific seismograph. In the new version, students use mobile devices to individually report readings from multiple seismographs, and as the readings are reported in aggregated form on a public display, affording learners an indicator of activity and progress in their spatially distributed work. Included in that visualization is a map of the room showing the distance estimates from each seismogram, reinforcing the "intersection of circles" framing that is difficult to achieve at classroom scale because of the occluding walls (Figure 1, right).

Expanding the pedagogical design space with indoor spatial technologies

Anthony Perritano, Alessandro Gnoli, and Tom Moher

We are interested in expanding the space of pedagogical designs by leveraging current advancements in indoor location tracking technologies such as Radio-Frequency Identification (RFID), inductive and capacitive Near-Field Communication (NFC), and Bluetooth Low Energy (BLE) iBeacons in technology-augmented classroom learning environments. They introduce the notion of a *proxemic interaction*, which is defined by the Human Computer Interaction research community as a way to describe an individual's technology-enhanced, socially-mediated, micro-located actions within a physical space (Marquardt & Greenberg, 2012).

Within learning environments that utilize spatial technologies, location has a meaning, which can become an input or information source for learning activities within an indoor classroom. In our investigations, location becomes an input into a participatory simulation and inquiry-based knowledge building activities (Slotta, 2014).

The affordances that location-tracking technologies add to classroom learning environments can be categorized in three ways: (1) hotspot location tracking—student movement can be detected in and out of discrete activity hotspots or zones; (2) distance tracking—discrete points within the classroom are able to detect, track, and compute distances of students in its proximity, and (3) high resolution tracking— student exact location within the classroom can be tracked continuously in real-time, making student-position an input into new types of learning activity designs. Distance tracking could potentially exchange information with the student or reveal an interaction (Marquardt, Ballendat, Boring, Greenberg, & Hinckley, 2012).

We used indoor location-tracking technologies and concepts within a classroom participatory simulation called Hunger Games (Moher et al., 2013). Hunger Games engages learners as foragers in an environment consisting of several food patches. Students learn the fundamentals of game theory by enacting strategies for survival under optimal game conditions: patch depletion, predation, safety in numbers, etc. Students employed small plush animals or "avatars" with embedded RFID tags to forage, choosing among food patches that were distributed around the room (see Figure 2).

Our choice of indoor location-tracking technology (i.e., RFID tags and readers) had an interesting outcome and created interaction opportunities that we did not anticipate. In our original design, we envisioned that we would track the location of individual students using bracelets or lanyards, with hotspot location tracking. However, this approach proved to be unreliable and technically difficult due to signal overlap from the RFID readers, which produced too much attenuation and false positive detection. To overcome this issue we tuned down the RFID readers' signal to a smaller range (< 30 cm) around the patches. We outfitted each student with an avatar (i.e., a plush toy that that served as an information carrier of his or her accumulated calorie information throughout the simulation) and required that those avatars be placed directly on top of the patches (i.e.., RFID readers). First, students developed affective connections with their avatar (observable by kissing, hugging, etc.; Moher et al., 2011). Two, students had the ability to both participate as an agent in the simulation (by placing their avatar in an optimal food patch) and to be an observer in a meta-role (by walking over to information displays that showed their progress within the game). With this freedom to roam, students moved to displays that showed their score while their avatars were feeding.

We used location as an informational source for students for: (1) *reflection-in-action* during foraging bouts, with the aid of large public ambient displays that provided information about total calorie accumulation for each animal, patch utilization, and a real-time map of each animal's location; and (2) *reflection-on-action* in post-foraging activities supported through community knowledge-building tools.

Figure 2. *Left:* Small plush toys with embedded RFID tags served as avatars for student foragers. *Middle:* Student places her animal on food patch and views foraging scores on iPad. *Right:* Student moving between food patch and large display.

In summary, we described the conceptual and practical use of indoor spatial technologies within a classroom environment. We discussed the affordances that these technologies create, e.g. the notion of micro-locational proxemic interactions, which have the potential to serve as informational inputs into learning activities. Finally, classroom use of these spatial technologies is still at the outset. Our experiences could help inform the educational technology developer community (e.g., the Educoder community; Slotta & Aleahmad, 2009), on the design, implementation, and deployment of location-tracking technologies in educational research contexts.

Spatial mapping of inquiry discourse in the classroom through knowledge visualization

Cresencia Fong, Rebecca M. Cober, Tom Moher, and James D. Slotta

Technology has long been used to support online discussions (Coopey, Schneider, & Danahy, 2013; Peters & Hewitt, 2010; Dougiamas & Taylor, 2003; Linn & Hsi, 2000) and knowledge building (Scardamalia & Bereiter, 1996), where it has served an important role in making student idea advancement dynamically and persistently visible to peers, allowing for collaborative knowledge work on these ideas. However, such environments do not incorporate a phased inquiry discourse progression, and rely instead on the teacher's intuitive sense of inquiry progress. We continue to innovate on the development of Common Knowledge (CK) – a content-agnostic pedagogical and technological note-sharing application for collaborative inquiry. Through tight coupling of an inquiry script and a technology script, CK's third iteration (CK3) scaffolded student knowledge communities through a student-driven phased inquiry progression. It also capitalized on the physical classroom layout as an additional dimension of collaboration scripting and collective knowledge mapping.

Method

We engaged two classes of grade 5/6 students in a nine-week astronomy inquiry progression mediated by CK3. Using tablets, students contributed to a community knowledge base that was publicly visible on the "Common Board", displayed on the classroom's interactive whiteboard (IWB). This interactive display visualized the community's idea flow and enabled learners to sort their ideas by topic. CK3's inquiry script scaffolded the community through phases of science inquiry: *Brainstorm*, *Investigate*, and *Propose*. Students first *brainstormed* questions and theories, by using CK3 to contribute "Brainstorm" notes. They then *proposed* research trajectories and designed experiments to test their theories, by contributing "Proposal" notes. Contributions informed subsequent work in fluid interest-based groups (each group supported by a large-format "Topic Board" interactive display), in which students *investigated* the proposed research in a topic specialty of their choice, sharing findings via "Report" notes, and making inter-group connections. Throughout all inquiry phases, teachers and learners could manipulate visualizations of community ideas (i.e. CK notes) from the IWB, or from a group's Topic Board (during Investigate phase only), clustering ideas by topic relatedness.

Outcomes

Teachers and students used the public displays (i.e., Common Board and Topic Boards) to gain a global awareness of their community's overall state of knowledge, including the relationship between notes and tags/topics (see Figure 3). While students could read and compose notes from their tablets, such knowledge relatedness was not readily apparent on the tablet interface, which simply listed a note's associated tags at the end of the note, and included tag-based color-coding of Proposals. Furthermore, spatially distributing the Topic Boards in the classroom during the Investigative phase facilitated the formation of student-selected interest-based groups that focused students' attention, while also spatially localizing the topics in the classroom. As a means of facilitating inter-group knowledge exchange, students had the option of going on a "knowledge walk" to visit other groups during the Investigate phase, to speak with peers and read their notes.

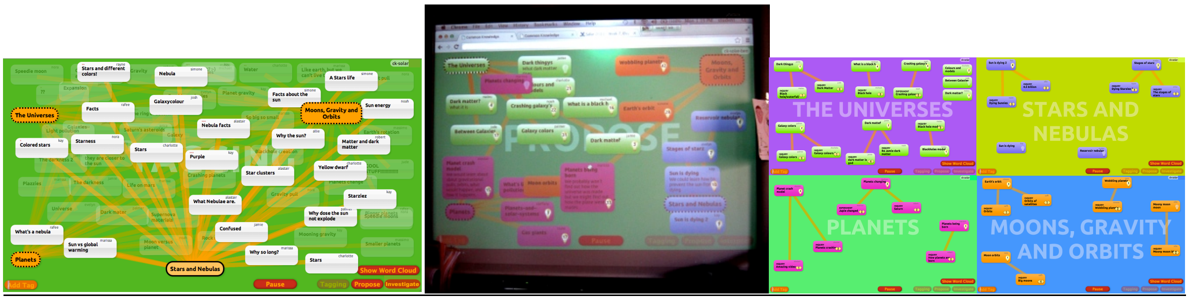

Figure 3. *Left:* One class' Common Board (displayed on the classroom's IWB) during the Brainstorm phase; white Brainstorm notes are visually connected to corresponding tag nodes (which act as filters). *Middle:* Common Board during the Propose phase; Proposals are visually connected and color-coded to align with corresponding topics (tags were elevated to the status of "topics"). *Right:* Topic Board displays (each located at one interest group table) for all four interest groups in the class; all Proposals are visually linked to corresponding Investigate Reports.

Classroom observation data and student feedback indicated that such interest-based co-location enabled students with common inquiry interests to dialogue about their work and offered opportunities for collaboration on investigations. Furthermore, the Topic Boards served as a grounding reference for small-group interactions about the inquiry at hand.

Teachers used students' CK contributions that were visualized on the Common Board to spur oral classroom discussions and guide inquiry. The public displays firmly maintained the goals of inquiry at the foreground; and the final Investigative phase spatially mapped topic specializations to distributed classroom locations, thereby spatially distributing topic-based student collaborations. Thus, CK became a meditational tool between the two learning environments: (1) students' collective inquiry performed in the digital note-sharing environment during student-directed small-group interactions, and (2) teacher-guided classroom discussions.

Using maps to support investigations of animal behavior in our schoolyard

Rebecca M. Cober, Alisa Acosta, Tom Moher, and James D. Slotta

Scientific inquiry can take on many forms, including field investigations; through systematic collection of evidence and communication of results, students can answer their own investigative questions (Windschitl et al., 2007). However, real world environments can be challenging for learners to work in because of their inherent complexity (Kamarainen et al., 2013). One means by which learners can organize and represent descriptive results is through maps, by indexing observed phenomena to physical locations within an environment of interest (Sobel, 1998). Maps can help learners to make sense of an environment, allowing them to explore data (e.g., analyze data and spot trends; Liben, 2001).

Method

We engaged one class (n=22) of Grade 5/6 students in Toronto, Canada in a six-week curricular unit of animal behavior. The goal of the activity was to identify animal species that inhabited the schoolyard, and to understand their behaviors and interactions through the collection and interpretation of photographic evidence. Our interest was to help students to work together as a scientific community and to enable students to create their own visual representations of their results (Ainsworth et al., 2011). We supplied the class with 10 camera traps (i.e., motion-activated cameras) for students to position strategically throughout their schoolyard (i.e., in locations that would likely yield photographs to address their inquiry questions). We provided the class with 10 laminated 36 x 24 maps of their schoolyard and a toolkit to "mark up" the maps, consisting of tokens and stickers with icons (e.g., of animals) and dry-erase markers. In addition, we provided students with iPads (including camera) and a mobile application called Common Knowledge, to allow learners to contribute notes and photographs (e.g., camera trap photos and map photos) to a shared note-space (Figure 4).

Figure 4. *Left:* Camera trap and student placing a camera trap in the schoolyard; *Middle:* Planning map with stickers showing locations of animals sightings; *Right:* Student using iPad to share notes and photos with peers.

What role(s) did maps serve in advancing students' understanding of animal behavior in their schoolyard?

Outcome

Maps were used in three different activity structures throughout the unit: (1) In the initial phase of the unit, students cooperatively constructed aggregate representations of daytime/night-time animal behavior by placing animal tokens on a group map. The tokens corresponded to locations where animals had triggered the camera traps. A whole-class discussion concerning these aggregate maps served to orient students to i) the species that inhabit their schoolyard, ii) location-specific information about species (e.g., raccoons were sighted near garbage cans), and iii) basic temporal patterns of behaviour (e,g., some animals appeared in the daytime only). Students used findings from this preliminary activity to drive their subsequent inquiry questions and activity (i.e., strategic camera trap placement). 2) Throughout all six weeks of the unit, students used iPad cameras to take photographs of maps that were annotated with tokens, markers, etc. and attached these photographs (n=39) to Common Knowledge notes. Maps were used both i) formatively and ii) summatively. Students used maps to plan investigations; for example, students placed camera trap tokens on their map to show where they intended to place a camera, and the accompanying text of their planning note provided a rationale for the placement. Students also used maps to summarize findings; for example, students annotated their map with text and tokens to show results from previous camera trap placements (e.g., depicting a route that raccoons take by synthesizing location-based sightings from multiple camera traps). 3) At the conclusion of the unit, student groups presented their "research stories" to their peers, using PowerPoint. Most of the student groups elected to include photographs of their maps in their presentations. The role of these maps was similar to the role that they played in the second activity structure—to depict a plan for camera trap placement or to show a summary or synthesis of results.

In interviews that were conducted at the conclusion of the unit, one student said that the maps gave him "a bird's eye view [of the schoolyard], as opposed to walking through it." Placing the tokens on the map enabled patterns in the data to emerge; by "connecting the dots" he was able to establish a route that the raccoons took.

Consideration of the physical environment when selecting and instrumenting sites for field investigations

Alexandra Silva, Chandan Dasgupta, Brenda López Silva, and Tom Moher

Field investigations conducted by scientists represent one method of inquiry used to build scientific knowledge that can also be undertaken by students within the classroom (Windschitl et al., 2007). As with general scientific inquiries, field investigations require students to generate research questions, plan investigations, collect data, and report findings (Marx et al., 2004). When planning successful, real-world field investigations, scientists consider the physical environment of a potential field site to determine: 1) if it is amenable to investigation; and 2) how it should be instrumented. The physical environment, or landscape, of an area is an especially important concern in the development of ecological field investigations (Turner, 2001).

Method

Three classrooms of Grade 7 students in Chicago, IL participated in a seven-week instructional unit of animal diversity and behavior. Students worked in small, autonomous groups within the context of the classroom's scientific community to learn from and build upon each other's work as they completed a series of scaffolded, research-based activities. The unit culminated in a succession of autonomously-planned field investigations of animals at sites off school grounds. The five field sites across Chicago represented an extension of the classroom, which learners accessed through landscape- and local-level images (Figure 5), but did not physically visit. As part of the planning process, students selected which field site to investigate and determined how to instrument the selected site with motion-activated camera cameras (i.e., placement and/or positioning of camera traps). The camera traps produced photographic evidence of animals, which students then cataloged and analyzed using a tablet-based application. A separate application, Common Knowledge, allowed students to create and share notes via a shared-note space. Groups produced a *planning note* for each investigation describing the motivation for selecting a given site and instructions of how we (i.e., researchers) should instrument the site. Conclusions drawn from each investigation were shared within the classroom.

Figure 5. Examples of images provided to students allowing access to the extended classroom. *Left*: Map of available field sites distributed across Chicago; *Middle*: Landscape-level, aerial image of an individual field site; *Right*: Local-level, terrestrial image of a field site.

To what extent did the physical characteristics of students' extended classroom influence 1) the decision of which field site to instrument and 2) the instrumentation of the field site?

Outcome

We coded and evaluated the *planning notes* from each field investigation and found that considerations of the physical environment were incorporated into site selection and instrumentation in the majority of cases. In fifteen of twenty-five cases, students justified their site selections based on physical characteristics of the environment. Despite having access to landscape-level data of the entire extended classroom via an online map application, landscape-level characteristics (i.e. physical composition or configuration on a scale greater than a single site) were only considered in five cases. A comparatively greater number of site selections were motivated by the local-level characteristics of a single site (e.g. presence of a body of water). In thirty-three of the forty plans to instrument field sites, learners explicitly considered some aspect of the physical environment. For example, one group opted to instrument a certain area within a field site "that's not on a trail… so people won't scare the animals away." These learners actively considered the absence of a trail and planned their camera trap placement accordingly. In many cases, students considered the physical environment in conjunction with animal biology or behavior when deciding how to best instrument the field site (e.g., camera height must allow for the capture of larger animals).

The successful planning of real world field investigations requires serious consideration of the physical environment's composition and configuration. In many cases, the physical environment may be an underlying mechanism influencing animal diversity or behavior, and thus essential to consider and understand. During their final presentation, one group effectively alluded to this importance of landscapes within field investigations: "Certain animals like open areas for example, deer, while others like hidden areas like rats… One of our deployment places was Brookfield and we saw many deer there because there was an open space."

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Posters

Visualization of Progressive Idea Development in a Knowledge Building Community

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Abstract: This study aims to visualize the progressive idea development in an undergraduate level knowledge-building classroom in teacher education. In order to do this, I investigated the online discourse of the pre-service teachers in tandem with Knowledge Building Discourse Explorer (KBDeX; Oshima, Oshima, & Matsuzawa, 2012) that is a social network analysis-based collaborative learning discourse analysis tool. This study presents preliminary methods and results to depict word connectedness that might help uncover idea development.

Keywords: knowledge building community, idea improvement, progressive discourse

Introduction

New ideas are essential for the development of human capital since they are the key engines of economic growth, drivers of market productivity, and sources of cohesion for all nations (Goldman & Scardamalia, 2013). Knowledge building (KB) is principle-based pedagogy that encourages students for sustained creative work with ideas in assumption that the students will take collective responsibility for idea development (Scardamalia & Bereiter, 2003; 2006). Twelve KB principles were defined by Scardamalia and Bereiter (2006, cited in Hong & Scardamalia, 2014) in order to represent design challenges, ideals, and objects of continual improvement. In this study, I will focus on "improvable ideas" as one of these principles in order to investigate progressive idea development over time in a KB community in teacher education. "Improvable ideas" refers that participants are supposed to work on the ideas that arise in order to improve the quality, coherence, and utility. In an environment where all ideas are considered as improvable, the students feel safe in taking risks, in not hesitating to voice incomplete thoughts, and to engage in providing and receiving criticism (Scardamalia, 2002).

Methods

The purpose of this study is to visualize idea development in an undergraduate level KB classroom in teacher education. I taught this course and conducted the analysis to explore participant-generated notes in Knowledge Forum (KF) using Knowledge Building Discourse Explorer (KBDeX; Oshima, Oshima, & Matsuzawa, 2012).

Participants and procedure

Participants were 30 pre-service teachers (F:27 M:3) who were studying eight different programs in the Faculty of Education at Bogazici University. During the six weeks, pre-service teachers worked on four sub-problems, which are initiated week by week with the aim of developing ideas for top-level goal.

Analysis

I applied retrospective analysis to explore idea progression, starting with analysis of the discourse in the top-level goal view. I identified twenty-one words—words referred to below as keywords-- in this view because other ideas were shaped around them and they seemed possible indicators of significant ideas. I conducted this impressionistic analysis from my perspective as course instructor, followed by a time-based analysis to determine when each word first entered the discourse in the top-level view. To further explore idea development, I conducted a time-based analysis for the same keywords in the sub-problem views, tracing their appearance in the discourse from the beginning to the end of the course. Through this analysis I hoped to identify ways in which each sub-problem contributed to the top-level goal and to determine analysis of keyword evolution over time in an effort to uncover idea progression in the community discourse over the course of the term.

Findings

In the top-level goal view there are 54 notes created by 25 of the 30 participants. All the keywords were connected to each other with varying strength. In addition to this, 14 notes were unconnected to the main cluster of 40 notes. I investigated the twenty-one keywords in the four sub-problem views in order to describe the pattern of the discourse. Six of the keywords ("skill", "project", "monotype", "efficiency", "curiosity", and "creative") were sustained in the discourse throughout the course. Two keywords ("guidance" and "inquiry"), which were initiated but unconnected in the first problem, were connected in the second problem and supported the sustained discussion. Moreover, two new keywords (“assessment” and “design”) were initiated in the second problem which also supported the sustain discourse until the end of the term. The keyword “curriculum”, which was initiated in the first problem and it was missing only in the fourth problem. But it came on the scene in the top-level goal again. As a result, I can say that 11 keywords (see the red dots in the Figure 1 and Figure 2a) were consistently used for progressive discourse.

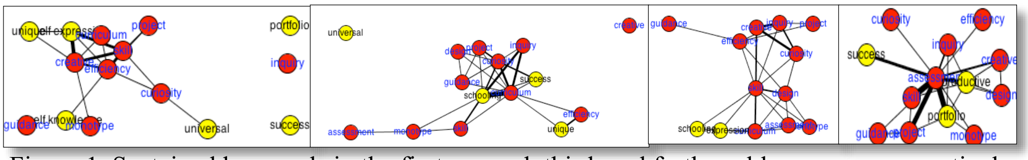
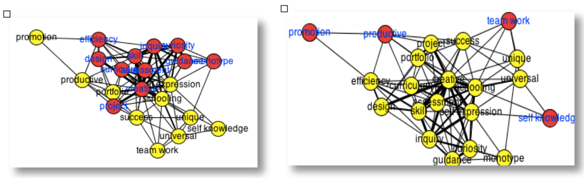


Figure 1. Sustained keywords in the first, second, third, and forth problem spaces respectively

Furthermore, some of the keywords, which were used in some of the sub-problems, were brought back in the top-level goal. For instance, the keyword “portfolio” was disconnected in the first problem and missing in the second and third problem; “schooling”, “unique” and “self-expression” were connected in two different problems and were missing in the other two; “success” were connected in two different problems and unconnected in another problem; “universal” was connected in one problem, unconnected in another problem, and missing in the other two. An interesting finding is that the keyword “promotion” and “team-work” were emerged in the top-level goal, even though they have never been used in any sub-problem before. Another keyword “productive” can be considered as emergent too since it was used only in the fourth problem and top-level goal. Another interesting finding is that “self-knowledge” was used in the only first problem and missing in the followings, was rehearsed in the top-level goal again.



(a) (b)

Figure 2. a) Keywords (see red dots), which sustained the discourse in the top-level goal view b) Emergent and rehearsed keywords (see red dots) in the top-level goal view

Discussion and conclusion

As a result, the keywords, which have emerged in time and which were kept sustained over time should be investigated for deeper understanding of idea progression. It is also important to explore how this emergent discourse affects the formation of community and participatory structure of the pre-service teachers. This study provides preliminary results regarding the development of the ideas in a KB community. In a broader sense, it is aimed at monitoring the growth of KB communities, by identifying significant moments at both idea and community development, while also investigating the moments in relation to discourse and community dynamics for deeper understanding of the factors that foster and/or hinder the evolution of KB communities.

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The Teacher's Conception of Technology and Its Impact on the Possibilities For Inclusion

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Abstract: In this paper, there is focus on a possible connection between concepts of normality, conceptions of technology and the work with ICT and differentiation in the practical classroom context. Through the analysis of three cases considered as part of the introductory studies for my Ph.D. thesis, I will present three different conceptualisations of ICT in the classroom. These three ICT conceptualisations in different ways open and close collaboration processes, which can facilitate processes of inclusion.

Keywords: Inclusion, normality, ICT, differentiation, materiality

Introduction

Since 2011 there has been significant changes in the policies governing inclusion in Denmark. There has been substantial change to the legal basis for special education. In 2013 a new school reform was introduced, which among other things demands greater inclusion. This puts teachers and students in a new situation. This project is locally based in the municipality of Vordingborg, which has bet on inclusion and ICT as two tracks in a larger programme for developing primary education. The empirical work, which forms the basis for this abstract is the preliminary pilot study, anticipating full fieldwork that is the basis for my Ph.D project in the field of ICT Education and Inclusion. For two weeks in the autumn of 2014, I have observed three 6th year classes with three different teachers in two different schools in a Danish municipality.

Conceptions of technology and conceptions of normality

In the abstract, I will use Wanda Orlikowskis four different conceptions of technology. Orlikowski shows that within organisational research it is possible to identify four different ways in which researchers approach ICT as an actor in social space. However, in this context, I won't use these conceptions of technology to classify research positions, but experimentally use them to categorise the practice of teachers. The typology follows four divisions. *Absent presence,* In this approach, ICT is not seen as being a co-creator of social practice. You could say that the educational technology is used as such, but not ascribed any value beyond its core technological function. *Exogenous force,* Technology is accepted as a social actor, but the technology itself is not subject to questioning. *Emergent process***,** In this position, ICT is seen as socially situated, through which the social interaction gains primary focus instead of the technological one. *Entanglement in practice*, In this position, it is taken for granted that ICT is inherently social practice in and of itself. Through this, the educational technology becomes an artefact almost with a life of its own. Users and creators of technology mutually influence each other and the context in which the technology is used. (Orlikowski, 2009).The field of special education has historically – and is still – characterised by divisions concerning between different perspectives and different ways of conceiving of what the problem is and what might be the solution. It is possible to identify at least three different main perspectives on the special: *The Individual Perspective, The Social Perspective, The Relational Perspective* (Tetler, 2009). Jointly conceptions of technology and perspectives on the special constitute the analytical toolkit that I will use to analyse three cases about how the use of ICT study aids affect the possibilities for collaborative learning having an inclusive potential.

Technology as disturbance

Peter, the teacher of the first 6th year class, tells me that he divides the class into 'good' and 'weak' students. There are students, who can and want to learn, and they should have the opportunity to learn as much as possible. Then there is a group of students, who can't and a lot of those have a diagnosable problem, according to Peter. It would appear that the classification of students into one or the other group is based on an individual based evaluation. Peter hasn't really started using the iPad and begins every class I'm there by asking the students to put it away. Consider the following morning. A couple of students have already arrived. There is a good mood in the class. The students chat among themselves. Several girls have their iPads out and are looking at a jewelry app. Peter arrives just before the bell rings. He says that it's time for reading and that the students need to put their iPads away. The students take out their books. Mike doesn't have a book, but is reading something football related on his iPad. Peter tells him, that he's not allowed to read on the iPad.

Technology as useful tool

Sandra, the teacher of the second 6th year class, tells me that the class is used to getting a lot of teaching as a complete group. The teaching that she uses the iPad for could, in most cases, equally well have been done on paper. The class has read short story. Sandra puts a set of questions on the smartboard. The students write the answers directly into the document on the iPad. They are allowed to solve the assignments individually or in groups, but everyone must have his or her own document. Jasmin is a girl with general learning difficulties who has been in the class for two years. When the other students begin she is the only one who doesn't. The others divide into small groups, but no one approaches Jasmin. She is looking at her nails. Sandra approaches her 'You need a new book. Did you hear what the book was about? Try to take your iPad out'. Jasmin finds her iPad in her bag. Afterwards Jasmin finds the assignments with help from Sandra. When Sandra leaves, Jasmin looks around the room and fidgets with the assignment. She doesn't get anything done. In the following lesson Sandra brings a Danish book for Jasmin for 3rd year students. She works on that while the others do the assignment.

Technology as part of the team

The third teacher, Lonnie, tells me that the introduction of the iPad in her class has changed her categorisation of the students and given them new options for positioning themselves in the learning community. She says that she no longer categorises students as strong' or 'weak', but looks at what particular resources the students have when performing in a group using the iPad as the central study aid.For instance, Lonnie constructs a teaching scenario based on the music video 'What if'. Lonnie says that they are going to watch the music video as the basis for an assignment. Lonnie divides the students into pairs. The students are instructed to find as many verbs in the video as they can. Some have difficulty finding the video on their iPads. Lonnie says that they need to search on YouTube with the words 'what if'. The students find it and song fragments are heard around the room. James (a boy with hearing aids) and his partner go to a more silent group room. Marvin (a boy with ADHD) and his partner Bibi follow. I go with Bibi and Marvin into the small room. Bibi decides how they will approach the assignment and they start immediately. Marvin controls the iPad and Bibi writes. First they watch the video with sound and then without. As they are watching Marvin starts to participate. He knows a lot of action related words, when there is a clip with children playing football. Lonnie brings us back when the lesson is over. They will go through the assignment on the following day.

New communities of practice, new opportunities for inclusion

Based on this, admittedly limited, pilot study it seems that the teacher's conceptualisation of technology can be understood in conjunction with their perspective on the special and that there's an interaction between the two. Together they impact whether the introduction of ICT study aids will help to encourage more inclusive communities of practice in the classroom. In the case of Peter, where technology is conceptualised as 'Absent presence' he misses the social interaction the students create among themselves, for instance through games. The knowledge and competence the students could potentially gain through that activity is not made an object of learning or inclusion. At the same time, the individual perspective enforces a division into competent and less competent, which effectively divides the communities of practice within the classroom, which makes active participation difficult or impossible for some students.In the example of Sandra, where technology is conceptualised as 'Emergent process', it looks like the rigid understanding of the study aid means that there's only one right way to participate and the study aid itself has an exclusionary effect as a consequence. This is a logical consequence of the individual based perspective as there are hard requirements before active participation is possible. If ICT study aids are to have an inclusive potential, it looks like it's most constructive to conceptualise technology as 'Entanglement in practice' combined with a relational view on the special as in the case of Lonnie. In this position both the study aid and the social processes that happen through collaborative learning are given substantial attention. By working with software that develop as the work progresses and opens different ways of solving the assignment and participating in the learning process, it does appear that ICT study genuinely can have a positive impact on inclusion.

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Tracing the Change in Discourse in a Collaborative Dynamic Geometry Environment: From Visual to More Mathematical

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Abstract: In this paper, we examine the change in three middle-school students' mathematical discourse as they worked on a geometry construction problem within a virtual collaborative dynamic geometry environment. We trace how their word use, use of visual mediators, and routines changed character during an hour-long collaborative problem-solving session. Our findings indicate that students gradually moved from a visual towards a more formal discourse -- one that is primarily characterized by a routine of constructing dependencies. We conclude that interacting with expert interlocutors may not be the only path towards advancing one's mathematical discourse; this process may also take place within a computer-supported collaborative learning setting.

Keywords: mathematical discourse; collaborative dynamic geometry; middle school

Introduction

In this paper, we investigate how three middle-school students, who initially treated a geometry construction task visually, moved towards more mathematical ways of approaching the problem while working within the Virtual Math Teams (VMT) environment (Stahl, 2013). By doing that, we argue that interacting with expert interlocutors may not be the only path towards advancing one's mathematical discourse. This process may also take place within a virtual collaborative setting where dynamic geometry, collaboration, and task instructions collectively fulfill a role similar to that of the discourse of experts. Better understanding how that transition was made and the characteristics of the intermediate stage will help in designing more effective tasks and approaches for DGEs.

Theoretical framework

Sfard (2008) distinguishes mathematical discourses in terms of their tools, *words* and *visual means*, and the form and outcomes of their processes, *routines* and *narratives*. Different mathematical discourses employ particular mathematical *words*, which might signify different things in different discourses, and *visual objects*, such as figures or symbolic artifacts. In addition to these discourse tools, participants functioning in different discourses produce what Sfard calls *narratives*, that is, sequences of utterances about mathematical objects and relations among them. In order to produce mathematical narratives, participants engage in mathematical tasks in specific ways. The set of metarules that describes a patterned discursive action are named *routines*, since they get repeated in certain types of situations.

Method

The data come from a team of three eighth-grade students (about 14 years old) who worked on a geometry construction problem collaboratively within the VMT environment. None of the team members had studied geometry, but they were taking first-year algebra at the time of data of collection. They were all females. The task given to the students had two parts. In the first part, the team was asked to construct two lines, which are perpendicular bisectors of each other. The second part of the task asked students to construct a perpendicular line to a given line through a given point.

In order to investigate the changes in participants' discourse, we particularly focused on the changes in (1) their use of the word "*perpendicular*," (2) the visual mediators they acted upon, and (3) their routines, as the changes in these features were the most salient aspects of their changing discourse. Given the nature of the task, this study investigated two routines: (a) the production of the perpendicular and (b) the verification of perpendicularity.

Results and discussion

Regarding the change in the production of the perpendicular routine, the team started with producing spatio-graphical solutions including placing the perpendicular line visually and imitation of the paper-pencil procedure of drawing the perpendicular by using the PBC as a straightedge guide. These routines however evolved into first the use of circles and then defining certain relationships with the circles, such as use of equal-radius circles with the construction, leading the group to successfully completing the task.

A parallel progression can also be observed in the verification of the perpendicularity routine column. The team first felt the need to verify their solution, which was not explicitly requested in the instructions. Initially, this took a spatio-graphical form with Cheerios wanting to arrange the lines into a vertical-horizontal position. Then Cornflakes, who received help from Fruitloops, wanted to use the given construction of a perpendicular bisector as a protractor, turning the verification routine into one that is based on measurement. Eventually, Fruitloops, upon completing the construction, asked how they could be sure if the line was perpendicular. Cornflakes pointed at the visual appearance of the figure to convince Fruitloops. However, Fruitloops seemed to be looking for a verification routine that would go beyond the spatio-graphical. She even used the word 'proof' – though not necessarily in a deductive mathematical sense. This situation is quite contrary to the findings in the literature, as students' validation of a mathematical statement often takes the form of testing it against a few examples even at the more advanced levels (Chazan, 1993b; Coe and Ruthven, 1994).

The word "perpendicular" was first used by Cheerios in the first part of the task. She uttered the word only once, as if to revoice the instructions. Fruitloops, on the other hand, used the word throughout their problem-solving session. Her use of the word also represented a parallel advancement along with the production and verification routines. Initially the word signified a visual image of perpendicularity and was used to evaluate produced visual solutions. Later, however, her use of the word came to refer to a certain relationship between figures. Finally, it is reasonable to argue that the given example construction functioned an important role as the key visual mediator of the session. It was brought to the team's attention by Cornflakes, who first played with it randomly. But later she figured out a way to use it like a protractor, thus as a tool for verifying perpendicularity. This use may have led Fruitloops to view it as a straightedge that could in fact be used to draw the perpendicular. More importantly, however, it became the crucial visual mediator that triggered Fruitloops' use of circles, which led to framing the problem as a construction task.

Conclusion

We agree with Sfard (2008) that students cannot be expected to invent the meta-rules of mathematics on their own. However, our data indicate that an environment such as VMT may provide a context in which students can obtain a chance to engage in higher-level mathematical discourses. Thus, along with expert others, well-designed virtual collaborative learning environments can provide a form of expert interaction that supports discourse development. In that regard, our findings support Sinclair and Moss (2012), who suggested that dynamic geometry software could function as the discourse of experts.

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Towards Using Influence Diagram on Social-Network Based Analysis for Managing Students' Collaborations

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Abstract: Massive online courses assume that students construct their own knowledge and collaborate with their mates. Large-scale learners' interaction figures hinder both proper interpretation of learners' needs and prompt remediation actions. To this we describe a preliminary study of a two-step collaboration analysis, which consists of inferring domain-independent indicators on students' relationships obtained from social network analysis and using an influence diagram to warn teachers on students' problematic circumstances to facilitate prompt remediation actions.

Keywords: collaboration analytics, SNA, influence diagram, collaborative learning

Introduction

There is previous research that shows three related issues: (1) In massive online curses (MOOCs, students are supplied with cognitive surplus beyond traditional forms of tutelage, (2) In scaled up class sizes, there is an increased need for guiding students in their collaborative work (Sinha, 2014) and (3) In the collaboration process, analysis of the students' interaction should be done to help students (Johnson & Johnson, 2004).

Based on these evidences, we propose the combination of two well-known analysis methods to support the management of online collaborative learning: 1) Social network analysis (SNA) (Hanneman and Riddle, 2005) and 2) Influence diagrams (IDs) (Howard and Matheson, 2005). The latter can be further investigated in this context since it provides a framework where previous expert's knowledge can be considered for representing and solving decision problems under uncertainty, which is a feature of learning context (Johnson & Johnson, 2004). We try to clarify if these two methods, together, can be combined in reducing the workload involved in managing collaboration activities in online learning, where an increasing number of collaborations take place (e.g. in MOOCs). Our goal is to automatically warn teachers on students' problematic collaboration circumstances so that they can provide remediation actions when required.

In online courses SNA has been used for several purposes, such as: identifying students who are potentially at a risk of dropping out in a MOOC (Sinha, 2014); providing MOOCs' students with a personalized and social-oriented recommender system (Zhuhadar and Butterfield, 2014) and discovering relevant structures in social networks so that instructors are able to better assess participation (Rabbany et al., 2011). However, IDs have not been commonly considered in this learning context. In particular, Anaya et al., (2013) used ID dealing with uncertainly to warm teachers on problematic circumstances. They built an ID's network with a set of uncommon collaboration indicators and the network was fine-tuned with data from small groups of students in several collaborative learning experiences.

In the next sections we firstly define the proposed methodology, secondly describe our preliminary study and finally briefly provide the conclusions and further planned research.

Towards collaboration analytics in online courses

For online courses, which could be massive we propose to combine two analysis methods to support the management of online collaborative learning: 1) Social network analysis (SNA) and 2) Influence diagrams (IDs) The latter has the advantage of structuring students' indicators as a network based on expert's knowledge.

First, we propose the centrality metrics of the nodes as indicators of the collaboration process, because constitute a standard way to measuring network and node features. The centrality metrics are (read Hanneman and Riddle (2005) for the metrics description): 1) *Degree*; 2) *In-degree*; 3) *Out-degree*; 4) *Closeness centrality*; 5*) Betweenness centrality*; and 6) *Eigenvector centrality*.

Second, IDs provide us with a framework for representing and solving decision problems under uncertainty. We propose an ID where the indicators obtained from the SNA are structured (see Figure 1). We warn that the values of the nodes have to be discretized in three values: high, medium and low. These values are easy to understand when the teachers or students study the ID's decisions to realize the reason of the decisions. The proposed ID offers two alternative values for taking a remediation action when needed: "yes", which means a problematic circumstance has been detected, or “no”, as “no remediation” action is required. This way ID is intended to support teacher with a suggestion on making corrective actions or, at least, on further investigating if a problematic situations requires their intervention.

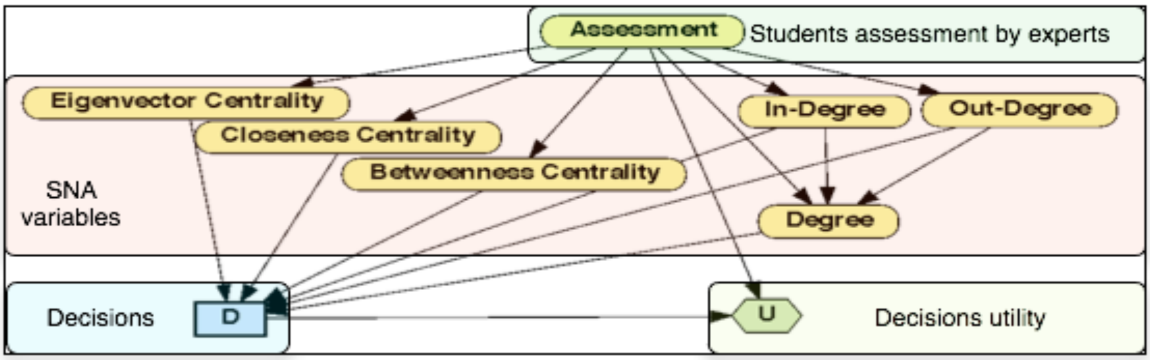

Figure 1. Network of the influence diagram

Preliminary study

We have used data from an online course, which has mimicked the characteristics of MOOCs, to fine-tune the ID’s network. The experience was done with 16 students of the subject "Complexity and Computability" in the 4th course of the degree of Computer Systems Engineering at UNED (Spanish National University for Distance Education). Each of these students were assessed to obtain their SNA centrality attributes. We then discretized the data in the aforementioned three values and the ID was tuned. Afterwards, the ID offered a decision for each combination of the SNA variables values. Results show that the ID is capable of identifying situations where remediation decisions seem to be appropriate according to the students SNA centrality attributes values.

Conclusions and future work

Our approach is meant to supply teachers with warnings on collaborative learning problematic circumstances detected from a SNA of students’ interactions in online courses. Preliminary results confirm that the approach can be used in a common online course and can be further investigated in large-scale learning situations such as those taking place in MOOCs, although this require further evidence. To clarify this issue we are considering larger scale learning situations where ID’s network probabilities are expected to be of practical use.

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Mapping Wiki User Contribution Types to Motivations for Participation: A Case Study

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Abstract: Different classifications of Wiki editor have been proposed. However, so far there has been no mapping between user classes based on their contributions and their motivations, which can be useful to design persuasive functions in wiki systems to increase participation. In this study, we attempt to bridge this gap by developing a customized MediaWiki system, used by 10 senior undergraduate students for their coursework. The participants were classified into three editors' classes and mapped to their motivation factors, using the system data and the results from the exit questionnaire.

Keywords: wiki editors, collaborative learning, wiki design, motivational strategies

Introduction

Users differ in their ways of using wiki systems. Many user classifications have been proposed. For example, based on users' frequency of editing, they have been classified as *passive, novice* and *committed* users (Bryant, Forte and Bruckman, 2005; Antin and Cheshire, 2010). Also, Gaved, Heath and Eisenstadt (2006) suggest a classification of wiki users, based on their editing behaviour or type of contribution, as *placeholders*, *completers* and *housekeepers*. Understanding users' motivation to contribute is important because it relates to the sustainability of an online community. Researchers have discussed wiki editors' motivations through interviews and questionnaires, and interpreting them from psychological perspective. Among these studies, wiki editors were generally treated as a homogeneous group (Rafaeli and Ariel, 2008; Ling *et al*., 2005). However, previous researches suggest that users cannot be treated equally (Orji, Mandryk, Vassileva and Gerling, 2013). Yet, no one has matched wiki editors' motivations to statistics of their actions or discussed their motivations based on their classes of editors. In this study, we propose to explore the motivations of different types of wiki editors by analysing their actions and questionnaire' responses.

Research method

We developed a research tool, a wiki system, called *WikiMentor*, which is a customized MediaWiki system with a content authorship module that mandates login for every user. *WikiMentor* is able to figure out the authorship of each character (or word, sentence) and send email notification to the authors when their contents have been modified. Also, changes made to editors' contributions are highlighted and they are able to accept or deny these changes, which are used to compute their reputation, using the formula $T = (r+1)/(r+s+2)$, by (Noorian, Marsh and Fleming, 2011). While the reputation value. However, they were aware that their contribution was rated.

Our participants were 10 undergraduate students of a computer science class on ethics, who engaged in four collaborative writing sessions required for their coursework using *WikiMentor*. The students were encouraged to contribute to the wiki assigned each week using pseudonyms. They could start a page, add, edit and delete contents. To ensure that students make meaningful contribution, their contributions to each wiki article were graded by a teaching assistant. Each student got notified by emails of changes made to their contributions and the resulting changes were highlighted within the wiki article page. Therefore, the user could either accept or reject the changes and this translated into a rating value of the change, that could be either positive (+1) or negative (-1), and was used in computing the reputation of the student who did the change as described in the previous section. For each participant, we collected data on the number of characters contributed and the number of characters of their contributions that survived revision by the other participants, the revisions they made, the time they spent making their contributions and revisions, the numbers of their revisions that were accepted or rejected by the authors. We kept an audit of their contributions, which they could view from the "history" tab once they logged in to the wiki system. At the end of the term, participants were given a questionnaire to evaluate their satisfaction with the wiki system and also to know what features of the wiki system enhance their collaborative writing.

Results and discussion

We used the number of characters contributed to each wiki article, number of edit times and the type of contribution (add, edit or delete) to classify the editors based on Gaved's (2006) classification. For every assignment, we classified the participant that made the first contribution – typically a plan for the article, as the *placeholder* editor for that page. Participants who edited others' contents were classified as *housekeeper* editors, while other contributors who were neither first contributors to the page nor engaged in editing others' contents, but were making new and complete contributions were classified as *completer* editors. We defined that each user belongs to a single dominant class in each assignment (Table 1). Since the *housekeepers* engage in many corrections on the entries made by other editors, according to Gaved *et al*. (2006), we assessed their classes by comparing the number of edits made by each participant against the average of edits for a wiki article, in order to classify them exclusively as *housekeepers*. The number of characters contributed by each participant was compared against the average number of characters contributed for the wiki article to classify users exclusively as *completers*. We retained the number of *placeholders* as they were, because there are no other factors that can be used to classify them, beside being the first contributor to every wiki article.

Wiki editors require motivation to enhance participation. Content analysis was used to analyze the questionnaire data. The results of content analysis over participants feedback is shown in Table 1.

Table 1: Classification of the wiki editors

Classification	Student ID	Shared Motivation	Differential Motivation
Placeholder	1, 8, 10	open contribution, email notification when changes were made to their contents, highlighting of the changes made to their contents, other editors accepting or rejecting their contents, and their perceived status to their peers.	Perceived status to peers (i.e. how competent peers think you are)
Completer	3, 6, 7, 8, 9, 10		highlighting changes made by others, other contributors accepting changes made
Housekeeper	2, 4, 5		marks, poor contribution by peers and obligation to fix these contributions

Conclusion

We classified users based on Wiki usage data and also matched the user classes to the feedback received by these users from the exit questionnaire. Our findings show that Wiki users require differentiated features to motivate participation, depending on the class of editors that they belong to. Specifically, *placeholder*s are motivated by their perceived status, or reputation, to their fellow editors. Also, we found that *completers* are motivated by the ratings, whether positive or negative, on their content changes that they get from their fellow editors. In addition, we found that *housekeepers* are motivated either extrinsically by the marks they get on their contents or intrinsically – by the wish to help improve the article or help their colleagues write better. A useful persuasive feature to motivate *housekeepers* would be a visualization of their editing statistics, since having the highest number of edit frequency in the Wiki system is a measurable factor that can be easily mapped to extrinsic rewards. Alternatively, intrinsically motivated housekeepers may be motivated by including a score of user ratings received by correcting other users' contents, demonstrating the helpfulness of their work to others. These design suggestions may be useful also for instructors applying collaborative editing assignments in their classes, since they can include tailored feedback to motivate their students depending on their editor type, which can be determined after the first assignment.

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Conceptualizing, Analyzing, and Visualizing Massive Data on Student Engagement in MOOCs: A Literature Review

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Abstract: MOOCs produce massive learning data that can provide insights on how students engage in these environments. This preliminary review examined 80 graphs produced in 20 empirical studies on student engagement in MOOCs. The review focused on the following questions: (1) What data has been collected to analyze student engagement in MOOCs? (2) How has the data been analyzed and visualized? The results show that different data sets were used and student engagement trajectories are often plotted in diverse ways.

Key words: MOOC, engagement, analysis of massive data, data visualization

Introduction

Massive Open Online Courses (MOOCs) have been criticized for high dropout rates. MOOC designers and researchers are therefore interested in understanding learners' engagement, why and when they leave, and how to prevent them from quitting. We need deep insights on student engagement. One natural resource to study this issue is the large-scale learning process data (e.g., tracking logs, discussion boards, and assessment results) automatically produced in MOOCs. Different from traditional learning data, these types of data are large in magnitude, cover diverse background of learners, and track relatively unrestricted sequence of leaners' interaction (DeBoer et al., 2014). Different researchers may collect data from different sources, conceptualize them in different ways, and present them in an array of graphs in order to make sense of learners' engagement. These diverse approaches motivated us to conduct this review study. Specifically, we reviewed empirical studies that focus on student engagement in MOOCs using large-scale data. Our review was guided by the following questions: (1) What data has been collected to analyze student engagement in MOOCs? (2) How has the data been analyzed and visualized?

Method

Our conceptualization of student engagement in a MOOC world involves three spaces: the user space, the MOOC space, and the interaction space. The user space includes students, teachers, teaching assistants, or other personnel. The MOOC space includes MOOC elements such as syllabus, video, text, and discussion forum. The interaction space focuses on how students engage in MOOC elements or social interactions. Here we focus on two types of *engagement that are related to course content*: (a) a student may directly engage in a content-related element (e.g., a lecture video); (b) a student may interact with others (e.g., comment on a discussion thread) in order to engage in the content. Under this framework, three major types of logging data can be collected: data about individual student profiles, data about learning processes, and data about student artifacts.

To gather relevant literature, we searched two electronic databases - Educational Resources Information Center (ERIC) and ACM digital library - and Google Scholar, using the following keywords: "MOOC," or "massive open online courses," and "data." We applied the following criteria to include the papers for this review: an empirical study, on a peer-reviewed journal, and including data visualization related to student engagement. The search resulted in 80 graphs from the 20 papers.

We coded each graph using three categories related to our research questions: *data sources* (sources of data), *student engagement* (student engagement throughout the length of MOOCs), and *space informed* from data (interpretation of graphs). Within *data sources*, we developed codes that separated *relational data sources* (data involves students making transitions between MOOC elements) from *non-relational data sources*. In *non-relational data sources*, *focused data sources* and *multiple data sources* were used to distinguish graphs that include less than or equal to two data sources from graphs that include more than two content-related data sources. Within *student engagement*, *engagement persistence* (EP), *engagement intensity* (EI), and *engagement in social interaction* (ES) were codes that reported graphs on students' learning trajectories over time, students' overall interaction with one or more MOOC elements without examining the temporal pattern, and student' overall interaction with others in the MOOC community respectively. Within *space informed*, *students' characteristics* and *characteristics of MOOC elements* were coded as two spaces informed by data.

Results

Table 1 shows the results of our coding. In terms of data sources, there are 62 graphs (in 19 studies) that used focused data sources, but only 14 graphs (in 7 studies) used multiple data sources and 4 graphs (in 3 studies) used relational data sources. For example, Kim et al. (2014) studied students' engagement peaks within videos whereas Santos et al. (2014) visualized students' funnel pattern of accessing multiple data sources, including all materials provided in MOOCs. In terms of space informed, there are 53 graphs (in 17 studies) that characterized students, while only 27 graphs (in 6 studies) that characterized MOOC elements. As an example of the latter, Fast et al. (2013) analyzed the amount of time students spent on each assignment to get assignment time distributions, which were used to determine assignment difficulty. In terms of student engagement categories, EI (52 graphs in 16 studies) was analyzed through all three types of data source interaction: focused data sources, multiple data sources, and relational data sources. In addition, there are 24 graphs (in 11 studies) that visualized EP, which gave detailed information of students' engagement behavior over time. Specifically, all 4 graphs that visualized ES used focused data sources. Among them, 3 graphs explained patterns of students' interaction with others using replying posts in discussion forum.

Table 1: Corresponding number of graphs (in number of studies) in different categories. A study may include multiple graphs, and therefore, can be categorized in multiple categories.

Data Sources		Student Engagement			Space Informed	
		Engagement Persistence (EP)	Engagement Intensity (EI)	Engagement in Social Interaction (ES)	Student Characteristics	MOOC Characteristics
Non-relational	Focused	18 (9)	40 (12)	4 (4)	35(14)	27 (6)
	Multiple	6 (4)	8 (5)	0	14 (7)	0
Relational		0	4 (3)	0	4 (3)	0
Total		24 (11)	52 (16)	4 (4)	53 (17)	27 (6)

Conclusion and implication

In this review, we found that the data sources selected by researchers included data about user space, data about student artifacts in MOOC space, and data about students' interaction with MOOC elements. Most studies in the collection used non-relational data sources, while only a few used relational data sources to show transitions of student engagement from one element to another. Investigating interaction transitions is valuable for MOOC designers because a MOOC is a complex world with lots of elements.

Student learning has been analyzed through bidirectional interaction between engaging in content provided in MOOCs and engaging in social interaction through forums and chat. When characterizing students, the literature explained that there are clusters of students who engage in MOOCs in both similar and different ways. When characterizing MOOCs, the literature showed that certain kinds of MOOCs could make students engage more. However, rarely, a study would provide detailed instruction on how to design corresponding MOOCs to facilitate different groups of students.

Student learning has been visualized in different kinds of graphs. Instead of visualizing data in a traditional way (line and bar charts), some MOOC-related studies investigated and visualized students' interaction trajectories over time (log plots). By understanding students' interaction trajectories, instructors can make interventions when students are found to be disengaged from MOOCs. However, these visualizations have been developed for researchers; little work has been done on visualizing the rich sources of data available for other stake-holders including instructors, students, and administrators.

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The Evolution of TrACE: Integration of a Collaborative Learning Platform in Flipped Classrooms

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Abstract: Web-based video players play an increasingly larger role in educational media, but these systems often fail to support collaboration among students. Utilizing design-based research and learner-centered design, TrACE was developed as a collaborative system in the classroom that fosters student participation. This paper follows TrACE through three implementation phases in a flipped Calculus I course over three semesters. The first two iterations saw limited use, but found a positive correlation between contributing and viewing posts with student performance. It was also found that participation depended on instructor intentionality in using the system for class. It was in the final iteration, the semester with notable pedagogical changes and intentional system use, which found significant results.

Keywords: collaborative annotation, video, flipped classrooms

Introduction

Educational media is playing a larger role in classrooms. However, these uses of instructional media reflect primarily a "learning by knowledge transmission" view, rather than a more active style more closely aligned with cognitive theories, such as collaborative learning. Collaboration, which offers several benefits in comparison to knowledge transmission, plays a role in active learning and student knowledge development, thus promoting a knowledge building community. Additionally, collaborative learning creates more opportunity for a shared understanding of class content (Scardamalia & Bereiter, 2006; Guzdial & Turns, 2000).

Educational software must be designed around the needs of learners, an approach referred to as *learner-centered design* (Quintana, Krajcik, & Soloway, 2000). Technology often fails to address learners' goals, activities, and educational contexts, limiting the opportunity for positive impact on learning. Our aims are to address these barriers through TrACE, a web-based media player intended to promote collaborative, asynchronous discussion of video content (Dorn, Schroeder, & Stankiewicz, 2015). Learning environments, such as TrACE, must offer the essential tools to address learners' varying levels of understanding and provide effective scaffolding to promote knowledge advancement (Guzdial & Turns, 2000). An ecologically valid methodology to incorporate elements of learner-centered design is design-based research wherein a learning environment is iteratively and holistically evaluated using real classroom settings(Barab & Squire, 2004). In this study, we observe the extent to which features of TrACE are integrated into classroom practices and to see how and to what extent changes between iterations correlates to student participation, class performance (i.e. final grades), and collaboration.

Methods

TrACE is designed using an iterative, design-based approach. The broader goal of design-based research is to empirically investigate how systematic changes to a learning environment influence learning and practice, providing logical chains of reasoning for modifications made in later iterations that are supported by empirical data and theory. Factors such as instructor and student feedback, bug reports, and user behavior analysis inform the changes in features and pedagogy from one iteration to the next, guiding the next phase of TrACE's design. A flipped undergraduate Calculus I course taught by one professor over three semesters was observed. Flipped classrooms are an active learning approach to engaging students both inside and outside of the classroom (Demetry, 2010). Table 1 describes an overview of the key features of TrACE in each iteration as well as the pedagogical changes the instructor made to her course.

In the pilot, there were few posts to the system and limited use by the instructor. The next iteration included the addition of new annotation types, such as forced pauses. A forced pause allowed the instructor to encourage learners to reflect on the material in the video at the time where the annotation was placed. These were added to elicit responses and questions from students who would not otherwise participate. The Fall 2013 iteration of TrACE consisted of 17 consenting student participants from a class of 25 that produced 11 annotations overall. The instructor made 18 annotations, and forced pauses were only used to direct students.

Table 1: Key feature and pedagogy changes in TrACE

	Pilot Study	Iteration 1: Fall 2013	Iteration 2: Spring 2014
Features	• Video playback • Annotations • Activity logging	• Email notices • Custom annotation types • Instructor forced pauses • Question scaffolding	• Private replies to instructor • Forced pauses allow replies private replies • Anonymous posting • Reflect and reminder annotation types
Pedagogy	• Fewer videos • Last 5 weeks of course	• Whole semester • No participation expectations • No instructor guidance	• Intentional fading of prompting • Participation grade • Instructor aggregate of feedback from TrACE lead to class discussions

In general, students watched videos without discussion. This implied that there is a necessity to make intentional use of TrACE in the classrooms; more value on the system and stronger scaffolding is most likely needed to facilitate collaboration among students. In the Spring 2014 iteration, forced pauses allowed for private replies to the instructor. Also, anonymous posting encouraged participation of students resistant to expressing a lack of understanding. There were also a number of pedagogical changes made by the instructor, such as scaffolding responses using forced pauses with replies. There were 16 consenting students from a class of 23 that produced 797 annotations. The instructor posted the remaining 290 for a total of 1087 annotations for the class. There was overall greater system use than any previous iteration, and 42.3% of all student posts were made using the new anonymous posting feature. Comparing student behaviors to performance data (final grades in the course) using Spearman's rho correlation, there is a distinct difference between generating content (posting original top-level annotations) ($r_s = 0.47$; $p < .05$), replying to existing content ($r_s = 0.31$; $p = 0.13$), or simply observing existing content (viewing annotations) ($r_s = -0.08$; $p = 0.39$). Of these activities, generating content had the strongest and most significant correlation to student performance.

Conclusions

This study finds that there was a significant difference in activity between the first and second iteration of TrACE. There were several key system and pedagogical changes, specifically adoption of the system by the instructor, which made a major impact on student participation. While our goal in every lifecycle of TrACE was to increase student participation, it was only in the final semester, the only semester with notable pedagogical changes and intentional use of the system, which saw significant results. The effects seen in TrACE reflect existing pedagogical theories. That high class performance correlates more strongly to generating top-level content supports the idea of knowledge building pedagogy, where discourse (e.g., generating annotations) should be seen as a first-order learning activity. However, we also find that there are students that quickly embrace the system while others seem to struggle. One issue with the current scaffolding system is that every video is the same for all students without taking into account their current skills or readiness to contribute to discussion. We can only obtain these insights about content by asking students, so our upcoming goals within TrACE will be to both shift activity to the public space to increase student-to-student collaboration as well as begin obtaining qualitative data to understand why the system is used in these ways. The completion of this study will inform future questions for interviews, surveys, and focus groups with students.

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How Collaborative Successes and Failures Become Productive: An Exploration of Emerging Understanding and Misunderstanding Turning Points in Model-Based Learning with Productive Failure

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Abstract: While computer modeling, productive failure, and contrasting cases have all been shown to support deep learning, the micro-level mechanisms supporting collaborative success in these processes remain relatively unknown. This paper reports on a detailed exploration of turning points in emerging understanding and misunderstanding in two dyads working through model-based learning activities in a productive failure learning design.

Keywords: conceptual change, collaborative learning, science education, turning points

Introduction

Computer models (Nersessian, 2008), productive failure (Kapur & Bielaczyc, 2012), and contrasting cases (Gentner, Loewenstein, & Thompson, 2003) have all been shown to support deep learning and transfer. From a sociocultural perspective, knowledge is co-constructed through interactions (Säljö, 1991). As few studies have addressed how emerging knowledge relates to interaction over time (Damşa, 2014), the collaborative mechanisms underlying how these processes work, particularly when all are combined, remains relatively unknown. In an initial exploration of these micro-level interactional mechanisms (Portolese, Markauskaite, Lai, & Jacobson, 2015), one of our findings was that segments of misunderstanding seemed to propel extended correct understanding. However, it remained to be explored what exactly occurred at these critical turning points. This paper reports on a detailed exploration of these turning points in two dyads. This initial exploration is an innovative suggestion for how a multi-layered, temporally-sensitive analysis can be applied to understand the mechanisms of emerging understanding and misunderstanding in computer-supported collaborative learning environments. It also aims to provide a foundation for further analyses and theory development.

Method

Two dyads were selected from a larger design-based research study that investigates how students learn complex climate systems knowledge with agent based modeling tools in a productive failure context; the selected dyads improved substantially on target complexity concepts (Kelly, Jacobson, Markauskaite, & Southavilay, 2012; Portolese et al., 2015, Jacobson & Markauskaite, 2015). Four Year Nine classes at a selective Australian girls high school collaborated on inquiry activities with either one or two (contrasting cases group) NetLogo (Wilensky, 1999) models. Process data included video captures of students' faces and computer screens, transcript of students' discussion, and written responses to activities. The interactive process data was analysed at three increasingly large parallel grain sizes – Idea, Understanding, and Experiment – using a scheme based on impact coding (Kapur, Voiklis, & Kinzer, 2008; see Portolese et al., 2015). In this approach, each segment is categorised as +1 (towards solution), 0 (not changing progress), or -1 (away from solution).

Our multi-layered parallel impact coding gave a rich picture of understanding changes during students' problem-solving interaction. At the Understanding Level, turning points were defined as when the impact direction changed and continued for at least two segments when tackling a conceptual issue (e.g. -1, +1, +1). Across the two dyads, 26 turning points were identified (17 positive towards understanding, 9 negative towards misunderstanding). For each turning point, the Idea Level segments were analysed: a) in the Understanding Level segments before the understanding changed, and b) in the subsequent Understanding Level segments during the change itself, until two Understanding Level segments in the new direction occurred (see Table 1).

Findings and implications

Three key patterns will be discussed. First, incorrect observations were common, both before positive turning points and as the substance of negative turning points. Students grounded their knowledge construction in their observations; when these were incorrect, misunderstandings emerged. Follow up correct observations usually reversed this pattern. Second, missing the bigger picture was an elusive problem. Similar to incorrect observations, the nature of this issue means students may not realise a problem exists. Additional observation, experimentation, and elaborated discussion supported students in approaching realisation of the bigger picture. A third pattern, poor experimental design, was simpler to turn around, as this resulted in confusion more overtly. Understanding turned largely through predictions that focused, and hence improved, experimental designs.

This initial yet deep analysis unveils some of the collaborative mechanisms that may support changes in emerging understanding and misunderstanding. The results suggest that positive turning points most often appeared with additional experimentation and observation. For practice, students should be encouraged to generate as many diverse ideas as possible (Kapur & Bielaczyc, 2012), and in particular, make predictions and careful observations before developing extended understandings. Perhaps technical or representational errors can be prevented, as these misunderstandings appear less productive. More research is needed to unpack these issues, which is the focus of our current research program.

Table 1: Selected turning point patterns

Before Turning Point	**Turning points**	**Key Idea Level characteristics during turn**	**How understanding turned & emerged**
Incorrect observations	4	Correct observations and suggestions	New observations
Poor experimental design	4	Correct predictions and experimental design	Predictions and experimentation
Missing bigger picture	5	Correct observations, explanations, understanding, and experimental design	Experimentation and elaborated discussion
Correct explanation; Solved technical problem; Challenged incorrect idea	3	Incorrect observations	Incorrect observations
Correct task orientation; Focused experiment; Partially correct understanding	3	Incorrect/correct observations, incorrect explanations and misunderstanding	Focusing on wrong details (Missed bigger picture)

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The Development of Collaborative Practices in Introductory Engineering Courses

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Abstract: Mapping the development of collaborative practices in groups who work together repeatedly is important to understand how best to support collaborative learning activities in classrooms, where repeated interactions are common. Drawing on data from 19 groups who worked together on engineering tasks over a four-week period, we examine the emergence of stable practices, the types of interactions, and the use of technology to support the creation of shared representations.

Keywords: Temporal aspects of collaboration, STEM, higher education, collaborative practices

Introduction

An increasing emphasis on using collaborative learning in science, technology, engineering and math (STEM) disciplines has led to numerous new curricula in universities around the world. Students who would typically have worked individually, or watched as instructors worked through problems on a chalk board, are now being asked to work collaboratively to solve more complex problems, applying their developing knowledge to realistic problems. The goals of these new activities are to provide students with the opportunity to engage in authentic problem solving, while also developing collaboration skills that they will take to the workplace. In order for this to be successful, however, students and instructors need to understand the collaborative process, and be supported in their development of collaborative practices (Barron et al., 2009).

To fully support students engaged in these types of activities, we need to understand the unfolding of collaboration over time, and understand how the issues that they encounter in building joint knowledge change over the course of multiple activities. The recent focus on the temporal aspect of collaboration has been more concerned with temporality within a single activity (e.g. Kapur, 2011), however, we argue that for students working together over a number of weeks, practices develop both within each activity, and over multiple activities. Tracing this progression will provide deeper understanding of the types of collaborative engagement more common in classrooms in higher education and during the K-12 years.

Methods

Participants were from a large introductory engineering course in a public university in the US. Approximately 650 students are enrolled in the course; they met weekly in one of 15 discussion sections of about 45 students. The course was in its first semester of implementing collaborative problem-solving activities in the discussion sections; students were assigned to groups of between 2 and 5 students for these activities. Two teaching assistants are present in each discussion session. Students and teaching assistants attend the same sections each week, although some movement occurred between sections in the first weeks of the semester, and both students and teaching assistants attended different sections when they had scheduling conflicts.

Video data were collected from five of the 15 discussion sections. Four groups per section were selected to videotape each week; groups were selected based on their location in the classroom, with one group in each corner selected. The five sections were selected based on percentage of students consenting to be videotaped, agreement of teaching assistants to participate in the study, and the research team's availability. During October, the students were asked to remain in the same groups for every discussion section. Due to a attendance issues, we have video from a small number of complete groups every week, and a smaller number of complete groups for the rest of the month (see table 1); data on incomplete groups was also collected when students were absent. A total of 76 students were videotaped over the four weeks in 19 groups. Each group was recorded with a video camera and table microphone placed as close to the center of the group as possible.

The technology

This dataset was collected at the beginning of a multi-year project focused on the development of sketching tools to support collaborative problem solving on interactive surfaces such as tablets. As such, the goal was to collect baseline data about the collaborative practices that students engaged in without intervention. Two forms of interactive surfaces were provided during the discussion sections – either a 10” tablet or a 27” tabletop computer. Basic sketch applications were available on the tablets. Each group was given one device, which they could use as they wished. Use of the technology varied, with about half of the groups choosing not to use them. When groups used the tablets, the sketches were saved and analyzed together with the video data.

Table 1: Number of full groups recorded over four weeks

Number of groups	Number of weeks all students were present	Total Number of students
3	4	13
8	3	32
7	2	27
1	1	4

Analysis

The data is being coded to examine the use of technology, interaction patterns and collaborative practices within the groups. The use of the technology was coded every five minutes for whether it was used, if one or more students use it during the activity, and if the content created was created jointly or shared with their teammates. Every minute, the interaction behaviors were coded as showing 1) no interaction, 2) off-task interaction, 3) on-task interaction and 4) teacher intervention or whole class discussion. Each segment could receive more than one code (of 2, 3 and 4), and a time segment was identified as on-task if at least one task-related utterance was made. The on-task segments will be transcribed and coded to analyze how students respond to ideas proposed by their teammates. The changes across the month will be analyzed and reported.

Findings

Initial results indicate that many group sessions begin with off-topic conversation and/or no interaction between group members. Frequently the off-topic conversation occurs between some of the group members, while others read the worksheet silently, began to work on it, or continued typing on their phones (when screens could be seen this was frequently identified as texting). The length of time students were not engaged in the collaborative activity before starting to jointly work on the problem was reduced over the four weeks – with groups getting more quickly involved in the task together as the weeks progressed. In addition, there were fewer ignored attempts to get the group working on the task each week. In the early weeks, one student’s content-free prompts for the group to start working were often ignored, whereas in later weeks, these prompts tended to be content-driven and responded to by the group members.

The patterns of responses to ideas also changed across the task and weeks, once students were working collaboratively. While the initial proposals of ideas were often responded to with clarification about the task itself, over time, responses became more substantive. Rather than asking the initiator to clarify what section of the task the group was meant to be working on, the person responding tended to ask for clarification about the statement, what part of a diagram the student was referring to, or how they were making sense of the task.

Conclusions and implications

Understanding the development of collaborative practices in groups who work together over the course of four weeks provides insight into the issues that groups encounter initially, and where they need support. In our initial analysis, groups appeared to have difficulty initiating collaborative, on-task conversation and engaging their peers in substantive conversation about the task. Over time, the students developed ways of providing prompts to initiate work that were grounded in the task (rather than generic) and were often responded to by requests for content-specific clarifications. Further analysis of the responses will provide a deeper understanding of the practices seen in groups, the issues that persist and where intervention could support their learning opportunities.

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Exploring the Interplay of Various Support Forms in CSCL Settings

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Abstract: This paper reports on a study of students' development of conceptual understanding in a computer-supported collaborative learning (CSCL) setting. The study provides an insight on the interplay of social and material factors. Findings show that social and material mediational tools dialectically determine how each is used to support learning: peers elicit each other's understanding, digital tools are used as depictive resources, the task frames peers' discourse, teacher interventions organise learning and structure students' knowledge.

Keywords: computer – supported collaborative learning, science education, peer collaboration, teacher intervention, task design, digital tools

Introduction

The focus of the current study is on students' development of conceptual understanding in a CSCL setting within science education. During the last decades much research has been undertaken in order to scrutinize the way support in forms of peer collaboration, task design, teacher intervention or digital tools impact students' learning. Several CSCL-related studies provide valuable knowledge about the effect and impact of each of the mentioned support aspects. Nevertheless, a characteristic feature of the majority of the studies is that they tend to have a one-dimensional focus in the sense that they focus on one support aspect in search for possible effects on students' knowledge or inquiry skills acquisition. In naturalistic educational settings, however, various support forms coexist and are applied simultaneously. Hence, understanding students' learning process in the space created by these forms of support is important. This study aims to contribute to the existing body of research by providing a deeper insight on the interplay between peer collaboration, task design, visualising digital tools and teacher intervention in students' learning process in a naturalistic classroom setting. Cultural Historical Theory (Edwards, 2005; Galperin, 1969; Vygotsky, 1981) constitutes the applied theoretical perspective of the study. This enables conceptualising the complexity of students' learning process in naturalistic CSCL settings and exploring the way students' conceptual sense-making is formed in the interplay of coexisting potential support forms. The following research question is addressed:

- What characterises students' learning in the settings with the support in the form of peer collaboration, digital tools, task design and teacher interventions?

Methods

The empirical data was collected in spring 2014. The participants were 76 lower secondary school students (aged 15-16) and their teacher. The empirical setting is a project on Genes and Inheritance taking place in 12 school lessons over the course of 4 weeks. Teacher-led lectures, whole class discussions and task-oriented group work were accompanied by the use of various digital text-based and visualising digital learning resources (e.g. animations and depictions). Group-based settings where students engaged with reasoning tasks, i.e. tasks aimed at triggering discussions and shared reflections about the topic the students had been introduced to in preceding whole class sessions, constitute the analytical focus (Furberg & Arnseth, 2009). These settings were designed by the researchers with the aim of creating a situation where students would apply their understanding of a specific problem supported by peer collaboration, teacher interventions, visualising digital resources and a task, in this setting, the task with a compare-and-contrast design.

Analysis

The main data material constitutes of 25 hours of transcribed video recordings of the students' and teacher's interactions in whole-class and group work settings. The study presents detailed analysis of interactions taking place in two student groups during their work with a designed reasoning task about meiosis and mitosis, a topic proven to be challenging for students. The analytical procedure employed is interaction analysis (Jordan & Henderson, 1995) focusing on how students make sense of the concepts at issue, as well as their interaction with the digital representations and the teacher.

Mira: Is this, for example, a copy of this? ((points at the blue and the red chromosomes on the screen))

Chris: No! These two blue are just one chromosome with two identical – This is a copy of that one.((points at the copied chromosomes))

Mira: Yes, this is a copy of that one.

Chris: Yes, in fact, it's just one blue and one red that make a pair of chromosomes.

Helene: In a normal process of mitosis.

Mira: Yes.

Chris: Yes. So, now in E – If this was a normal process of cell division, this part would have replaced that part and this part would have replaced that part ((points at the red and blue stripes on the chromosomes)), so you would have had two similar chromosomes.

Mira: Now I understand what you mean.

Findings

On a general level the empirical analysis displays the complexity of naturalistic learning settings where simultaneous and co-existing support forms are provided, and that students' sense making is intertwined with the interplay of *digital tools*, *teacher interventions*, *peer collaboration* and the *task design*. These mediational tools interplay to the extent that they dialectically determine how each is used to support student learning.
On a more specific level, the study shows the significance of:

- support provided by *peers*, in the form of elicitation of mutual ideas and understanding, posing questions, initiating discussions
- *digital representations* as central depictive resources for the students enabling them to explicate their (mis)understandings for each other
- *task design* provided support in the form of guiding the students' analytical attention towards the similarities and differences in depictions, which in turn enabled them to provide valid explanations about meiosis and mitosis.
- *teacher interventions* that provided support in organising, structuring and eliciting students' understanding, helping students to frame the concepts into a broader system of scientific knowledge.

Implications

The findings of the study have theoretical as well as educational significance. Concerning the theoretical significance the cultural-historical lens conceptualises the complexity of students' learning process in naturalistic CSCL settings. Furthermore, the interaction analytical approach enables to see how and why support in form of peer collaboration, visualising digital tools, task design and teacher intervention are intertwined in students' learning process. Concerning the educational significance, the study provides an insight into the design of learning situations where various forms of support are provided. When designing CSCL settings is it recommended accommodating for the interplay of social peer collaboration and teacher interventions as well as material digital tools and a designed task. Identifying the right juxtapoints between these support forms, as the present study shows, may ensure their joint beneficial contribution to students' conceptual sense making.

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University Students as Networked Learners? Evaluation of a cMOOC in Higher Education

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Abstract: Data on connectivist courses with a student population is scarce as connectivist MOOCs (cMOOCs) mostly focus on and attract professional participants. The poster presents evaluation data of a cMOOC that has been conducted with mainly student participants from three German universities.

Keywords: MOOC, networked learning, connectivism, higher education, evaluation, case study

Introduction

The concept of connectivism (Siemens 2005) and the emergence of massive open online courses (MOOCs) have triggered an ongoing debate on perspectives, possibilities and obstacles of learning in open networks in higher education. Discussion centers i.e. on prerequisites on the learner side for participation in connectivist courses (e.g. Kop 2011) and the question in how far open, networked learning can be realized within the institutional constraints of universities (Pscheida et al., 2013). Focus of the combined qualitative and quantitative analysis are the questions to what extend an experience of open networked learning can be provided within a university course and which learning outcomes can be identified.

Networked learning in cMOOCs: Background and state of the art

Learning in cMOOCs postulates a decentralized infrastructure for learning and network building and a constitutive influence of the participants on the course (vgl. Saadatmand & Kumpulainen 2014).
Research on learner experience and learning outcomes in cMOOCs indicates an important role of teachers as facilitators within the process of learning (e.g. Cormier/Siemens 2010, p.36). Kop (2011) shows also that networking and interaction with others can foster a positive learning outcome. Other authors emphasize the beneficial effects of networked learning in cMOOCs on the development of participants by an “emerging and growing practice across the learners” (Mak, Williams & Mackness 2010, p.283).

Case study: “Saxon/Siegener Open Online Course” (SOOC)

Background of this paper is the case of a cMOOC called SOOC (Saxon/Siegener Open Online Course), which was developed and implemented as an academic innovation project in summer term 2013 as SOOC13 (www.SOOC13.de) and winter term 2013/14 as SOOC1314 (www.SOOC1314.de) by three universities in Germany (Dresden, Chemnitz, Siegen). The course on learning and teaching with social media was organized via a central weblog, which supplied participants with impulses and materials (texts, videos, links). All organizational information, a blog aggregator to collect course-related blog posts and tweets could be accessed there. A series of expert talks in form of regular live sessions via Adobe Connect provided additional input and were the highlight of each course section. In both courses students were the main group of participants. In the SOOC13 altogether 56% students took part, while in the second course 61%, indicated student status or a certain study program in the registration form. Additionally, the SOOC was also open to high school teachers and other interested people. Overall, a number of 242 participants for SOOC13 and 159 participants for SOOC1314 had registered. Of those students who planned to earn Credit Points, each time about 30% have done so successfully.

Database and methods used

The evaluation results presented are based on a triangulation of different data sources and methods: participants blog-postings and comments (SOOC13/SOOC1314: 38/51 participants weblogs; 272/310 blog postings by participants; 269/445 comments on blog postings) as well as data from online questionnaires used at the beginning (99/52), in the middle (28/29) and at the end (30/24) of each run were analyzed via descriptive statistics, qualitative data in form of participant blog postings as well as participants feedback given in the closing workshops of each course were analyzed via content analysis.

Findings

Challenge and excessive demand

Throughout the course, but especially at the beginning and in the first weeks, the dominant topic of student experience was the experience of being challenged and of excessive demand connected to the specific unfamiliar course setting. Students reported feeling stressed through a variety of issues including: blurred boundaries between study and leisure, constant availability, openness to the public, information overload, uncertainty on meeting demands, high amount of time spent, familiarization with social media tools, fear of missing something, necessity to change personal internet-routines, uncertainty on learning content. But analysis also provided evidence that students conceived and searched for challenge as occasion to learn.

Networking

Interconnectedness and interaction are as described above of paramount importance for the concept of cMOOCs and have been associated with positive learning outcomes (e.g. Kop 2011). In the SOOC, participants' reported feeling of interconnectedness improved between the two runs according to the mid-term surveys: While in SOOC13 59% agreed to feel well interconnected this number could be raised to 84% in SOOC1314. Within SOOC1314 two innovations were introduced that might have had an impact on this change: One comment of a blog post in each thematic block was mandatory in the second run for those who wanted to receive ECTS and direct timely written feedback and badges were introduced, possibly increasing felt presence of instructors.

Learning outcomes

In the final surveys of both course runs 41% (SOOC13) and 48% (SOOC1314) of the participants agreed ("fully agree" or "rather agree") to "reflect learning more consciously". The experience with new tools and practices could lead to a permanent integration into personal learning environments and practices as nearly one third (SOOC13: 28%, SOOC1314: 27%) of the respondents stated they'd plan to continue to use their course weblog for personal learning and knowledge management.

Summary

SOOC succeeded in transferring the concept of cMOOC to the institutional context of higher education and university courses. Reasons for the dominant feeling of challenge reported by participants were aspects related to orientation, structuring and participation that are inherent to learning in open, decentralized environments. The development and reflection of personal practices and resources to cope with these challenges could be fostered by the course as analysis shows. Thus, SOOC supported the acquisition of reflected action in media cultures. In this sense, following Mak et al. (2010) a cMOOC in higher education can contribute to the development of practices of networked learning and strengthen the capability for self-organization in the context of informal lifelong learning.

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Use of a CSCW Platform in Reunion Island University

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Abstract: We study the traces left by various groups of students on a CSCW platform at Reunion Island University. By observing the functionalities used and the size of the groups we note that, most of the time, the platform is not used for collaborative work. Furthermore, according to the academic programs, use can be very different from one program to the other. At the time the MOOCs are developing, those results could pose problem.

Keywords: CSCW, higher education disciplines, MOOC, trace analysis.

Introduction

The Reunion Island University is a small university in the Indian Ocean. It hosts more or less 12,000 students per year. It uses essentially two distance learning devices: Moodle for eLearning and a Computer Supported Collaborative Work (CSCW) platform, called "Bureau Virtuel" ("BV") which is used only in five universities in France. For the moment, Moodle is used effectively for two goals: courses uploading and exams; BV is used for sharing. So we looked more closely at the BV. We wanted to know if this sharing has consisted in collaborative work. For this, we have studied traces left by students on it. First, we will see that we confirm the results of other researchers (Bruillard & Baron, 2009) about collaborative work in French higher education: we are, for now, still very far from what is called collaboration. Then, we will see that, according to academic programs and levels, the use of the platform can be very different. This has not been showed yet in other researches, as far we know.

Methodology

In Reunion Island University, disciplines are gathered together in what is called "components" or "faculties". Here, we analyze the traces left by students on the CSCW platform distinguishing three components of a same campus (6407 students): "Law and Economics" (abbreviated "LE"; 2581 students); "Literature and Humanities" ("LH"; 2493) ; "Science and Technology", ("ST"; 1333). We also look at the different levels (year of training): Licence/Bachelor's degree (3 years : L1, L2, L3), Master (2 years : M1, M2) and PhD because from one level to another there can be very large differences as will be seen.

The "Bureau virtuel" is a CSCW platform which allows to create groups on it and to share in these groups: folders, documents, URL, contacts, calendars, forums… Each year there is a students' training to the main functionalities of the platform so they know how to use it. As we study collaborative work, we were interested to the different groups formed on the platform and, for each group, to the traces it had left (Simon, 2009). There were 646 groups: LE 184 groups gathering all together 80% of their students, LH 203 groups, 30%, and ST 259 groups, 86%.

The traces to which we had access were completely anonymized. Data we got have been related to the component to which the group belonged and to the level of study (licence, master, PhD).

Results and discussion

The platform of Reunion Island University is rarely used for collaborative work. This appears through the main features used. Some tools that can be used for collaboration or cooperation are very little used whatever the component. Thus, "notes" and "tasks" that allow planning joint work are not exploited. URL deposits are also rarely used (0.7 URL per group). Similarly, while the forums are also considered very popular tools for students, they are rarely used (only 1.4 message per group). The use of the diary or calendar seems not uniformly spread across all groups only 29 have performed 95 or more events. Ultimately, the only feature used by all groups is the documents deposit. However, the groups from the LH component have fewer documents, in average, than those from DE or ST (20 in LH vs. 35 in DE and 36 in ST). *We can see also that the work is not collaborative through group sizes*: most of the groups have a size greater than 20 members (from 51 on average in L1 to 3 in PhD). Thus, this platform is mainly used to pool or disseminate documents. It is only in the higher levels (especially PhD) that groups have characteristics consistent with those of collaborative work. This result on the low use of the platform, confirms those of others researchers (Bruillard & Baron, 2009).

More interesting is the relationship between this use and academic programs. Depending on the discipline, all students do not use the BV systematically. While 86% of students of Science and Technology disciplines or 80% of Law and Economics had to use it, only 30% of students of Literature and Humanities have practiced it. These disparities change when we look more closely at a possible CSCW use: 10% in ST vs 5% in DE and LH. So, if more students in DE use the CSCW platform than in LE (80% vs 30%) they don't use it more for collaborative work. It seems that it is in ST that the use is more for collaboration. Maybe, this is to be compared with what Endrizzi (2010) says: in French universities, it is paid more attention in science and technology, than in others disciplines, to the internal organization and educational coherence of the course. Anyway, here we find this extreme heterogeneity between disciplines that Rey (Rey, 2005) has observed in the training plans of the different curricula in French higher education.

This is problematic when it is considered that the Ministry plans that teaching in higher education relies more and more on Massive Open Online Courses (MOOCs). MOOCs are based on various forms of collaboration (Blom & al, 2013). Thus we may wonder if the students, at least those of the Reunion Island University, will be prepared to face. Their only use of social networks should not be sufficient because it has been shown that digital natives do not necessarily have sufficient mastery of the tools they handle (Baron & Bruillard 2008). They must therefore be trained and not only the students of Sciences and Technology or Law and Economics but also and particularly those of Literature and Humanities. We insist on this point because students of Literature and Humanities come from more socially disadvantaged environment than those in Law and Economics, or Science and Technology (Rey, 2005). So we see that those students accumulate disabilities. In one way, that confirms the relationship between the "digital divide" and the "social divide" (Van Dijk, 2006).

This study doesn't give any explanation to those results. Getting these explanations will be the work of the "Digital Observatory" that the University has established. We conducted interviews with a teacher of each component to have a beginning of answer. It appears that, most of the time, they use the tools, not for teaching better, but because they cannot do otherwise. For example, the document uploading is used by all components because the budget for photocopies decreased. Another example, in Law and Economics, they use Moodle because it allows exams for large cohorts of students and it marks them automatically. However, as we can see, this is less pedagogical reasons than economic reasons. Thus we have to go further in the study. This is the reason why the "Digital Observatory" has launched a big investigation among students and teachers. The results of this investigation should permit to answer to the questions why the platform is so little used for collaborative work, why the components don't seem to use it in the same way and what we have to do to change this trend.

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Paper-Based Tabletop Application for Collaborative Chinese Character Learning

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Abstract: Although positive effects of computer technologies to improve vocabulary learning have been widely reported, most of these technologies are designed specifically for individual learning, or disregard formal classroom learning. In this paper, we present the design rationale (including specific requirements of Chinese character learning) and the implementation of an interactive tabletop system that uses augmented paper interface elements to aid in collaborative Chinese character learning in classrooms.

Keywords: paper-interfaces, tabletop, Chinese character learning, collaborative language learning

Introduction

So far, technological innovation in Chinese language education has mostly targeted learners' structural understanding of the logographic system beyond rote learning and mechanical practice (Wing et al. 2003). The advent of touch-screen devices has shifted the design focus from simple visual aids to interactive interfaces. However, existing proposals tend to focus on content delivery, neglecting the use of these new technologies to support interaction and collaboration (Kukulska-Hulme & Shield, 2008). Furthermore, like most other systems for vocabulary learning, these are designed for individual learning, and disregard formal everyday classroom settings. This paper explores the potential of interactive tabletops for enabling collaborative language learning in classrooms, through the pedagogical design and technical implementation of an augmented paper application for Chinese character learning. We thus seek to arouse CSCL researchers' interest and discussion towards collaborative language learning in general, and the potential of tabletops for use in language classrooms.

Hanzible: Tangible interface and activity for Chinese character learning

Hanzible, our paper-based system to aid in Chinese character learning, is inspired on TinkerLamp (Fig 1a), a tabletop environment that uses fiducial markers to track paper elements like sheets, cards or other tangibles across the table (Bonnard et al., 2012). This augmented paper form factor aims at exploiting our ability to handle physical objects (and concretely, paper), thus making interaction with the system more natural, while affording face-to-face conversation and collaboration. The user interface of Hanzible is composed of two main parts: a) paper sheets with fiducial markers, which act as the main workspace for each activity (Fig 1b); and b) several sets of cards, which represent various character components (Fig. 1c), as well as system actions (Fig. 1d, 1e). The visual output of the system can be projected over the paper elements (as in TinkerLamp), or in a separate computer screen showing also the video feed of a camera with the workspace and the paper elements.

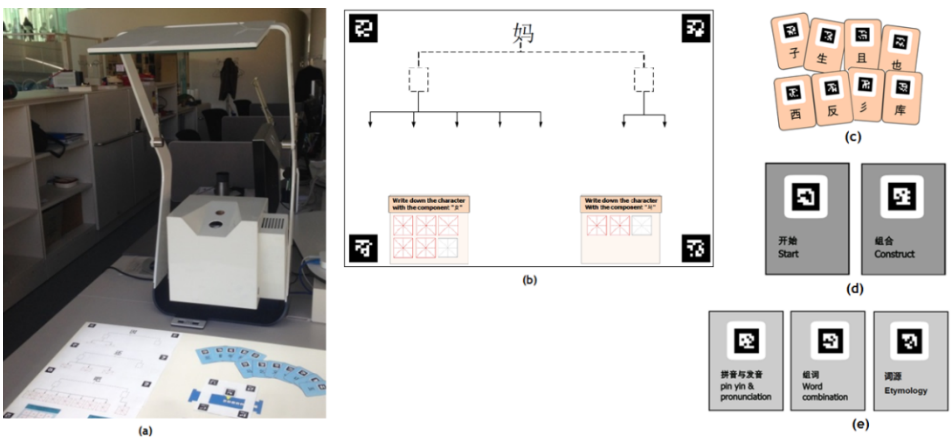

Figure 1. Paper-based user interfaces: (a) TinkerLamp; (b) Paper sheet; (c) character component cards; (d) action cards; (e) hint/exploration cards

As a first approach to paper-based collaborative language learning activities, we have developed a set of exercises about *composing and decomposing Chinese characters* (source code available as open source at https://github.com/chili-epfl/qimchi/tree/chinese). As shown in Figure 1b, a paper sheet with a Chinese character printed on top (e.g., 妈, meaning "mother"), can be decomposed by the system into its components (e.g., "女" and "马"). Afterwards, students can construct new characters containing those components, by picking other component cards to combine with (Fig. 1c). The properties of these newly constructed characters (their pronunciation, calligraphic stroke order, example word combinations, etc.) can be further explored using additional hint cards (Fig. 1e). Students can also write down the newly constructed character using normal pen and paper, following the stroke sequence animation. Thus, this activity combines ease of handling and playful exploration, to address one of the main challenges in Chinese character learning: the retention and retrieval of the all three elements of a character (sound, shape and meaning) in the learner's long-term memory (Shen, 2004). It is also worth noting that the learning materials (e.g., the sets of Chinese characters and components), have been selected and developed in collaboration with institutions and practitioners (such as the Confucius Institute), and are in fact based on their official syllabus for first-year learners of Chinese.

Enabling collaborative Chinese character learning

One of our main goals when designing and implementing the Hanzible system was to enable interaction and discussion while learning Chinese characters. The tabletop form factor and the ability of paper tangibles to be handled simultaneously by several people, lend themselves well to this aim (Dillenbourg & Evans, 2011).

Also, such tabletops can be integrated in authentic classrooms in multiple ways, e.g., by placing a tabletop in a corner of a classroom where a group of students can work while the rest of students do a different task, or by having multiple such systems in the same space, thus enabling the whole class to work in small groups in parallel (Dillenbourg & Evans, 2011). More micro-level classroom scripts can also be used with Hanzible: teachers can assign roles for students to encourage students to more effectively communicate and negotiate. This sort of design is in line with Roschelle's (1996) *convergent concept change* (i.e., the criterion for useful collaboration is that all group members are able to generate ideas and evaluate them); it provides students with a joint task focus to make a decision, encouraging them to discuss their conflicts, exchange their knowledge, negotiate their ideas and finally improve their content-related knowledge and collaborative learning skills.

Conclusion, ongoing and future Work

Language learning is not only an internal mental process of an individual, it is also a semiotic process attributable to participation in social activities. We have presented an interactive tabletop system and learning activity design aimed at triggering such social activities for language learning. We have conducted first user studies at our lab, unveiling performance and usability issues (e.g., system responsiveness, placement of paper elements). However, we are most interested by the integration of Hanzible in everyday Chinese learning classrooms. A preliminary study of classroom usage of the system is currently being conducted as of this writing, in collaboration with the Confucius Institute at the University of Geneva.

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Individual Preparation and Argumentation Scripts in Social Networking Sites

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Abstract: We analyse collaborative argumentative learning in Social Networking Sites. In a controlled 2×2 study (N = 128), we crossed individual preparation and argumentation scripts implemented through Facebook apps. The results show that argumentation scripts can have positive effects, while individual preparation can have negative effects on knowledge co-construction. We discuss, how early knowledge solidification may impede knowledge co-construction.

Keywords: Argumentation, knowledge co-construction, Social Network Sites, Scripts

Argumentative knowledge construction in social networking sites

Social Networking Sites (SNS) can be considered an authentic context for social and informal forms of learning. However, it is not yet clear if SNS can be appropriated for academic knowledge construction. We investigate how argumentative knowledge construction (AKC; Weinberger & Fischer, 2006) can be leveraged for learning in SNS.

Argumentation scripts are used to foster AKC in CSCL (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013), and may prompt learners to form formally adequate and elaborated arguments, consider multiple perspectives, and gain argumentative knowledge (Weinberger Stegmann, & Fischer, 2010).

Individual preparation allows students to prepare their individual arguments, reflect on their standpoints, and anticipate counterarguments (Marttunen & Laurinen, 2001; Weinberger et al., 2010), but may hinder multiperspective problem analysis, in comparison to collaboration with additional epistemic support (Wang, Rose, & Chang, 2011).

Based on the above findings, our hypotheses are: (i) Individual preparation may reduce process losses and foster argument elaboration, and knowledge co-construction. (ii) Argumentation scripts will enhance argument quality, argument structure, multiple perspectives, argument elaboration and knowledge co-construction due to the extra epistemic support that can reduce process losses from simultaneous processing of diverse ideas. As a result, (iii) all learners will gain knowledge, (iv) individual preparation and argumentation scripts will influence both individual and group knowledge outcomes. Finally, (v) there may be interaction effects on individual and group knowledge.

Methods

Figure 1. App with argumentation script, individual (left) and collaborative phase (right).

A 2×2 study with factors individual preparation and argumentation script (N = 128, Age M = 21, Women / Men = 74% / 26%) was conducted in the lab and lasted approximately 120 minutes. Participants were German university students and joined the study optionally. All participants filled in a pre-questionnaire with a knowledge test and read a text on behaviourism before constructing arguments on the question "*Should behaviouristic principles be applied in the classroom?",* which was followed by a post-questionnaire including a knowledge test. All participants worked in an App integrated in Facebook. Individual preparation allotted extra time for the creation of arguments before collaborating with a partner. The argumentation script was operationalized through the App that prompted students to annotate their arguments with general argument types as well as domain specific categories (Figure 1). The knowledge test was analysed and adjusted in a previous study (Tsovaltzi, Puhl, Judele, & Weinberger, 2013). For our process analysis, we adjusted the multi-dimensional coding scheme by Weinberger and Fischer (2006). The interrater reliabilities were between moderate and very high agreement ranging from *Cohen's k* = .56, p=000 to *Cohen's k* = .81, p = 000. Group-level knowledge outcomes where measured as knowledge convergence (Weinberger, Stegmann & Fischer, 2007).

Findings

An ANOVA showed a strong main effect of argumentation script on argument structure, $F(1,60) = 6.05$, $p = .017$, $\eta_p^2 = .094$, and argument elaboration, $F(1,60) = 5.04$, $p = .028$, $\eta_p^2 = .08$, and a medium effect on knowledge co-construction, $F(1,59) = 7.65$, $p = .008$, $\eta_p^2 =.12$. Individual preparation showed two negative trends, for argument elaboration, $F(1,60) = 3.30$, $p = .074$, $\eta_p^2 = .05$, and multiple perspectives, $F(1,60) = 3.27$, $p = .075$, $\eta_p^2 = .05$, and a small negative effect on knowledge co-construction, $F(1,59) = 5.08$, $p = .028$, $\eta_p^2 = .08$. There was a large significant main effect of time on knowledge outcomes, $F(1,124) = 124{,}27$; $p = .000$, $\eta_p^2 = .50$. Comparing post-test means, we found a small negative significant main effect of individual preparation on knowledge outcomes, $F(1;124) = 5.121$; $p = .025$; $\eta_p^2 = .04$. Post-hoc contrasts showed a significant effect of argumentation script over the combination condition, $t(124) = 2{,}896$, $p = .005$, $d = 0.69$. A repeated measures GLM showed a significant negative main effect of individual preparation on knowledge convergence over the three measure times, $F(1,60) = 4.93$, $p = .030$, $\eta_p^2 = .08$. After the collaborative phase knowledge convergence becomes worse for all conditions, apart from the condition with argumentation script only.

Conclusions

Our results indicate that the argumentation script facilitated argument elaboration, argument structure, and knowledge co-construction. Argumentation scripts have the potential to promote collaborative processes and outcomes in SNS. However, in our study, the argumentation script could not alleviate the negative effects of individual preparation. Individual preparation hampered argument elaboration, multiple perspectives, knowledge co-construction and knowledge convergence. The results show that individual preparation may not always have benefits, but in some contexts can lead to premature knowledge consolidation and hinder knowledge co-construction.

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Characterizing the Identity of Three Innovative Teachers Engaged in Sustained Knowledge Building

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Abstract: This study characterizes the identity of three elementary teachers who have productively engaged in innovative classroom practices using knowledge building pedagogy and Knowledge Forum, a collaborative online environment. Grounded theory analysis of teacher interviews reveals five distinctive features of the teachers' identity: (a) innovative vision, (b) symmetrical relationships with students, (c) innovative collaboration with colleagues, (d) a proactive stance toward contexts of practice, and (e) a professionally oriented relationship with the Principal. Teacher education and professional development need to foster such new professional identity.

Keywords: teacher identity, collaborative inquiry, knowledge building

Introduction

Research on teacher learning and practices to support CSCL needs to understand the professional identity of teachers who are dedicated to collaborative, inquiry-based pedagogy. While most studies focus primarily on teacher knowledge and practices (Fishman et al., 2014), this study was conducted to provide a detailed account of the professional identity of three elementary school teachers who have been working persistently and productively with knowledge building pedagogy and technology (Scardamalia & Bereiter, 2006). Investigating teacher identity involves understanding a number of its interrelated features in specific contexts: an ongoing process of reflecting on teaching experiences (Beijaard et al., 2004), dynamic interactions between the person and the context (Beijaard et al., 2004), forming relationships with students, peer teachers, and school administrators, and an empowerment to act (Beauchamp & Thomas, 2009). To better understand teacher identity in support of collaborative inquiry, the present study examines the professional identity of teachers who are engaged in classroom innovation using the knowledge building pedagogy and technology (Scardamalia & Bereiter, 2006). "Knowledge building" is an inquiry-based pedagogy that aims to bring authentic knowledge-creating practices into classrooms. A networked knowledge building environment—Knowledge Forum, formerly known as CSILE (Computer-Supported Intentional Learning Environment)—was developed to support knowledge building (Scardamalia & Bereiter, 2006). Our previous analysis based on rich data collection at an elementary school over eight years demonstrated the teachers' continual improvement of knowledge building practices (Zhang et al., 2011). This study conducted deeper analysis of the teachers to understand what characterizes their professional identity that supports their sustained innovation using knowledge building.

Methods

This case study was conducted as a part of a larger research initiative to examine the enactment of knowledge building as an innovation at an elementary school over a decade: The Dr. Eric Jackman Institute of Child Study (ICS) Laboratory School in Toronto (Zhang et al., 2011). The present study re-analyzed the interviews with three teachers to understand their professional identity. Although teacher professional identity has been investigated in the literature in light of theories of identity, inquiry-based teachers with high levels of innovativeness have never been examined for this purpose. Therefore, we analyzed the interviews using a grounded theory approach (Strauss & Corbin, 1998), with attention to features of teacher identity reviewed in the literature (Beauchamp & Thomas, 2009; Beijaard et al., 2004) and triangulated the themes with data from the teachers' reflection journals and field observations.

Results

The data analysis identified five overarching themes—each involving a number of subthemes—that characterize the professional identity of the knowledge building teachers.

1. **Innovative vision**: Viewing teaching as ever improvable to open new possibilities for student knowledge building and development. The teachers share a unique view of teaching practice with a primary focus on whole child development and lifelong learning (e.g. intellectual curiosity, creative problem solving, caring and collective responsibility, open-mindedness). In order to sustain such a

demanding focus, they subject their pedagogical knowledge and practice to continuous improvement, which necessitates openness to testing and adapting new classroom arrangements and technologies.

2. **Symmetrical relationship with students**: Releasing student agency so they can take on the highest level of responsibility for learning and knowledge advancement. For the teachers, striving to build a respectful, non-authoritarian, symmetrical relationship with students is necessary to achieve spontaneous, student-driven knowledge building and to cultivate lifelong learners. They see themselves as co-researchers and honor students as research team members who are capable of proposing ideas for research, building theories, designing experiments, and driving sustained cycles of inquiry without pre-specified timelines.
3. **Innovative collaboration with colleagues**: Forming into a professional community that encourages continual innovation. Innovativeness that characterizes the focal teachers is encouraged and strengthened through their collegial collaboration as a professional knowledge building community. They believe in the power of sharing and collaboration, show courage to openly recognize and reflect on failures as part of their adventurous teaching, and think of themselves as both practitioners and researchers—a dual role essential to educational innovation.
4. **A proactive stance toward contexts of practice**: Addressing constraints and barriers to make continual improvement possible. The teachers face challenges resulting from the context, such as the challenge of implementing their vision of creative education across all age levels and subject areas and responding to time constrains and technology malfunctions. Nevertheless, they have learned to approach these challenges in a proactive way in order to make continuous improvement possible, recognizing the complexity of education while developing coherent strategies to deal with complex, multiple demands.
5. **Relationship with the Principal:** Perceiving the Principal as both a leader and a professional colleague who supports teacher innovation and collaboration for continual improvement. The focal teachers have a supportive relationship with the Principal who is professionally instead of administratively oriented, with a mutual understanding that innovation and collaboration are crucial for continual teaching improvement. They share with the Principal and other colleagues their teaching expertise, ideas and designs, understanding of children's needs, and a vision of innovative teaching.

Discussion

The data analysis illuminated five features of these teachers' identity: new visions of teaching, symmetrical relationships with students, innovative collaboration with colleagues, and a proactive stance toward contexts of practice, supported by a professionally oriented relationship with the Principal. As these features enabled the teachers to productively incorporate CSCL into classrooms, designs of teacher education and development need to incorporate these tenets to develop teachers who can advance collaborative, inquiry-based pedagogy. The best form of professional development is probably to create knowledge building communities among teachers in which such identities are enacted (Zhang et al., 2011).

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Examining Teachers' Support of Students' Learning of Dynamic Geometry in a CSCL Environment

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Abstract: We report on a case study of a teacher's implementation of a CSCL project to understand how teachers' pedagogical interventions influence students' mathematical reasoning in a collaborative, dynamic geometry environment. A high school teacher engaged a class of students in the Virtual Math Teams with GeoGebra environment (VMTwG) to solve geometric tasks that the research team designed to promote collaboration and mathematical justification. The VMTwG allows users to share both GeoGebra and chat windows to engage in joint problem solving. Our analysis of the teacher's implementation and his students' interactions in VMTwG shows how his technological and pedagogical content knowledge, revealed through his instructional interventions, shaped his students' movement among empirical explorations and deductive justifications.

Keywords: dynamic geometry, teacher practice, teacher knowledge, student reasoning, justification

Introduction

Dynamic geometry environments (DGEs) afford learners the ability to construct, visualize, and manipulate geometric objects, relations, and dependencies. These affordances support empirical explorations and theoretical justifications or proofs (Christou, Mousoulides, & Pittalis, 2004). In DEGs, empirical explorations are experienced immediately while the need to formulate proofs is latent and to be realized requires either learners' disposition towards justification or pedagogical intervention. Pedagogically motivated transitions from empirical explorations to theoretical justifications depend on carefully designed tasks, teacher guidance, and classroom climates that support conjecturing and deductive justifications (Öner, 2008).

In our study of the movement between exploration and deductive justifications, we focus on the discursive, recursive trajectories in which learners are motivated by relations they notice while manipulating objects to develop and communicate convincing arguments about the relations that satisfy their peers. A guiding research question frames our analyses: What pedagogical interventions promote learners' movement among exploration and deductive justifications? To understand this movement, we analyze a teacher's pedagogical interventions and his students' consequent actions.

In the context of this CSCL study, we view teachers' pedagogical interventions as emerging from a complex interplay among their knowledge of content, pedagogy, and technology. To understand this interplay, we draw form Mishra and Koehler's (2006) model of teachers' technological, pedagogical, and content knowledge (TPACK). Teaching effectively with technology requires teachers to integrate these three domains of knowledge and to understand how each can influence instructional decisions (Mishra & Koehler, 2006). In particular, we are interested in instructional interventions that shape students' interaction with the technology to move them towards deep mathematical understanding.

Methods and findings

The research setting is a professional development project that involves middle and high school teachers in two semester-long, online and technology-focused courses. The first course engages teachers in interactive, discursive learning of dynamic geometry through collaborating to solve tasks in a CSCL environment: Virtual Math Teams with GeoGebra (VMTwG). The teachers reflect in writing on the mathematics, collaboration, and technological components of the course and collaboratively plan how to implement course modules with their students. In the second course, a reflective practicum, the teachers engage their students in at least 10 hours of class sessions to learn dynamic geometry through VMTwG to solve geometric tasks.

The data for this case study come from the second course. We performed conventional and directed content analysis (Hsieh & Shannon, 2005) on the data. We were particularly interested in coding and categorizing the teacher's, Mr. S.'s, pedagogical interventions and the deductive justifications of his two teams of students as well as inferring the knowledge domains that shaped his interventions. Our analyses of Mr. S.'s implementation of the project design revealed that his interventions were directed at supporting students' actions that can be grouped in three categories: collaboration, mathematical reasoning, and the use of technology. In addition, the analysis reveals that Mr. S. followed a trajectory of pedagogical interventions first focused on his students' discursive interactions and then on their emerging knowledge of dynamic geometry. In his reflections on his students' work, Mr. S. expresses an overall goal that, within their teams, students manipulate and construct dynamic geometric objects and notice and discuss relations among the objects, particularly relations of dependency. To achieve this goal, Mr. S.'s pedagogical interventions focused on how the teams of students collaborate.

Mr. S.'s pedagogical interventions focused initially on collaboration and reveal interplay among the three domains of TPACK. He decided to focus on collaboration, as he reported in his analysis of his students' work after the end of the school year, so that students are "building on teammates' observation, using each other's words, and refining their statements". His pedagogical knowledge (PK) was evident in this decision and his related interventions.

As Mr. S.'s teams of students increased their effective collaborative interactions, he shifted his pedagogical interventions more explicitly towards supporting their mathematical reasoning. He discussed with his class the concept of dependency in dynamic geometry, in order to contrast it with dependency in other mathematical domains, and modified the tasks to explicate particular mathematical ideas.

In his analysis of their work after the end of the school year, he expressed satisfaction with some teams' collaboration and for those teams he was more concerned with their reasoning. The impact on the student work seemed apparent in the analyses done by both Mr. S. and the research staff, where we saw, for example, a team of three students (Team 6) improve their collaboration, explorations, and mathematical reasoning. In their third session, the task asked them to construct an equilateral triangle, find the relationships among objects in their construction, and justify their claims. The students first dragged a pre-constructed figure of an equilateral triangle to explore elements of the construction and their behavior. Afterward, they each constructed a similar figure and dragged their construction vigorously to validate and justify their construction. They successfully build on each other's ideas and justify why their constructions yield equilateral triangles and justify other equivalences that they notice. They also note that the congruence of their circles depends on the segment that they share.

Conclusions and implications

Examining a teacher's pedagogical interventions provides valuable insight into the interplay of three domains of knowledge as illustrated in the TPACK model. His trajectory of pedagogical interventions began with a focus on supporting teams of students to have effective collaborative interactions. Once he was satisfied that students were listening to each other and building on each other's ideas within teams, he then shifted to focus his instructional interventions around ideas of mathematical reasoning and justifications. Our analysis of his weekly reflections, his later analysis of his students' work, and our analysis of his students' work show that, in parallel with his trajectory, his students progressed toward more pointed justifications of geometric relations that they noticed, including relations of dependencies. Further research is needed to determine in general whether students' movement among exploration and deductive justifications in a CSCL environment can be promoted effectively by a trajectory of pedagogical interventions that first focuses on their discursive interactions such as collaboration and then attends to mathematical reasoning and justifications.

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Investigating the Relations between the Learning Styles, the Collaborative Roles and the Learning Outcomes of the Students Playing a Mobile-Assisted Chinese Character Game

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Abstract: A mobile-assisted game to assist young learners in developing the knowledge of the structures of Chinese characters was developed. In playing the "Chinese-PP" game in a 1:1 (one-device-per-student) setting, each of the 31 target students in Primary 3 (9-year-old) was assigned a Chinese character component in her smartphone. A student may use her own and peers' character components to form a legitimate Chinese character, and invite the peers with matching components to join her group. We analyze relationships between the students with varied learning styles and their game behaviors and learning gains and conclude that all the students achieved high learning gains regardless of their learning and game playing profiles.

Introduction

A common challenge in learning Chinese Language is the component-based nature of Chinese characters (Shen, 2005; Wong, Chai, & Gao, 2011). There are about 15 types of commonly used configurations (Zhang, 1987); and most characters are formed by a combination of several components. One example is the "top-bottom" configuration where components are "stacked" together to form a character (e.g., 古 or 早). In this study, we designed novel learning activities to foster orthographic awareness, i.e., understanding the ways which components can be combined to form characters, and also the commonly used structures in these formations. A mobile-assisted Chinese character forming game, "Chinese-PP", was developed. In playing the "Chinese-PP" game in a 1:1 (one-device-per-student) setting, each student is assigned a character component on her smartphone. She needs to use her own component and components of her peers to form legitimate Chinese characters, and invite those peers to form a group. A student who invites others, known as 'inviter' hereafter, must negotiate with the 'invitees', and explain to the invitees on the proposed character in case it is unfamiliar to the latter, thereby convincing them to join the group and score points.

Research design

31 Singapore Primary 3 (9-year-old) students with Chinese as a second language standard participated in the pilot study of Chinese-PP. This paper focuses on comparing the roles that the students play in the Chinese-PP game according to the various learning styles of the students. In particular, we investigate which learning styles have resulted in greater learning effectiveness, and whether students of these particular learning styles played the role of "inviter" (who invites others to form groups) or "invitee" (who accepts an invite) most of the time. We used the pre-test results (see below) before the intervention to split the students into three ability bands: low achievement (LA, 9 students), medium achievement (MA, 13 students) and high achievement (HA, 11 students). Some HA and MA students scored the same marks and hence resulted in higher numbers of students in those bands. All the students were then split into two "communities" heterogeneously with 15 in Community 1 and 16 in Community 2 (as the ideal total players of Chinese-PP is 15-20 (Wong, Hsu, Sun & Boticki, 2013)).

The intervention was carried out in three game sessions, with 30 minutes allocated to each community per session. In addition, we administered a questionnaire to measure the students' learning styles. Two out of the four constructs in The Index of Learning Styles (ILS) questionnaire (Soloman & Felder, 2001), "Active/Reflective" and "Sensing/Intuitive", are adopted in the study as they are more relevant to the gaming behaviors of the players of Chinese-PP. Furthermore, pre and post-tests were conducted, where the students were assigned 20 components to form characters individually. They received 2 points for each legitimate character formed, 1 point for illegitimate character but based on a correct orthographic rule, and 0 for illegitimate character that is not based on any rule.

Findings

A paired samples *t*-test on the pre- and post-test scores showed that the post-test scores were significantly better than the pre-test scores ($t=-4.38; p<.05$), i.e., there was significant learning effectiveness out of the intervention. Subsequently, independent samples t-tests were conducted on the accumulative game scores of students of different learning styles and the different social roles they played. The result shows that here was no significant difference (t=-0.6; p>.05) in the learning effectiveness between students of active and reflective learning styles. The learning effectiveness of sensing-style students was significantly better than that of intuitive-style students (t=2.70; p<.05). Contrarily, there was no significant difference in learning effectiveness between students who were predominantly playing the inviter role and those in the invitee role (t=1.23; p>.05). Thus, the students had achieved learning gains regardless of whether they were predominantly inviters or invitees.

We then examine the variations of the students' collaborative dynamics by consolidating: (1) the frequencies of the inviter or invitee roles played by students of different learning styles throughout the three game sessions; (2) the student interactions during the games as seen in the video recordings. Table 1 presents the number of invites sent according to the system logs. We discover that sensing-style students played the invitee role on a significantly higher frequency compared to intuitive-style students. There is no significant difference between active- and reflective-style students in playing either role; and neither in the case of sensing- versus intuitive-style students in playing the inviter role.

Table 1. Analysis on roles played for two groups of students with different learning styles

Game role	Learning style	N	Mean of frequency	Standard deviation	t-test
Inviter(L)	Active (A)	16	5.44	3.72	-.73
	Reflective (R)	15	6.33	3.02	
	Sensing (S)	13	6.62	3.15	1.05
	Intuitive (T)	18	5.33	3.51	
Invitee(I)	Active (A)	16	7.81	3.35	-1.18
	Reflective (R)	15	10.00	6.43	
	Sensing (S)	13	11.54	4.74	2.72*
	Intuitive (T)	18	6.94	4.57	

By cross-checking video recordings and system logs, we discover frequent switches of roles that the students played (inviter or invitee) in the communities. HA, MA and LA students were all engrossed in searching for the right partner(s) to form the correct character in order to score points. Due to the fact that each student held a different component, even the LA students were needed in the games, thus resulting in a natural way of collaboration with everyone working towards the common goal of scoring high.

Discussion and conclusion

The findings indicates that there were indeed a complex variety of factors that shaped the students' learning experiences during the Chinese-PP intervention. Whereas the sensing-style students played the invitee role more often than the intuition-style students, the learning outcomes of the former were significantly better than the latter. As such, it can be seen from the game that students who played the invitee role did not necessarily achieve lower learning gains than students who played the inviter role. Chinese-PP promotes the premise of "learning from doing and learning from errors". Even if characters cannot be formed with 100% accuracy, the students may still advance their orthographic awareness due to the *in-situ* discussions and reflections.

In the future, we intend to collate the three sessions of game process information and conduct a more comprehensive qualitative analysis. We will also incorporate the theories of language learning into the analysis so as to investigate the characteristics that are not only related to mainstream CSCL field, but also make a better sense of the unique nature of the game model.

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Assessing the Quality of Students' Arguments in Yammer

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Abstract: In this poster, we discuss the analysis of students' online posts for an introductory human-centered design course using a quality of argument coding scheme based on four criteria: 1) *alternative claim or idea*; 2) *weighing of options*; 3) *use of evidence*; and 4) *professionalism*. While almost all posts demonstrate professionalism (95.9%), few posts justified claims by weighing options (17.5%) or using fact-based evidence (2.1%). A minority of posts includes alternative claims or ideas (13.4%).

Keywords: argument, content analysis, discussion thread, online post

Introduction

In a previous study, Borge and Goggins (2014) utilized the social media environment, Yammer, to support the development of an online community of learners. The researchers noted significant variation in quality among students' posts where a claim is made with supporting evidence, rationale, or weighing of ideas. In other words, students' posts differed in the quality of their arguments. In this poster, we discuss an extended analysis of these posts using a coding scheme that focuses on how students should construct and critique claims. Our findings will inform the redesigning of future course sessions to support students in constructing high quality arguments.

Research question

Our main research question is: What is the quality of students' posts on the social media environment, Yammer? Specifically, we are interested in whether students: 1) provide an alternative claim or idea; 2) justify their claims through weighing of options; 3) justify their claims using evidence; and 4) are professional in making arguments on a social media environment utilized for learning purposes.

Context of analyzed posts

The posts analyzed in this study were made by students enrolled in a 16-week introductory human-centered design course at a major U.S. research university. The course requirement includes making weekly posts on a professional social media site, Yammer, to discuss course related topics. Yammer offers similar user interactive features as the social media site, Facebook. Students were assigned to initiate and moderate weekly discussion topics. They were encouraged to initiate original posts that required others to make a decision or share their ideas (e.g., their views about large scale data collection through technology). Details of the course design and data collection are reported in Borge and Goggins' (2014) paper. Ninety-seven posts (24.0% of total student posts) made by 31 students across 42 discussion threads meet our minimum definition of an argument as a justified claim and were included in our analysis. These posts were either replies to an original post or replies to a reply post.

Method of analysis

We analyzed the content of each individual post using a quality of argument coding scheme, which is adapted from a more elaborate coding scheme for assessing the quality of small group collaborative talk in synchronous online discussions (Borge, Ong, & Rosé, in print). The finalized coding scheme comprises four criteria: 1) *alternative claim or idea*; 2) *weighing of options*; 3) *use of evidence*; and 4) *professionalism*. Each criterion is evaluated on a binary scale of '1' or '0'. A post scores '1' on a criterion if there is evidence for it; otherwise it scores '0'. Evidence for *alternative claim or idea* includes an alternative claim/idea to an existing one (in a previous post within the same discussion thread), call for further evaluation of an existing claim/idea, and/or identification of problem(s) with an existing claim/idea. Evidence for *weighing of options* includes justification of a claim/idea by discussing cost(s) and benefit(s) or pro(s) and con(s) of one or more claims/ideas. Evidence for *use of evidence* includes justification of a claim/idea using identified, fact-based evidence (e.g., articles, books, website information, documentaries) to support its rationale. A post scores '0' on this criterion if it justifies a claim/idea using opinion-based rationale, including personal experience, anecdotes, or fictional works (e.g., movies, novels), or uses unidentified evidence (e.g., mentions website without providing hyperlink). A post demonstrates *professionalism* if the language used is respectful and not potentially offensive, and any criticism is targeted at the claim/idea and not individuals who made it. The profile of an argument can be created using scores of the four criteria, producing 16 possible profiles. Thirty percent of the posts were coded independently by the first author and a student researcher (Cohen's kappa range from 0.65 to 0.71, $p < 0.001$; no kappa was computed for *professionalism* as all sampled posts were scored as '1' by both raters). Differences in the codes were resolved through discussion, and the first author coded the remaining 70% of the posts.

Findings

Of the 97 posts, 13.4% include *alternative claim or idea*; 17.5% have evidence of *weighing of options*; 2.1% include *use of evidence*, and 95.9% demonstrate *professionalism*. Majority of claims are not justified by weighing options. Only two arguments are justified by identified, fact-based evidence; others are justified using personal experience or anecdotes. Few arguments presented an alternative claim or idea. Our findings suggest the students have difficulties in justifying claims and critiquing others' claims.

Of the 16 possible argument profiles, only seven profiles were identified among the posts. The most common argument profile (68.0% of all posts) is one with no alternative claim, no weighing of options, no use of fact-based evidence, but demonstrates professionalism. An example of such a "typical" argument is Student N's reply. The original post asks for students' opinion on Google Glass, and claims it is an amazing idea and can be used with prescription glasses. Student N makes the following reply to a previous reply post: "I completely agree [Google Glass has unique design and will have widespread use], I didn't think social media and communication with friends could get any easier than it is now, until Google revealed this". There is no alternative idea as Student N agrees with previous reply ("I completely agree"). He justifies his support for Google Glass based on his personal opinion (it makes social media and communication with friends easier) without using evidence. The argument demonstrates professionalism, as the language used is respectful and non-offensive. In contrast, the highest quality arguments we identified among the posts have the profile of providing alternative claim, weighing options, and professionalism, but no fact-based evidence. This profile is found in 4.1% of all posts. The other five argument profiles, with their corresponding percentage of posts in parenthesis, are as follows: arguments without alternative claims, include weighing of options but no fact-based evidence, and demonstrate professionalism (13.4%); arguments with an alternative claim or idea, demonstrate professionalism, but do not weigh options or use fact-based evidence (8.2%); arguments without alternative claims, do not weigh options, but include evidence and demonstrate professionalism (2.1%); arguments with an alternative claim but do not weigh options or use evidence, and do not seem professional (1.0%), and posts with no evidence for any of the four criterions (3.1%) - such arguments can be considered the lowest quality.

Discussion

Our findings indicate majority of the students' arguments had claims not justified by weighing options; neither were alternative claims provided. This suggests most students might not have considered alternative claims or ideas other than the one they supported. Furthermore, very few posts used fact-based evidence to support the claims; most claims are supported using personal experience or anecdotes. The findings suggest a need for change in the learning environment to promote students' justification of claims by weighing options and using fact-based evidence, and making these the shared goals among the students. Further studies on potential changes such as the types of original posts that promote high quality arguments, the effect of modeling justification of claims by the instructor through online posts or providing examples of high and low quality arguments in discussion guides for students, as well as approaches for introducing alternative claims in a discussion thread, could identify effective ways for promoting higher quality arguments in students' online posts.

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A Study of Developing Students' Scientific Argumentation Skills in a Computer-assisted Project-based Learning Environment

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Abstract: The purpose of this quasi-experimental study was to explore how 111 7th graders in the United States developed argumentation skills and science knowledge in a graph-based computer-assisted project-based learning environment. Verbal collaborative argumentation was recorded and the students' post essays were collected. A random effects ANOVA was conducted and a significant difference in science knowledge about alternative energies between conditions was observed. A MANOVA was conducted and there was a significant difference in counterargument and rebuttal skills between conditions. A qualitative analysis was conducted to examine how the graph-based, computer-assisted program supported students' development of argumentation skills and affected quality of collaborative argumentation. The findings indicated that with the graph-based computer-assisted program, the quality scores of collaborative argumentation were high and consistent. The difference in argumentation structure and quality of argumentation between conditions might explain a difference in science knowledge as well counterargument and rebuttal skills (argumentation) between both conditions.

Keywords: argumentation, graph-based computer-assisted program, project-based learning

Introduction

The *Next Generation Science Standards* (NGSS) (National Research Council, 2012) identified "engaging in argument from evidence" (p. 12) as one of the essential eight science practices for students in the United States. As a common practice for scientists, argumentation is a process for constructing explanations and identifying solutions. A number of researchers (Kuhn, 1993) have defined essential elements of argumentation: position, reason, evidence, counterargument, and rebuttal. A position refers to an opinion or conclusion on the main question that is supported by reason. Evidence is a separate idea or example that supports reason or counterargument/rebuttal. Counterargument refers to an assertion that counters another position or gives an opposing reason. A rebuttal is an assertion that refutes a counterargument by demonstrating that the counterargument is not valid, lacks as much force or correctness as the original argument, or is based on a false assumption.

Recent studies (Scheuer, Loll, Pinkwart, & McLaren, 2010) have explored the potential of graph-based computer programs in improving learning outcomes and facilitating cognitive processes. The present study addresses the limitations of existing research (Dwyer, Hogan, & Stewart, 2012) on graph-based computer programs by engaging students in a project-based learning environment that involves using a computer-assisted program to support collaborative argumentation. The purpose of the study was to explore the impact of the learning environment on the development of middle school students' science knowledge and argumentation skills in a suburban school in the United States. The following research questions were addressed:

1. What is the difference in science knowledge between students in a graph-based computer-assisted project-based learning environment (treatment condition) and students in a project-based learning environment without such a computer-assisted program (control condition)?
2. What are the differences in argumentation skills (as measured by reason, evidence, counterargument, and rebuttal) between students in a graph-based computer-assisted project-based learning environment and students in a project-based learning environment without such a computer-assisted program?
3. How does a graph-based, computer-assisted program support students' development of argumentation skills?
4. How does a graph-based, computer-assisted program affect the quality of collaborative argumentation between the conditions?

Literature review

With the general positive impact on argumentation skills, the previous studies all involved students in active construction of content knowledge in an authentic problem (e.g., public policy, law) and collaborative argumentation, which reflects the critical elements of project-based learning (Fogleman, McNeill, & Krajcik, 2011). Thus, in the present study, project-based learning was used to develop argumentation curriculum and is discussed. Moreover, with the advance of technology, numerous researchers (Moursund, 2003) have proposed to add technology to augment the effectiveness of a project-based learning environment. Thus, this study examined the role of a graph-based, computer-assisted program in supporting collaborative argumentation process in project-based learning environment.

Methods

A total of 54 students comprised the treatment condition while a total of 57 students were in the control condition. In the treatment condition, the students worked in teams of three to five. Each team in the treatment condition was engaged in verbal collaborative argumentation and argued with other teams using the graph-based computer-assisted program. In both conditions, verbal collaborative argumentation was recorded with a digital camcorder. After one week, the students in both conditions were asked to write post essays. The topic was, "If the US could fund only one form of alternative energy, which one should you select?"

Findings

To address RQ 1, results indicated that the treatment group scored significantly higher in science knowledge than the control group, $F(1, 3.66) = 8.45$, $p = .049$, with a standardized group mean difference of $d = 0.68$, which corresponded to a large effect size. To address RQ 2, results of the MANOVA showed a statistically significant group difference on the four dependent variables considered simultaneously, $\Lambda = 0.86$, $F(4, 109) = 4.50$, $p = .002$. The canonical correlation between the treatment condition and the dependent variables was .38. Follow-up univariate ANOVA comparisons, using a Bonferroni-adjusted alpha level, showed that the treatment group showed significantly higher scores than the control group on the outcomes of counterargument [$F(1, 109) = 17.29$, $p < .001$] and rebuttal [$F(1, 109) = 12.15$, $p < .001$].

To address RQ 3, in the treatment condition, four argumentation structures emerged from the analysis. 20 teams in the control condition started by supporting their selected form of energy and then argued against other forms of energy. To address RQ 4, the teams in the treatment condition demonstrating argumentation structures 1, 2 and 3 received a quality score of 5 or 6. The teams in the treatment condition that demonstrated argumentation structure 4 received a score of 3. The teams in the control condition scored from 2 to 5.

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The Theoretical Products of Design Research

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Abstract. Design remains methodologically underdeveloped, especially in defining the nature of its theoretical products. To more rigorously define design research products we argue that design research products are arguments for how people should learn in the form of practical prototypes and theoretical models including blueprints and design arguments. Understanding the products of design research helps improve the methodology and solve educational challenges.

Keywords: design-based research, design research, design products, theory, methodology

Design research (DR) is an important methodological approach because it promises to simultaneously develop new interventions and theory for solving educational problems (Easterday, Rees Lewis, and Gerber, 2014) but remains a low paradigm field in which there is uncertainty about the goals of research and the means to achieving the goals (Pfeffer 1993). One uncertainty is the nature of the theoretical products of DR. Confusion about the products of DR makes it more difficult: to conduct DR; to communicate with other researcher; to train new researchers; and even to publish because there is disagreement about what counts as a contribution.

What are the products of design research for?

Rhetorical theories of design define design as a form of argumentation. Just as a rhetorician creates arguments designed to move an audience to adopt some idea, designers create products that interact with people to achieve some desired purpose (Buchanan 2001a, p. 14-17; 2001b, p. 195-197). In this view, *learning environments are arguments about how we should learn*. Learning designers and design researchers create arguments for how people learn in the form of interventions that we call learning environments or *prototypes*.

What forms should the theoretical products of design research take?

Models are the core theoretical products of DR. Researchers build theory by creating representations of the world for different purposes (Giere 2006) including explanation, prediction, and intervention. This representational activity occurs through the creation of *models*. Researchers *interpret* these representational models to make claims that are *identified* with features of the real world (or rather models of data from the real world). Researchers interpret and identifying models to make specific hypotheses that can be tested and used to assess the fit of the model with the world and the usefulness of the model for achieving its purpose (Figure 2). Table 1 describes the elements in Figure 2 in more detail including their theoretical role in DR.

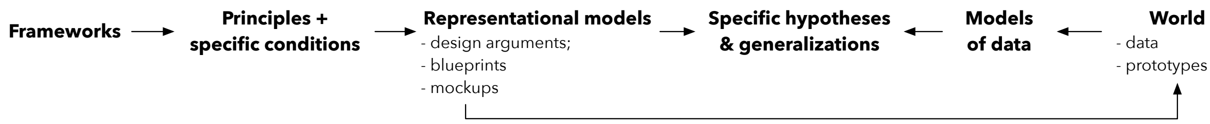

Figure 1. Principles are templates for representational models that create testable hypotheses (after Giere 2006)

Table 1: Models are the core theoretical products, based on frameworks and principles, materialized in prototypes.

Description	Theoretical role	Issues
Frameworks provide theoretical structure by specifying the abstract entities and the relationships between entities that theories make claims about (Ostrom 2011, p. 8)—the "grammar" from which principles are constructed.	Define the important constructs for building specific models and design principles.	Because frameworks serve to define entities, they do not provide specific guidance for design or make testable claims.
Principles provide theoretical components. Design principles are typically presented as general causal statements that serve as vehicles for making empirical claims (Giere 2006, pp. 61-62). In educational design research, principles describe how an intervention leads to a desired learning outcome.	Provide a basis for constructing other models that *can* be tested.	Too general to be tested because they do not specify the conditions in which they apply or how to map these principles onto the world and prototypes.

Description	Theoretical role	Issues
Model: *Design arguments* are representational models that describe the features of design necessary to promote a desired learning effect in a given context. They describe the principles behind the features and process for constructing a prototype to achieve learning goals for a particular set of learners in a particular context either in prose (van den Akker 1999), *impact maps* (Adzic 2012), *conjecture maps* (Sandoval 2014) or *causal diagrams* (Collins 1992).	Map principles to specific conditions and provide templates for more specific blueprints. Their simplicity allows them to quickly communicate the core idea of a design	Difficult to falsify because it is difficult to say whether the success/failure of a particular prototype undermines an the abstract design argument or the argument was "not implemented properly."
Model: *Design blueprints* provide more detailed descriptions of the important features of a design and the learning outcomes it supports and the interactions with learners, including *service blueprints* (Bitner, Ostrom, & Morgan, 2008) and *patterns*. Blueprints help designers create new interventions with the desired learning outcomes.	Are the core theoretical product because they abstract away contingent features and are specific enough to map to the real world for testing.	Learning sciences has not adopted blueprints as have other design fields such as interaction, service and software design. May not fit well with in publication limits.
Model: *Design mockups* are representational models that allow designers to create and test preliminary low-fidelity elements of prototypes before they are fully materialized. These include paper prototypes, design comps, preliminary pilot units, and so on.	Provide tools for exploring and "testing" ideas because they help avoid obvious problems before implementation.	Too detailed with respect to theory because they include a contingent features irrelevant to the overall theory.
Prototypes are physical instantiations of the intervention in the real world. They provide existence proofs by showing that all the design challenges can be solved and guide future design through analogy and adaptation.	Like data they provide necessary supports for theoretical claims.	Prototypes alone do not specify the intended effects, interactions with learners; or which features necessary and which contingent.

Conclusion

Learning designers create arguments for how we should learn, and learning sciences is the study of how to better create these learning environments. Designers create arguments in the form *prototypes* and design researchers develop explicit, formalized *theory* that guides the design of future prototypes. The theoretical products of DR are representational models of how learning environments help people learn in the form of blueprints, and also design arguments, principles, mockups, and frameworks. By defining the theoretical products of DR we further its paradigmatic development, helping increase our ability to train new researchers; funders' confidence in DR projects; and agreement about what constitutes a theoretical contribution. Taken together, allowing us to increase our knowledge of how to design interventions that solve educational problems.

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Exploring the Role of Social Media and Knowledge Management Processes in Organizational Learning

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Abstract: Based on theories from sociology and strategic management, this paper develops a conceptual model to understand how Enterprise Social Networking Systems usage will influence knowledge management processes (knowledge creation and knowledge sharing) and organizational learning. It further explores the possible mediating role of knowledge management processes in the path.

Keywords: Enterprise Social Networking Systems, knowledge creation, knowledge sharing, organizational learning

The massive adoption of social media in enterprise has changed the way people communicate, exchange information, solve problems and make decisions. Companies use various social media tools to perform different organizational functions. Enterprise Social Networking Systems (ESNS) are social networking systems implemented inside the boundary of organizations with a major purpose to support social networking within the organization. ESNS is believed to be most relevant to the current research context since ESNS are directly related to knowledge management processes, and social networking systems (in particular) has significant effects on organizational consequences (Fulk & Yuan, 2013).

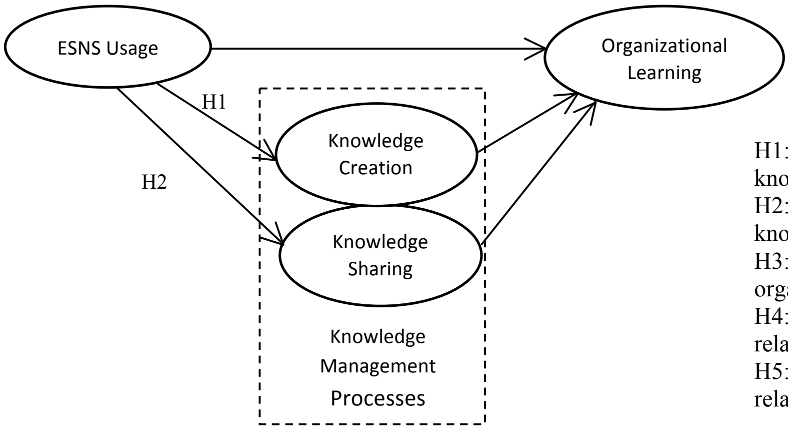
Enterprise social media usage has positive effects on various work outcomes. Knowledge management processes and workplace learning are among the most important two (Thomas & Akdere, 2014). Knowledge management is defined as a systematic and integrative process of coordinating organization-wide activities of acquiring, creating, storing, sharing, developing, and deploying knowledge to pursue organizational goals (Rastogi, 2000). Traditionally, knowledge management is a formal, top-down organizational process and in some cases, a compulsory organizational policy (Razmerita et al., 2014). Enterprise social media usage, on the other hand, is more informal, bottom-up and voluntary (Annabi & McGann, 2013). Recent studies have dichotomic opinions on the "marriage" between the two knowledge related initiatives, this paper supports the opinion that social media is different from knowledge management, and is a significant enabler of knowledge management processes due to its low cost and interactive nature. Enterprise social media also enhances organizational learning directly and/or indirectly via knowledge management processes. Learning activities under social media context is believed to be an "informal learning" (Marsick & Volpe, 1999) or "new social learning" (Bingahm & Conner, 2010). It encourages knowledge transfer and connects people in a way consistent with how they naturally interact. The learning activities with social media are the new generation of learning where social media is not only used as a tool for communication or marketing purposes but also a means to improve organizational learning (Huang, et al., 2010).

Based on the Knowledge-based view, knowledge management is identified as a critical capability providing organizations with a source of competitive advantage (Sabherwal & Sabherwal, 2007). The ability of continuous learning is one of the organizational advantages that knowledge management can help to obtain. Learning is much more effective if a system (e.g., enterprise social media) is put into place by which knowledge can be captured, shared, and understood. Many knowledge management processes exist in the literature, however, the present research only includes knowledge creation and knowledge sharing since they have been proved to be the most critical knowledge management initiatives under the "social" context (Thomas & Akdere, 2014; Ray, 2014).

Most of the studies in the literature have investigated social media's influence on the two dependent variables separately, and many of them are qualitative or conceptual in nature. Few efforts were paid to understand the causal relationship between social media, knowledge management and organizational learning. Even few studies have tried to explore specifically the influence of ESNS on organizational level of outcomes. For knowledge management processes, many researchers pointed out that knowledge creation and knowledge sharing are the most critical factors under the "social" context, however, few of them have tested the mediating role of knowledge management between organizational social media usage and organizational performance. This research helps to address the above gaps in the literature in a conceptual way.

Multiple theories were used to support the hypotheses development process. They are the theory of Information Public Good, Social Capital, Social Cognitive and Knowledge-based View. Information Public

Goods Theory (Fulk, et al., 2004) focuses on the motivational aspect of knowledge management processes, e.g., why people need to contribute and share knowledge within a collective; Social Capital Theory is usually used to explain the importance of social networks in influencing knowledge processes (Parise, 2009); Social Cognitive Theory is the individual level of the learning theory that has been extended to understand organizational learning; and Knowledge-based view considers knowledge as the most strategically significant resource of a firm (Kogut & Zander, 1992). Based on the above theories, we developed the current theoretical model with research hypotheses (Figure 1.).



H1: ESNS usage will be positively related to knowledge creation.
H2: ESNS usage will be positively related to knowledge sharing.
H3: ESNS usage will be positively related to organizational learning.
H4: Knowledge creation will be positively related to organizational learning.
H5: Knowledge sharing will be positively related to organizational learning.

Figure 1. Research model and hypotheses

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SSRL Scripts to Facilitate Student Regulation of Collaborative Learning

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Abstract: We developed CSCL scripts as scaffolds to facilitate university freshmen's regulation of their collaborative learning, monitoring in particular. Forty-three students were engaged in their project-based learning with Knowledge Forum to report their progress and monitoring. Students' engagement in reflection-in-action with CSCL scripts for monitoring their own collaboration facilitated students to be intentional about more layers of regulation (SRL, CoRL, and SSRL) when they appropriately reported their socioemotional challenges in collaborative learning during their monitoring activities.

Keywords: CSCL scripts, SSRL, project-based learning, reflection-in-action

Introduction

When contributing to a collaborative task, learners have to regulate themselves, others, and the group as a whole. In self-regulated learning (SRL), learners regulate their own learning in order to contribute to group performance, based on their individual perception of tasks and their strategic knowledge. In another layer of metacognition, namely, co-regulated learning (CoRL), learners also regulate themselves in relation to others. Each learner in a group monitors the task perception, goals, and standards of other group members and considers ways in which their actions and interactions influence one another and the task. In the final layer of metacognition, learners engaged in a collaborative task collectively regulate their group cognition: this is socially shared regulation of learning (SSRL). In Hadwin, Jäevelä, and Miller (2011), SSRL is defined as "interdependent or collectively shared regulatory processes, beliefs, and knowledge orchestrated in the service of a co-constructed or shared outcome/product" (p. 69).

For improving student collaboration skills, we designed project-based learning with CSCL scripts. In recent studies in the CSCL field, the collaboration script has been actively discussed as a promising approach to improving student learning (for a review, see Fischer, Kollar, Stegmann, & Wecker, 2013). Its basic idea for promoting collaboration is summarized by seven principles to make appropriate interaction between learner's internal scripts and instructional (external) scripts. We applied some principles to design our project-based learning through students' active engagement in regulation.

Study design

Forty-three university freshmen took the course for learning how to manage their collaborative learning through participating in project-based learning. They were randomly divided into groups of four or five then given a task to propose new solutions to reduce wastes at convenience stores for conservation.

Students were provided with four sets of documents related to their solution task and encouraged to decide who was in charge of which set of documents. Then students for the same sets of documents gathered and discussed in small groups. After learning documents, they came back to their original groups and further continued their projects by integrating knowledge resources from the four sets of documents and searching for new information to create their solutions. In this second phase of group work for seven weeks, we implemented scripts for them to monitor their collaboration at SRL, CoRL, and SSRL level in Knowledge Forum.

Before students started their group work in the second phase, a pre-questionnaire was conducted for evaluating students' internal scripts of regulating collaboration. Based on their experiences in the first phase of collaboration, students were asked to describe their own evaluation of group work and individual contribution to it. During the group work, students came to classroom every week to discuss their work in progress and spend time for searching new resources and collaboratively integrating their ideas from different resources. At the end of class every week, students reported work in progress as a group note on Knowledge Forum and their individual evaluations on their group progress as "build-on" notes (Figure 1). When writing their group notes, scripts for monitoring, evaluating and revising their group work were provided as scaffolds in Knowledge Forum notes (i.e., "What are your group goals?" "How did you as a group approach the goals?" "How much are you as a group satisfied with group progress?” “How can you as a group revise your approach?”). In their individual “build-on” notes, scripts for monitoring, evaluating and revising were provided for facilitating each student’s involvement in her group work (e.g., “How did you as a member approach the goals?”). Another post-questionnaire was again conducted as their reflection-on-action after the second phase of group work. They were instructed to report their questionnaire with accessing their own group notes and individual “build-on” notes.

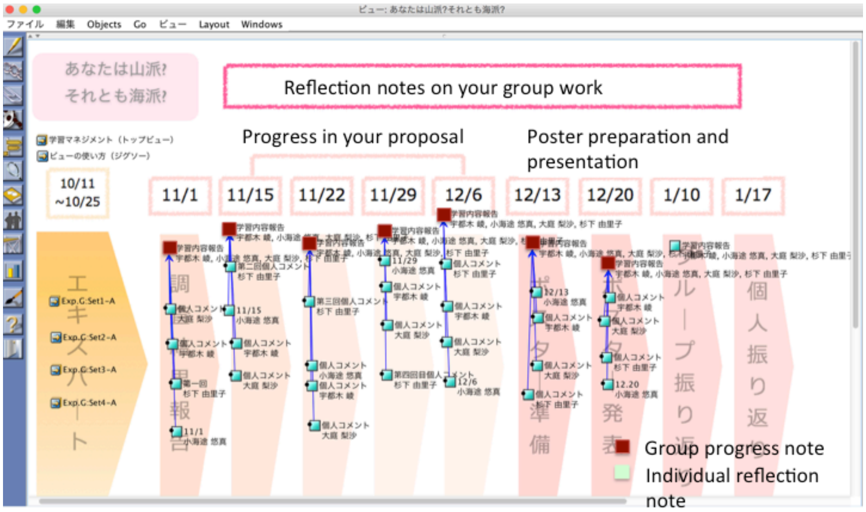

Figure 1. Knowledge Forum View on Project by a Group

Results and discussion

Students’ writings on the pre- and the post-questionnaire were independently evaluated by the first and the third authors as to which level of regulation (i.e., SRL, CoRL and SSRL) and which aspects (i.e., goal and planning, monitoring, and revising) they described (Winne, Hadwin, & Perry, 2013). When a student described an aspect at a regulation level (e.g., goal and planning at SSRL), we gave the student “1” for the aspect. With this procedure, each student’s writing on the questionnaire was converted into nine digits of 1 or 0 (three aspects at three levels of regulation). The agreement between two independent raters was .80, and the disagreement was resolved through discussion. We further conducted a clustering analysis with Ward method and identified three clusters: SRL, CoRL and SSRL–oriented. Binominal test showed that significantly more students (30 of 43) improved internal scripts by making a shift from one to another layer across questionnaires, $p < .01$.

For examining how students engaged in their reflection-in-action during the second phase of group work with using CSCL scripts, we further conducted quantitative and qualitative analyses. First, for examining differences in script use frequencies between students who improved their scripts and those who did not, 4 (new type of script in the post–questionnaire: SRL, CoRL, SSRL or No Change) X 6 (Scaffolding Script) ANOVA was conducted. We had no significant results suggesting that all students used scaffolding scripts frequently. Second, for qualitatively examining how students improved their internal scripts of regulation, we further conducted case analysis of two groups based on our field notes in the classroom, their responses in questionnaires, and their reported notes in Knowledge Forum. In summary, the case analysis revealed that students could revise and articulate their internal scripts when they monitored their group progress with appropriate awareness of socioemotional challenges they had in their groups.

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What Are Zombies Teaching Our Children? Video Games and Moral Reasoning in the Dialogical Classroom

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Abstract: The study reflects on game-based learning and pedagogical approaches in CSCL settings. A commercial video game was used in a citizenship and ethics course, being appropriated by the teacher and the students as a mediational tool for building collaborative knowledge and moral reasoning. The study concludes that the teacher´s dialogical approach was crucial and that both bottom-up and top-down reasoning processes were used to anchor theoretical and concrete knowledge and promote students' moral reasoning.

Introduction

Competences and skills for the 21st century are at the top of the list of priorities in regard to the need for new thinking about schools, where concepts of digital literacy and critical thinking are central. Innovative, advanced pedagogies for the design of collaborative learning experiences with the use of new mediational tools, including video games, are considered essential. The aim of the present study is to contribute to the discussion about the use of commercial video games as educational tools. It focuses on the dialogical processes in game-based learning (GBL) settings, specifically related to the promotion of moral reasoning in the education of citizenship and ethics and the reasoning that unfolds during classroom discussion.

Theoretical framework

Learning happens not only inside classrooms but also across contexts and there is a need for developing interest-driven, engaging school activities that take into consideration the students' out-of-school practices. Debate about the use of video games as educational tools is ongoing. Some researchers argue the need for educational video games that are especially designed to promote learning (Schaffer, 2006), while others claim that even commercial video games are embedded with good learning principles (Gee, 2003). Despite the controversy about the impact video games might have on moral development, some researchers fully defend the position that some video games are able to promote and foster moral and ethical reflection (Simkins & Steinkuehler, 2008).

Most research about learning from video games points to bottom-up reasoning processes: in the situated context of playing a game, the player builds on embodied experiences of game play to develop conceptual knowledge and general meanings (e.g. Gee, 2003). In addition, some researchers stress the importance of clear learning goals for the success of GBL experiences (Squire, 2005). In this study, the sociocultural aspects of the GBL setting are also emphasized, particularly the importance of the teacher´s role. Studies have shown the need to incorporate such top-down aspects in computer supported collaborative learning settings (Rasmussen & Ludvigsen, 2010; Mercer & Howe, 2012), and in GBL settings in particular (Verekinina, 2010). This focus on the importance of scaffolding resources aligns with Vygostky´s concept of zone of proximal development and how instruction can scaffold conceptual development and reasoning. From a socio-cultural perspective on GBL in classroom settings, both bottom up and top down processes become intertwined through student participation in teacher-led dialogue, or what may be termed 'a trajectory of participation' (Rasmussen, 2012). This perspective allows expanding the focus to include the social context of the GBL. The research question for this study is: what characterized the teacher and the students' participation during a GBL classroom activity and how does this relate to learning ethics theories and moral decisions?

Methods

A Portuguese high school class of 14 students (5 boys and 9 girls, aged 18 to 22-years-old) was video recorded during one month of participating in a citizenship and ethics course. Students collaborated on playing a commercial video game called *The Walking Dead*. The teacher stopped the game at decision points that presented moral dilemmas. The students had to reflect on possible actions to be taken and teacher-led discussions were aimed toward relating their moral reasoning to the curriculum content and to real world situations. After discussions, students voted on what to do using an application named *Kahoot*. The game resumed according to the decision taken.

The data has been analysed in the following way: video recordings were analyzed using methods from micro-analytic approaches of moment-to-moment interactions such as thematic analysis (Braun & Clarke, 2008) and interaction analysis (Jordan & Henderson, 1995), focusing on teacher-led discussion moments (315 minutes). Thematic analysis was used to identify discussion moments and patters (themes) within the data. The discussion moments included collective decision-making and collective reflection about the activity. Field notes and semi-structured post-interviews combined with ethnographic descriptions of the local school culture and practices serve as supplementary data to frame and connect the micro-analysis in relation to the whole citizenship and ethics course. The combination of the different levels of description makes it possible to see social interactions as part of longer stretches of activities, such as a course period. As such, the trajectory as a unit of analysis creates possibilities for the researcher to trace the way in which participants reason together (Rasmussen, 2012).

Findings

Findings suggest that both the participatory experience of the video game and the dialogical approach used by the teacher were central for eliciting moral reasoning during the class. The students' reasoning drew on three different types of references throughout the discussion, relating the video game context to the curriculum and exemplifications using real life situations. In making these connections, students' bottom-up and top-down processes were made apparent. In the game context, students and the teacher engaged in debates that led to general moral reflections linked to curriculum content (from the game narrative to ethics theories). This can be considered a bottom-up reasoning process. But they also used theoretical ethics concepts to analyze different dilemmas that arose in the game. This illustrates how top-down conceptual reasoning was also involved. Another top-down reasoning process can be inferred when participants tried to anchor the symbolic dilemmas that arose in the game in examples of real life situations. The *in situ* construction of a mixed use of bottom-up and top-down reasoning that characterized the participant's engagement may be considered a two-way *anchoring process*, connecting theoretical knowledge to contextualized practices and also connecting contextualized practical actions to more theoretical understandings.

Conclusions and implications

The analysis of the participation trajectory revealed how a mixed use of bottom-up and top-down reasoning served as an anchoring process in moments of dialogical reflection, linking theoretical and everyday knowledge in ways that facilitated content understanding and hence deeper learning. The use of commercial video games in the classroom can promote a participatory engaging learning experience. Nevertheless, the teacher´s role and the instruction given for the task seem to be of key importance. By providing a conceptual framework, using a dialogical approach, and providing tasks requiring the application of academic content, the teacher improved learning opportunities. The anchoring of knowledge through different realities also indicates a possibility for the transfer of learning across contexts. By bridging different realities, anchoring processes might also represent a valuable tool for promoting learning across contexts. This transfer potential requires more detailed future study but seems particularly important in citizenship education, as its goal is to contribute to the development of citizens that can ultimately contribute to the quality of society. In attempting to describe the ways in which moral reasoning develops in classroom settings, this study aims to contribute to a better understanding of how GBL may be relevant for 21st century education.

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Engaging Parents as Creative Learning Partners in Computing

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Abstract: Coding and design-based computing activities have gained recognition as important fluencies today, but studies show that few actually engage in creative production. Social support from parents, for example, can be essential to engaging children in these kinds of activities. However, parents are often unsure what roles they can play to support their children. We argue that for parents to develop supportive practices and roles, they must gain first-hand experience in design-based activities for themselves and with their children. We developed an out-of-school time program called Family Creative Learning where parents and children can design and invent together using creative technologies like Scratch. We describe case studies of how parents collaborated with their children on design-based projects and negotiated supportive practices and roles. Finally, we discuss design opportunities to provide experiences for parents and children to develop as creative learning partners in computing.

Keywords: parents, families, creative learning, computing, Scratch, MaKey MaKey

Introduction

Learning to code and engaging in design-based activities with computing have gained recognition as important literacies to develop in an increasingly digital society (Wing, 2006). Yet, studies still show large participation gaps in these activities as young people primarily consume rather than create their own computational media (Livingstone & Helsper, 2010). Social support from caring adults like teachers, mentors, and parents can be essential to providing the necessary scaffolding, expertise, and opportunities that deepen engagement (Ito et al., 2009). Barron and colleagues (2009) found that parents played many roles to support their children in developing such fluency, and enacted roles like collaborator, resource provider, and learner.

Although these roles did not require parents to possess domain knowledge, all of the families that Barron and colleagues (2009) studied had at least one parent who worked in computer engineering or technology design. For parents without such insights into the changing landscape of technology, knowing how to support their children, how to work together in computing activities, or even how to find opportunities related to computing can be a challenge (DiSalvo, Ried, & Roshan, 2014). Additionally, parents may feel unsure of what roles they can play to support their children and how their current supportive practices translate in the context of computing (Roque, 2013).

We argue that parents can benefit from first-hand engagement with the design practices of computing and with the practices of supporting their children in computing experiences. Such experiences can help parents develop supportive roles in computing and design-based activities. In this paper, we describe the experiences of parents and their children working together to design projects using the creative technologies Scratch and MaKey MaKey in an out-of-school program called Family Creative Learning (FCL). FCL builds on constructionist theories of learning, which argue that people learn best when they are building things that are personally and socially meaningful (Papert, 1980). Through a series of five workshops held in the evenings, parents and children learn to use new technologies and to design projects together based on their interests. Parents gain hands-on experience designing their own projects with creative technologies, while experimenting with practices and roles that they can enact to support their children in this context.

We ask (1) how did parents work with their children?; (2) how did this collaborative experience relate to parents' development of practices and roles to support their children with computing?; and (3) how can we best support families to develop as creative learning partners around computing in informal learning environments? We focus our study on three parents, each with children who are excited about the possibilities with computing. These parents ranged in their comfort with computing and with the roles that they played in supporting their children's interest in computing. Through case studies, we describe how parents collaborated with their children on design-based projects and how they negotiated both existing and new supportive practices and roles. Finally, we reflect on the opportunities for designers in providing experiences for parents and children to develop as creative learning partners with computing.

Context and methods

We implemented the workshops in a Computer Clubhouse housed within a Boys and Girls Club. Computer Clubhouses are informal learning centers designed for low-income youth to engage in creative activities with technology (Kafai, Peppler, & Chapman, 2009).

We observed families in two program implementations, one in Spring 2013 and one in Fall 2013. A total of 9 families participated with 24 participants. Nine parents were present (five mothers, three fathers, and one grandfather; ages thirty-one to fifty-nine) along with fifteen children (five girls, 10 boys; ages three to thirteen). Four of the families reported as Hispanic/Latino, one self-reported as Black/African-American, and four families self-reported as White.

To understand families' experiences, we primarily used ethnographic methods and collected multiple forms of data to triangulate our observations, in the form of field notes, individual and group interviews, and video recordings. We analyzed our data through case studies of participation (Yin, 2009). We coded the data for instances of practices and roles that family members enacted or talked about, building on top of the roles identified by Barron and colleagues (2009).

Case studies of participation

In this poster, we will describe the ways parents and children experienced the workshops, from their initial impressions to their shared projects. Each case study focuses on how parents negotiated these new computing experiences as they attempted to support their children in design-based activities. Each case analysis then focuses on describing how these experiences relate to parents' developing practices and roles to support their children's participation in design-based computing activities. For example, when a father Tim came to the workshop with his son Ethan, he felt nervous about learning to program and was also concerned and suspicious of his son's uses of technology. At home, Tim often monitored his son's computer use and imposed many rules about what his son can do on the computer. However, after experiencing programming with Scratch in the workshops, Tim came to appreciate the learning and creativity needed to develop a Scratch project. When Tim and Ethan worked on a project together, Tim consciously chose to let his son take the lead, while he supported him—reversing typical parent and child roles, with the son as the leader and the father as assistant.

Discussion

These case studies demonstrate the ways that parents' participation in these design-based activities with their children transformed the roles that they played in this program. At the beginning of the workshops, parents expressed concerns about what their children do with technology and anxieties around supporting their children with computing activities. Some parents called themselves "illiterate," while others saw themselves as monitors and regulators of their children's computer use. However, over the course of the workshops, the parents in these case studies demonstrated their commitment to supporting their children through a variety of practices and roles. More importantly, these negotiations that families experienced while working together enabled parents to explore and experiment with practices and see for themselves what worked and what did not to support their children. Facilitators and designers of these environments should pay attention to when these negotiations and tensions lead to disempowerment or marginalized participation.

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Designing for Collaborative Learning Expeditions by Using Wearable Technology and Smart Glasses

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Abstract: Wearable web-enabled technology is the newest social fad, but in what ways is it useful in education? In this paper, we illustrate an explorative study of wearable technology for supporting collaborative learning. More specifically, university students from three different study programs collaboratively developed a gamification activity for pupils in secondary schools. The study illustrates a new way of collaborative learning towards "learning expeditions" where the students become designers for a collaborative learning situation.

Keywords: collaboration, gamification, wearable technology, Google Glass

Introduction

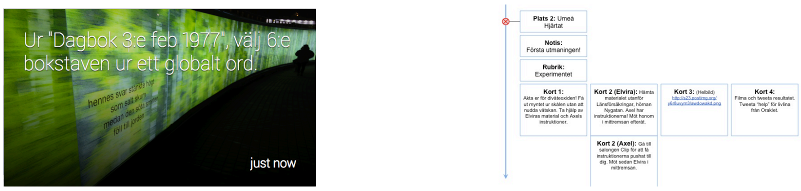
Wearable technology experienced a major breakthrough in 2013, but this was not a totally new concept. Steve Mann, the father of wearable technology, has been developing and researching computer-based glasses for many years (Mann, 2012). However, it was with Google Glass and the Glass Explorer Program that this type of technology caught the interest of the general public. Wearable technology is not only based on the fact that we carry around ubiquitous technology, but the technology is context aware and provides users with augmented experiences of reality (Greenfield, 2006). Hence, augmented reality is one of the most prominent features of such smart glasses. This involves the opportunity to create context-aware applications that analyze situations in real-time and present information to the user. However, although smart glasses have a potential for daily life outside education, there is still a knowledge gap as to whether wearable technology could be useful in education and in what ways. We conducted an exploratory study and focused on wearable technology by asking in what ways smart glasses (e.g., Google Glass) can facilitate and support collaborative learning in an educational context and what the benefits, potentials, and challenges of this technology are.

Study context

The study included a two-level collaboration between university students and secondary-school students. The university students consisted of two student groups across three study programs who created an application for Google Glass. The assignment was to create a gamification activity (with the characteristics of a treasure hunt) for children in grade 7. The university students developed a technical application for Google Glass and a pedagogical design that focused on the children's interaction with the technology. The children's assignment was to use Google Glass as a tool for solving a learning expedition (Jahnke et al., 2014). The university instructors did not design the learning expeditions *for* the university students; rather, they created conditions and provided an open environment where the university students were able to design the learning expeditions for the children.

The project was conducted during the spring 2014 with 11 participants organized in three groups. The first group from the study program Interaction Technology and Design (3 students) developed the technical application for delivering location-based information to Google Glass. The second group (6 students) from the study programs of Engineering Physics and Engineering and Management developed a pedagogical and social design based on the idea of a gamification activity. The pedagogical "design for learning" included challenges, problems, and clues (Figure 1). The third group consisted of two children in grade 7 (both about 14 years old), and they conducted the learning expedition in May 2014 by using Google Glass and the new app to solve the challenges put forward by the pedagogical design. The learning expedition focused on 'Cultures of Co-creation' that was the theme when Umeå was the European Capital of Culture in 2014. For example, one of the tasks for the children was to find words in poems painted on a big wall. The pupils had to combine the words to figure out what the next piece of the bigger puzzle was and to get to the next location in the assignment.

When the university students developed the Google Glass application for pupils in the form of a treasure hunt, they used the developed application to set information to specific real-world coordinates and within a specific radius. Location-based information supported the pupils' learning expedition and helped them to find the information they needed piece by piece. At each location they had to solve a riddle that provided clues as to how to proceed to the next location and level of the assignment.



(a) (b)

Figure 1. Technical application (a) and pedagogical design example (b)

Methods

Data were collected through observations and group discussions with both the university students and the school children. In addition, the university student groups wrote evaluation reports at the end of the semester. The reports described the work process, collaborations, and reflections on the potentials and challenges of the technology throughout the semester. The empirical material was analyzed through an inductive thematic analysis (Ely, 1991) with the aim of identifying key concepts and patterns. The following four views of collaborative learning were used in the analysis: a) the design of a situation, b) the interactions, c) the learning mechanisms, and d) the effects of collaborative learning (Dillenbourg, 1999).

Findings

This study provides insights into wearable technology for collaborative learning. The first step was to design a learning situation and an open environment for university students that provided the necessary resources for developing skills to become *designers for learning expeditions*. The study has increased the knowledge of the opportunities and pitfalls when using wearable technologies. The collective knowledge of the two student groups was necessary to successfully deliver and test the final application during the field study. The results clearly show that this project is pushing the limits of computer-supported collaborative learning situations and contributes to the debate over the digitalization of schools. A take-away message is that wearable technology provides the opportunity to reflect on and design teaching and learning in different ways where the teacher is the facilitator of an open environment that supports students in becoming collaborative designers across existing study programs and where the learning assignment develops "design-in-use experiences" for secondary-school students (Fischer & Herrmann, 2011). Such designs for learning have common features in that they take place:

- across existing departments and across established boundaries (e.g., different study programs),
- across different places and spaces (e.g., they connect higher education and secondary-school education),
- and through the connection to a real-world audience (i.e. the process and product designed by the university students are connected to a real audience, in this case primary-school pupils).

This can be called a two-level collaborative learning expedition. Such collaborative learning expeditions can be characterized as rather open-ended and problem-based learning paths. They include goal-oriented learning to master X, or to explore and understand the implications of N, but learning methods and instruments are open and unstructured. Such expeditions take place in sociotechnical communication spaces with reflecting peers (Jahnke et al., 2014). Nevertheless, there are limitations. Google Glass is still a prototype, and it is not customized to the Swedish language. These are attributes of an early-stage emerging technology that is difficult to use. For example, software updates sometimes crashed the new app that was developed during the project. However, in such situations the students learned to change their strategy.

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Sociomaterial Bricolage: Engineering Learning as the Practice of Making Sense by Making Do

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Abstract: Computer supported collaboration now forms the backbone of both professional and educational engineering practices and CSCL can provide a unique lens for understanding engineering learning. At the same time, looking at engineering practices can provide new conceptualizations for CSCL. In this paper I use empirical case studies to conceptualized engineering learning as "sociomaterial bricolage" – the ability of engineers to make sense while making do with the material and social affordances available within their practices.

Keywords: engineering learning, materiality, sociomaterial, bricolage, professional practice, CSCL

Introduction

Although research on actual engineering practices – what engineers *do* – is sparse (Downey, 2009), existing scholarship of professional engineering practice presents an account that diverges sharply from normative images of "the ideology of engineering" (Williams, 2002). The normative image of engineers is that they have a distinct technical domain of knowledge that they can apply rationally and in a more-or-less linear manner to the solution of technical problems. Under this ideology, the social and technical do not mix. In contrast, studies of engineering work have established that engineering work is complex, ambiguous, and full of contradictions (Stevens et al. 2014) and that the social and technical are inextricably tied up together in any engineering project. Given this assemblage, how engineers learn, what they know, and how they use their knowledge is intricately tied to both their social and material conditions.

Drawing on empirical case studies that I present in this paper I propose that engineering learning can be conceptualized as "sociomaterial bricolage" (Johri, 2011) wherein engineers learn by working on things (materials) but which often involves being able to innovate as needed in order to make things work, in other words, engineers making sense by making do. This ability to make do is a critical element of engineering practice and learning. I use sociomateriality to connote the intertwining of the social and material aspects of human practices. Bricolage comes from the work of Levi-Strauss (1967) and is way of highlighting the 'making do' of everyday practices, particularly those activities that are spontaneous and not designed.

Case studies

Case study 1: Design and development of a collaboration tool at TechLab

The first case study I present comes from an ethnographic study of an R&D laboratory working in the area of information and software engineering. The laboratory was an offshore R&D site of a Japanese multinational and was located on the west coast of USA. In this case, I take a close look at the professional practice of two engineering researchers, Brett who is based in the U.S. and Sato who is based in Japan, as they work on developing a prototype of a collaboration tool. These engineers were both trained in electronics and computer engineering and were developing a collaborative knowledge management tool for organizations. As they worked on this tool, they needed technical expertise in the area of research in addition to what they brought to the table, and also required technical expertise and support both for the project and for them to be able to collaborate and communicate across countries. They tried multiple collaboration technologies, including emails and videoconferencing, and different software technologies and programming languages. Based on their discussion and by trying things out, they began to formulate a solution to the problem. Although they were both experts in the topic, they read new research and had to develop additional expertise. For instance, one of the topics they were not that well versed in was turn-taking as a lot of that research comes from the social sciences. To advance their work, they looked at the literature and used that to formulate their problem. They then discussed their potential solution with other researchers who in turn offered new and better solutions. At each step, the social and material aspects of their practice were intertwined. By working on this project, they also learned both technical/material content and about social aspects of their work; this learning occurred in an ad-hoc manner as they both made do with what was available to them and were making sense in that process.

Case study 2: Design project in a sophomore level mechanical engineering course

The second case study comes from an introductory design course for mechanical engineering students offered in the sophomore year. I use qualitative data collected from a large study of engineering student design teams working on a class project. I look specifically at one team that appropriated collaborative tools to work virtually on their project (the class was face-to-face). The team's use of virtual means for meeting was not imposed by the instructor but was negotiated by the team members themselves. Team Virtual used programs like AIM chat rooms and Microsoft Office OneNote shared sessions to complete class assignments and design tasks outside of class. When they encountered a problem, as they did while using OneNote ™, they quickly modify their meeting tools and resorted to email and AIM document sharing to relay information. Team Virtual used the tools as means to move the design along and meet the requirements of the assignment. When assessing the use of a tool, one member of Team Virtual questioned whether the use was "enough to cover the bases", which was simply replied affirmatively by another team member. Their practice was aimed primarily at getting the assignment done with minimal requirements but they were innovative nonetheless. The students produced a design outcome which was comparable and similar to other teams but in the process learned not only the curriculum material but also new ways of working on design. Being able to work with technology for collaboration and using that technology for design went hand in hand. Discussions and interactions about the content mediated by technology occurred frequently. Fundamentally, the students had the ability to make do with the tools available to them and in the process learned how to make do and also valuable skills. Similar to the previous case, students learned technical (curricular) skills through their project but also learned valuable social skills and these skills were learned in practice and were intertwined.

Sociomaterial bricolage: Engineering learning as making sense by making do

In both cases the participants had several materials available to them – in this case computational tools and devices – that they used as they worked on their respective projects and problems. In both cases new technical or domain knowledge was needed to solve the problem and the participants acquired them in collaboration with others. For the student team, there was an element of "doing school" or getting things done just enough so that they were able to fulfill the requirements and get the intended grades. In the professional setting as well there was an element of this as who got to present the paper was determined by making sure that the Sato could travel to the conference. In essence, both cases depict the prevalence of norms within their practices. They also illustrate the ad-hoc nature of tool use – participants made do with whatever was at hand. They modified the tools to assist them in the practices and if something didn't work, they found an alternative – if AIM failed then some other chat channel was used. If institutional barriers prevent the use of a certain tool, a low fidelity alternate was developed. Both cases illustrate what is now commonly termed as "sociomateriality", the view that in human practices the social and the material are constitutively entangled (Fenwick, Nerland & Jensen, 2012; Orlikowski & Scott, 2008). I propose "sociomaterial bricolage" as a way to conceptualize engineering learning and argue that engineering students not only need to learn the use of tools but *making do* with tools in practice. This articulation is particularly relevant for CSCL as increasingly engineering practices are supported by computational tools and require collaboration to a large extent.

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Engaging Citizen Scientists in Model-Based Reasoning

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Abstract: We discuss initial findings from a citizen science research project focused on engaging lay people in collaborative model-based reasoning for natural resource management. We created collaborative online training and project development space for generating models and collaboration among peers to develop management plans for local environmental concern.

Keywords: citizen science, model-based reasoning, informal learning, collaboration

Introduction

Citizen science programs engage the public in authentic scientific research and provide an ideal venue for informal science learning. In co-created citizen science projects, participants who are actively involved in research endeavor to develop questions of common interest (Bonney et al., 2009). The projects are popular among individuals seeking to play an active role in environmental resource management and have the potential to draw individuals from diverse perspectives, from audiences that might not otherwise be engaged in science to those motivated by scientific interest who lack formal training in the field. Technology has transformed the way that citizen scientists are able to use computational techniques to engage in scientific practices (Bonney et al., 2014). Here, we report on the early implementation of CSCL in a co-created citizen science project.

In CollaborativeScience.org, members of the general public, who engage in environmental management courses through the volunteer Virginia Master Naturalist program, are given the opportunity to address environmental issues of local concern through planning project goals and actions in a hybrid in-person and online learning program. Thus, through the use of disciplinary tools in authentic activity, participants are enculturated into the wider community of environmental management practice and research (Brown et al., 1989). The first two stages of our adaptive management cycle include learning about the conceptual basis for their work and engaging in forums and model development. *Stage 1* provides conceptual information and background knowledge. The conceptual learning plan contains training modules: (1) ecosystem function and assessment; (2) adaptive resource management; (3) modeling and the practices of research. *Stage 2* consists of online forums and model development. After completing the conceptual stage, participant groups are given collaborative "forum" tasks which are designed to (1) define an open-land management issue of concern to study participants; and (2) develop a conceptual model of the local problem. Participants develop their models using an online tool (mentalmodeler.org) for Fuzzy Cognitive Mapping (FCMs; shown in Figure 1). An FCM is a cognitive map, in which the relations between the elements can be used to compute the strength of impact of these elements. These have been used to capture group mental models (Gray et al. 2011). The online forums and FCM's provide opportunities for learning to engage in intersubjective meaning making as they negotiate their models (e.g. Suthers, 2006). Here we examine models that participants generated from collaboratively generated parts, examining model development over time to see how participants used the model as a representational tool.

Methods

Our group of participants created models and a subsequent management plan on the suitability of certain public parklands for Red Cockaded Woodpecker habitat. The participants' initial inspection of this habitat determined that Japanese Stilt Grass, an invasive grass, was decreasing habitat quality. As Figure 1 shows, FCMs include not only components but also arrows representing relationships between the components. Each of these arrows contains a direction and strength (ranging from strong positive to strong negative influence). Within *Stage 1*, participants completed two FCMs, before and following collaborative component consensus. After the first year of their ongoing project, during *Stage 2*, a third set of individual models were collected. From the second (n=5) and third (n=6) sets of models based on collaborative components, we coded the participants' component connections by impact strength. To determine how models changed, we focused on the six most commonly connected components. Given our small sample, we present our qualitative exploration of these changes.

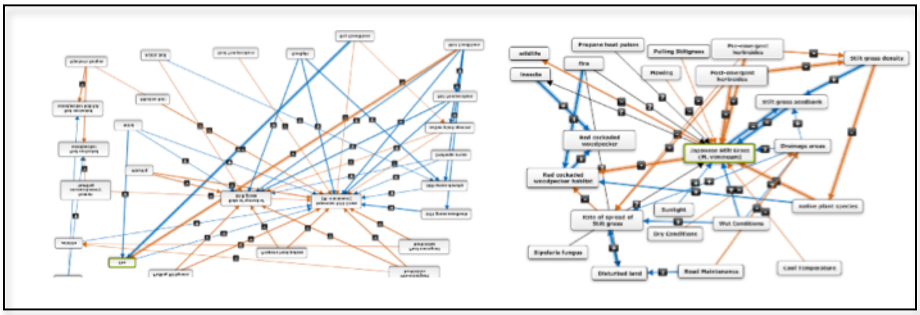

Figure 1. Example collaborative models at Phases 3 (left) and 4 (right)

Findings

Participants increasingly focus on more detailed aspects of their particular environmental problem as they learned from observational experiences after interventions (e.g., pulling and mowing, controlled forest burn). Initially, their individual models reflected little knowledge of more specific aspects related to their project that might curtail Stilt Grass: its rate of spread, seed bank, and density; however, their final models included many more connections to these elements within the system. Generally, the participants' final individual models reflected greater refinement of the relative impact of interventions tested within their activity, and components not investigated either remained stagnant or, more often, were not connected in the final model. Because participants developed a set of components via consensus, some included components not connected with any others (e.g., road maintenance, shade-dense canopy) or removed consensus components completely from their models. Components removed from or not connected within both early and final individual models were often abiotic, and in particular, less mutable factors like soil acidity, wind strength, or temperature.

Conclusions and implications

From our preliminary data, we draw two conclusions. First, final models reflect less complexity, as measured by the number of connections between components, but greater refinement of ideas. Our conclusion is consistent with Dauer et al. (2013) who found that model complexity peaked in the middle of an undergraduate life science course that used models to learn. Our second conclusion is that understanding of the complex ecosystem improved, noted by the reduction of abiotic factors, which in this particular problem are less likely the drivers of habitat suitability. Overall, models with greater accuracy were less complex; perhaps because irrelevant and less parsimonious explanations were removed, as increasing expertise eliminates extraneous detail. Further analysis needs to examine how the participants use adaptive management to develop their activity, the practices developed by meeting project goals, and the role of FCMs as boundary objects for collaboration.

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Embracing Cultural Diversity: A CSCL Inspired by an Internally Persuasive Discourse

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Abstract: The CSCL environment, *Interlaced Roots*, capitalizes on students' cultural diversity and is aimed at fostering internally persuasive discourse (IPD; Bakhtin, 1981). Such a discourse allows participants to express their individual narratives and to re-examine them in light of the narratives of others, and thereby sustain a dialogic society. A qualitative analysis that focused on the development of students' voices revealed evidence of IPD and learning and shed light on the role that the technology had played in the interaction.

Keywords: internally persuasive discourse, CSCL, multi-culturalism

Introduction

We had developed a CSCL activity, *Interlaced Roots* (IR), aimed at dealing with diversity in multi-cultural societies. IR builds on an existing unit in the Israeli curriculum for junior-high schools, in which students study their families' heritages individually. We added a consecutive phase in which students work in mixed-culture pairs and jointly investigate the similarities and differences between the narratives of both families, as well as the circumstances that shaped them. We aimed at teaching students to embrace multivocality and to use it to enrich themselves, and encouraged them to (re-)examine their voices, in light of what other alternative voices suggest. Bakhtin (1981) termed discourse characterized by these dynamics as "Internally Persuasive Discourse" (IPD). The potential of CSCL as a venue for IPD-inspired instruction is self-evident. The technology mediates students' interactions with the other voices, and therefore, might support and scaffold such interactions (Stahl, Koschmann & Suthers, 2006). Our research goal was to shed light on the learning processes and outcomes. There is little empirical work on CSCL in the contexts of multi-cultural societies and the role of technology. Moreover, very little is known as to the forms IPD takes and the conditions required. According to Matusov (2009), IPD occurs through "engagement in dialogue on the threshold, where social roles disappear, selfish interests disappear, and important social dilemmas present themselves in ultimate form." (p.237). Can this occur in a tense multi-cultural context, as in our study? Can IPD occur? And what roles do the technology play? The goal of the pilot study described here was to address these questions.

Methods

The study was conducted in Israel, which suffers from numerous cultural tensions between its diverse ethnic groups, such as the tension between Ashkenazi Jews (who immigrated from Europe) and Mizrahi Jews (who emigrated from Muslim countries), and the tension between Jews and Arabs. Participants were graduate students from the School of Education at the Hebrew University of Jerusalem. They interviewed their families about their formal education, investigated the relevant historical contexts, and uploaded to the Wiki the narratives of three generations: themselves, their parents, and their grandparents. We then grouped them into pairs and asked them to compare their narratives and compose a joint narrative. Interactions between peers were conducted mostly via the Wiki, but also through other communication channels (phone, mail, and face to face). They also had to reflect on the activity after each phase, and to upload their written reflections. In this paper we focused on four female students who worked in the following pairs: (1) Veronica, Mizrahi and Mary, Ashkenazi; (2) Allice and Kailey, both Ashkenazi; Kailey is an immigrant from the USSR; and (3) Olga, Mizrahi and Ellen, Ashkenazi. The average age was 35. Narratives from individuals and pairs (uploaded to the Wiki environment) were analyzed using narrative inquiry methods (Clandinin & Connelly, 2000). The written interactions and students' reflections were analyzed thematically. Next, for each student, we traced changes in his or her voice throughout the texts produced

Findings and conclusions

Has IPD occurred?

Veronica's criticized her family for not investing in education. Her mother, the only family member in her family, who had graduate from school, studied in a vocational school and she asked her why she had not attended a better school. In the joint essay, she changed her attitude and expressed her pride of her mother, who despite the harsh circumstances managed to graduate from high school. Her peer, Mary, first unquestionably accepted her grandfather's description of himself as an ignoramus because he did not have a formal education. In the joint essays, however, she questions this definition, given his efforts to informally widen his horizons (e.g., he mastered 4 languages, read history books, and so forth). The interaction between Veronica and Mary is in alignment with what Bakhtin (1981) termed "dialogue on the threshold". Questions regarding themselves emerged and were discussed. Neither Mary nor Veronica mentioned the Ashkenazi/Mizrahi cultural differences in their individual stories. However, this issue emerged in their discussion. Was formal education a personal choice or did society guide them differently? Their reflection on their collaborative process implies that indeed IPD had occurred: "the other's story…was used to contrast our own story or as leverage to better understand it."

Allice's and Kailey's narratives also provided many opportunities for discussion. One example is Kailey's grandmother, who lived in the former USSR and chose education at the expense of raising her own children, in contrast to Allice's grandmother, who made the opposite choice. However, as they explained in their reflections, they sought harmony and so when they recognized diversity, they chose not to delve into it deeply in order to avoid conflict and pain. Their behavior is reminiscent of the results in the study by Akkerman et al. (2006). Indeed, we found no evidence of a change in their individual stories.

Finally, in the third pair Ellen changed her perception of her grandmother. She first viewed her as a feminist, a wall breaker, and a non-conformist. However, after reading Olga's stories, especially, Olga's description of her grandmother, she noticed the similarities and therefore decided to describe her grandmother more as a conformist, as someone who follows social conventions, and supports her spouse. Olga viewed her family story as a success and did not change her story, although her family was much less educated than that of Ellen. This topic was not discussed through the interactions. They had difficulties to see any similarities.

Hence, the encounter with other voices and stories triggered half of the participants to undergo, what Akkerman et al. (2006) termed a deep exploration. We thus concluded that IPD is a feasible and a beneficial educational goal. The results also highlight the fact that IPD is characterized by asymmetry. Peers can gain knowledge differently from the discussion they had participated in. Accordingly, the joint essays should not be viewed as reflecting one's shared body of knowledge, but rather as a means for students to become dialogical, to learn to express themselves, voice their opinions, re-examine their voice against voices of others.

The role of technology

Students' reflections highlighted two characteristics in the technology that apparently played major roles in shaping the dynamics of their collaboration. First, the multiple channels of communication (Wiki, emails, phone, etc.) enabled the students to better deal with their emotions and therefore reduced tensions. They could choose the appropriate channel with which to communicate each time. These results are in line with the work by Amichai-Hamburger and McKenna (2006). Second, all the stories, as well as the asynchronous communication, were open to all the participants. Students reported that they enjoyed browsing and reading other people's stories and that it helped them deal with their own work. Specifically, some felt that they did not know how to collaborate and used other people's comments as guidelines. Others mentioned that reading other stories empowered them. Most felt that reading others' stories encouraged them to reveal more about themselves. Some, however, felt it was not safe to tell their stories freely. More work is required in order to provide scaffolding and create a sense of security.

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CSCL Opportunities with Digital Fabrication through Learning Analytics

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Abstract: This paper presents a recently started research project that aims to generate, analyze, use, and provide feedback for analytics derived from hands-on, project-based and experiential learning scenarios. The project draws heavy influence from digital fabrication activities and related inquiry-based learning. The intention of the poster is to raise the discussion about how learning analytics from the project can be used to support and enhance learning for tangible technologies, These activities include physical computing and other lab work for small group work in higher education and high school settings.

Keywords: Learning analytics, practice-based learning, design, physical computing

Introduction

Educators, researchers, business leaders, and politicians are working to redesign schools to teach 21st Century skills that include: creativity, innovation, critical thinking, problem solving, communication, and collaboration (Lai & Viering, 2012). Blikstein and others (2013) offer strong arguments for how hands-on activities like digital fabrication could be a new and major process for bringing powerful ideas, literacies, and expressive tools to learners. The current challenges for designing and evaluating CSCL activities in digital fabrication scenarios are: the open-ended nature of the projects, the small group work, and the use of physical computing components that require construction and programming. This poster presents on-going work in the Practice-based Experiential Learning Analytics Research And Support (PELARS) project that aims to generate, analyze, use and provide feedback for analytics derived from hands-on, project-based learning activities. The focus of these activities are on learning and making things with physical computing activities that provide learners with opportunities to build and experiment with tangible technologies and digital fabrication. The project addresses three different learning contexts (university interaction design, engineering courses, and high school science) across four settings in Europe.

The overall research aim of the project can be summarized as: *How can physical learning environments and the hands on digital fabrication technologies in laboratories and workshops be designed to support ambient and active data collection for analytics?* The goals of the project are first to define learning (skills, knowledge, competencies) that is developing, and how we can assess it in the frame of learning analytics. Then to determine what elements of this learning we can capture by designing the physical environment and activities around digital fabrication technologies. Then the need is to identify what patterns of data we collect can tell us about learning, collaboration and how the system can help support. Our aim is accomplish this by the development of technological tools and ICT-based methods for collecting activity data (moving image-based and embedded sensing) for learning analytics (data-mining and reasoning) of practice-based and experiential activities. This data is used to create analytics support tools for learners and teachers providing novel frameworks. These new tools can be further developed along the ideas of knowledge-communities and inquiry (Slotta, Tissenbaum, & Lui, 2013) and provide conceptualizing, representing, and analyzing distributed interaction (Suthers, Dwyer, Medina, & Vatrapu, 2010).

The current work in the project raises important questions for the CSCL community across the design of the learning environments, the technological system, and the design of the educational activities. Figure 1 illustrates an example workbench technology scenario for the project, highlighting potential elements of system implementations. The methodological approach starts with the temporal data collection, vision system data, table sensors, programming log files, and closed surveys (quantitative instruments) will be used to measure the relationships between team collaboration, object manipulation and construction, and programming code, system usability, and artefact generation (independent variables) and the computer vision and gesture recognition for learning, activity recognition system and workflow reconstruction, learning traces, data mining for analytics, and visualisation (dependent variables). At the same time, investigating the learners' understanding of knowledge and practice in STEM activities in the workshop and the lab (central phenomenon) will be explored using participatory design, qualitative interviews, surveys observations, and design critiques. The reason for combining both qualitative and quantitative data is to understand the different research problems better by converging both quantitative (broad numeric trends) and qualitative (detailed views) data.

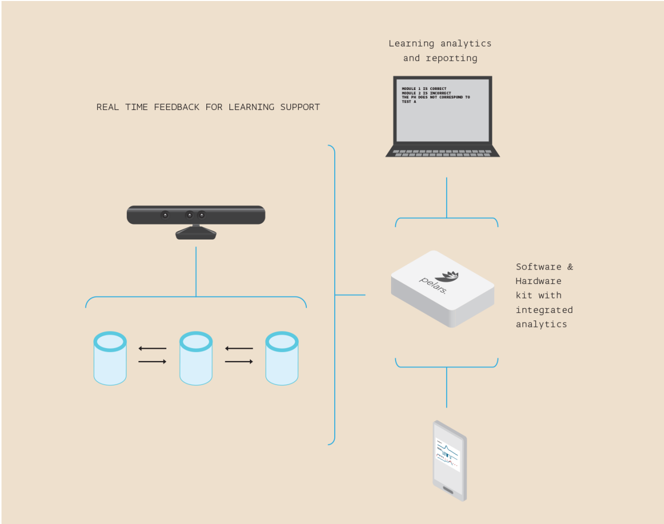

Figure 1. PELARS Learning Analytics System

One implication of the poster is to explore how the PELARS learning analytic system can be used to investigate face-to-face collaboration by capturing traces from the system while supporting open ended and hands-on learning in lab settings. Maldonado and colleagues (2013) argue that the potential of these systems is that they can be used to support learners and teachers by exploiting captured traces of interaction. Additionally, the data can provide insights by making the collaboration visible and highlighting potential problems. Secondly, the emergence of low-cost high resolution, multimodal sensors that capture diverse data opens new opportunities for supporting learning community and these technologies needs to be framed correctly in order to benefit research and practice (Worsley, 2014).

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Temporal and Material Conditions for Instruction in Simulation-Based Maritime Training

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Abstract: Simulator-based training in maritime education is a highly structured and technological advanced learning activity. By analyzing video recordings of exercises in a navigation course, the study specifically explores: a) the use of different tools and technologies in maritime training, and b) how the instruction shapes and are shaped by the temporal organization of the events. The results highlight instructional matters of connecting the general learning objectives with the particular details of the scenario throughout the whole training session.

Keywords: simulation-based training, instruction, technology, temporality, maritime education

Background

Training in simulators regularly involves three phases that afford different material and temporal conditions for instruction. First an introduction to the day's assignment is made, a so-called briefing. Typically, the introduction is focused on practical information – how to carry out the assignment and the learning objectives (Wickers, 2010). After the introduction, the scenario takes place where certain aspects of the work is recreated or mimicked for training purposes. As a final step, a debriefing is carried out, which offer opportunities for post-experience analyses and reflections on the event. Debriefing has been described as the "attempt to bridge a gap between experiencing an event and making sense of it" (Fanning & Gaba, 2007, p.116), as well as a way to integrate theoretical knowledge and practical experience. For these reasons, the debriefing phase is often seen as especially important for learning (e.g., Fanning & Gaba, 2007). In simulation-based training it is common to use different technologies for instruction and feedback. In health care, for instance, there have been studies of video assisted debriefs (e.g. Savoldelli et al., 2006) and in maritime training the use of simplified visualizations have been discussed as significant opportunities for learning (Honvendt & Arnseth, 2013).

The analytical framework of this study is based on Suchman's (2007) seminal work on plans and situated actions. Following this, instructions are seen as general prescriptions for action and their use are taken as contingent on the particular occasion in which they are applied. As the situation and its material and social circumstances set the conditions for actions, instructions are necessarily partial. It is only in the actual course of actions that instructions acquire their specific meaning. Even if the students are told what to do during the briefing, these instructions are unable to specify exactly what the students should to do or how to handle the situations. A central question is also when and how the instructions should be applied. During the actual simulation, another form of instruction takes place, which "draws pedagogical strength from exploitation of the unique details of particular situations" (Suchman, 2007, p. 45). By monitoring the actions of the students it is possible for the instructor to address the particular problems that the students encounter at the precise occasion where these problems emerge. In the debriefing phase, the particularities of the practical assignment and the actions taken are reconstructed and revisited in retrospect. In this phase, when the outcome of the assignment is known, it is possible to assess the appropriateness of performed actions. Here, the prospective plan is revisited to filter out the particularities that accord or diverge from the initial plan (Suchman, 2007).

Method

The methodological approach was based on Heath, Luff and Hindmarsh (2011) principles for video-based research. During a pilot study, three different training sessions were video recorded, in all 15 hours of training. Cameras were placed in the simulators, the instructors' room and the briefing room to capture interactions that were spatially distributed during training sessions. In addition, observations and informal interviews with the instructors have been central for understanding the educational content in navigation courses.

Results

In the technologically advanced simulator environments training activities are highly structured in order to connect the general learning objectives with the particular details of performance in the scenario.

In the *briefing phase*, the material conditions in the classroom setting and the use of a power point presentation set the frame for instruction. The power point presentation, produced by the instructor in advance, connects the exercise to the learning objectives. Furthermore, the instructor's use of power point, talk and gestures structures the instruction and establish joint attention to different aspects of the upcoming scenario (cf. Lymer et al., 2009). In this phase, the instructions are rather concrete and aimed to prepare the students for the upcoming exercise. At the same time, the instructions also have to address the various contingencies that might emerge in the upcoming situation (cf. Suchman, 2007). The instructions are thus both general and concrete.

During the *scenario*, instructions are occasioned by the monitoring of students actions on a screen in the instructors' room. When it is evident that the students display lack understanding of how to go on, it makes relevant a closer inspection of their performance and for different types of corrections. Instructions from the instructors' room are mediated by radio as a part of the scenario and are suited for in-role instructions that maintain the activity or for straightforward directives on what to do next. In contrast, face-to-face instructions on the bridge operations simulator draw on a rich context of material and social resources, and afford instruction on the many complex matters of navigating a ship.

In the *debriefing* phase, the prospective instructions in the briefing are revisited, connecting the particular scenario back to the general learning objectives of the exercise. In this phase, instructions take the form of assessment, providing feedback that is connecting the practical actions to the theoretical content of the course and to professional concerns. During debriefing different technologies provide the material conditions for revisiting the learning objectives and reconstructing the scenario. A power point is used to revisit the same points as during briefing, but now in retrospect. The use of power point here reconnects the scenario to the learning objectives, and affords assessment in general terms. The use of simulator technologies, in this case a playback of the scenario from a birds-eye view, makes it possible to reconstruct the prior actions and makes them accountable. In this way, the use of playback enables instruction and assessment of specific details of the students' prior conduct.

Conclusion

The results highlight the importance of systematic professional guidance and feedback in simulator-based training, supporting results from research on healthcare simulations (Rystedt & Sjöblom, 2012). The results address instructional matters in simulation-based training: a) how to connect the general learning objectives with the particular details of the scenario, b) how to bridge between theoretical knowledge and practical action, and how to relate the training professional to professional concerns. The results are in line with literature on debriefing, describing this phase as a way to integrate theoretical knowledge with practical performance, but this study contributes with new perspectives on how this is done through a structured process of abstraction and application in and through all phases of training. Furthermore, the results illustrate how technologies for feedback enter in educational practices. A pedagogical potential of such technologies is that they provide a record of the actions taken during the scenario that makes students' actions accountable. In this way their actions are publicly observable and discussable, opening up for feedback and reflection on a variety of theoretical and practical issues involved in the practice of navigation.

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Appropriation of Tablet PCs by Non-Tech Savvy Seniors: Options and Obstacles of Sustainable, Practice-Based Learning in the Elderly

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Abstract: Information and communication technologies (ICT) may offer solutions to demographic challenges our societies are faced with. Elderly people may be supported in their every-day lives by means of new media to stay connected to their social networks, families and neighborhoods and in order to prevent social isolation and effects of a "digital divide". However, there is not much knowledge up to date on how to support elderly and non tech-savvy persons' learning and appropriation processes of ICT to enable sustainable learning environments. On the basis of socio-constructivist learning approaches we outline specific obstacles and constraints in the set-up of an appropriate learning environment for elderly ICT novices.

Background and research purpose

Appropriation of new media by elderly people non-affine to ICT and their acquisition of media competencies are objectives which have not been examined a lot by the CSCL community. We report results of an ethnography- and action research-based study focused on elderly and non tech-savvy persons' first steps in the appropriation of tablet PC and internet applications which may contribute to their quality of life in the sense of getting new channels to communicate and to stay socially connected and informed.

Methodologically and conceptually speaking, we ground our work in socio-constructivist learning approaches (Stahl et al., 2006), which focus on informal and social learning, such as Communities of Practice (CoP) (Lave & Wenger, 1991). The shift from analyzing internal mental processes towards social interactions involved developing new methods in order to adequately describe and frame the observed phenomena. Lave & Wenger coined the term of Legitimate Peripheral Participation (LPP) in an effort to describe the highly social process of gradually integrating novices into an established community by taking part in their ongoing practices, routines and habits, thus being able to adopt and refine skills, informally learn basic principles and develop an identity inside the community.

For the specific group of learners in focus we identify several themes and obstacles, which are in contrast to concepts, tools and methods aiming at knowledge and competence building of younger and ICT-affine learners. Our empirical results cover the following questions: How can we get elderly, non tech-savvy people interested in new media usage; how can we foster their motivation to learn; what is the right level of learning objectives; which tools and measures can support a sustainable learning progress?

Setting, methods and methodological challenges

Over the period of two years biweekly workshops (3 hours duration) have been held with elderly tenants as part of a larger participatory design project. Overall aim of the project is the development of socio-technical measures including an internet portal for a local neighborhood aiming at the support of mutual awareness, social inclusion and informal help among elderly and younger tenants living in a housing complex. A special focus lies upon the support of the elderly to enable them to stay independently in their homes as long as possible.

In the workshops we handed out tablet PCs to interested elderly persons and in a mutual learning endeavor started to explore functionalities and apps which would be meaningful to them against their every-day life practices. We observed the ongoing appropriation process of the seniors with the tablet computers and mobile applications in these workshops in a community room of the housing company situated next to the housing complex. In total we conducted about 50 regular and three larger-scaled workshops up to now. After the first 9 months of work with the tablets, we were able to take up discussions and participatory design activities dedicated towards the development of the neighborhood portal. Our overall methodology combines elements from ethnography and action research (Hayes, 2011).

Empirical results

Getting access and fostering motivation

Our first access to the tenants took place in tenant assemblies organized by the housing company. When being presented the project ideas many of the elderly and non tech-savvy persons were not much interested to participate at first. This was because they could not envision the benefits of the new technologies in their every-day lives. We then took a second attempt to introduce our ideas framed into social activities organized by the local caretaker for the elderly tenants: “coffee and cake with your caretaker”. In this informal and social setting, we brought tablet PC and during chats with the people showed some features and apps which were connected to the stories they told, e.g. we browed the internet for locations they told about, such as former home towns, holiday regions, etc. By this practice- and story-based approach to link tablet PC activities to their individual interests we finally could motivate 10 tenants to step into a participatory design project with the design team.

Looking for “anchor points” to ground ICT usage in every-day practices

One of many examples of how learning objects and themes subsequently evolved and were grounded in the seniors’ sense-making processes was picture/video taking and sharing: Initially, we started with a demonstration of photo and video features on the tablets because some of the elderly had brought pictures to the workshops in order to show us their families or places they liked. As this practice was being perceived as both, very easy and joyful, taking pictures and videos became a major issue for the next couple of weeks. Next, some participants wished for the possibility to exchange their pictures. This was the starting point for introducing the concept and use of email, including the creation of an email account for everyone. Besides observing that the elderly successively integrated the new technology in their individual everyday life context we were able to observe a change in their overall attitude towards new ICT. Before using the tablet PCs, we were confronted with a high proportion of disinterest, anxiety and even embarrassment. During the usage phase people developed pride in their own skills and their way of mastering this new technology. “Anchor points”, i.e. technological features linked to their every-day practices proved to be an important basis for motivation and a joyful learning space.

Developing self-help measures to solve tablet PC usage problems

As after two years of cooperation, the elderly are not fully capable to use the tablets autonomously and need guidance in case of upcoming problems we started developing a set of sustainable self-help measures. During the project we already introduced tools to bridge the time between the biweekly f2f workshops and which support mutual help among each other. As the group is composed of native German speakers language difficulties occur as many terms are English – even in the German help sections of manuals. Hence one attempt was to create a *list of translations and explanations* in paper format. We also created a *handbook* explaining the basic functions of the tablet with screenshots from the original. In addition, in order to help individuals with specific problems in handling apps or the tablet we developed *stencils of the tablet* where we can draw and include annotations in the f2f sessions. Both tools address a pattern we observed: the people often use notes and write down the solutions given by us to be able to read them and repeat the related tablet interactions later on at home. In general, the elderly appreciate material with which they can recap the newly learnt interactions on the tablet when being at home on their own. Further, we introduced an instant messaging tool as a channel for asking us or the group remotely for help. Based on this, we exercised making a *screenshot* and sending it. This supported the demonstration of a usage problem and its explanation, and to foster mutual help in the group.

Discussion

Only on the basis of several month of action research-based workshops of mutual learning between elderly tenants and the research team, a status could be reached that the tenant were able (in the sense of having the ability to envision a future technology) and motivated to be involved in co-design sessions of the neighborhood portal. To come there involved dealing with many obstacles, such as a missing common repertoire and an overall lack of a common space of thinking. This could be tackled with an approach to experience-based and open-ended learning activities and mutual engagement between researchers and the elderly.

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Using Epistemic Synchronization Index (ESI) to Capture the Knowledge Elaboration Process of Students in CSCL

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Abstract: The research used qualitative content analyses on students' online text-based messages during CSCL. Based on the scoring, we arrived at standardized scores to visualize and measure students' knowledge elaboration process during CSCL. The method can be applied into various synchronous and asynchronous online dyadic collaborations.

Keywords: Epistemic development, knowledge elaboration, visualization

Higher-order thinking is important for problem-solving in Computer-Supported Collaborative Learning (CSCL) (Weinberger & Fischer, 2006). So far, very little research is able to capture the dynamic progress of the evolvement of individual epistemic engagement in CSCL. Questions such as how to distinguish gifted and regular students regarding knowledge elaboration remains a black box.

Based on three cognitive modes from Kumpulainen and Mutanen (1999), we (Ding, 2009; Ding., Bosker & Harskamp, 2010) developed a coding system to measure students' epistemic engagement, which was termed as "elaboration values" referring off-task, on-task and elaboration activity. Each piece of student online messages was coded into a discrete numerical value as -1, 0, or +1, see Figure 1.

Table 1: Sample of the coding categories

Category	Numerical Value	Definition	Example
Off-task	-1	Content of the message is not related to the question solving	*What is your plan for the Christmas vacation?*
On-task	0	The message only shows an agreement, however, without justification or critical thinking.	- *(If we visualize it, each part should be 0.4722.)* - *You mean 47.22%?*
		The message is relevant to the question, however, without any advancement of solution.	- *Ok, we know the z score now. Then, what shall we do?*
Elaboration	+1	The message shows a step towards the final solution.	*It is a finite population because n/N is 0.2, smaller than 0.5.*

In our newly published research paper (Ding, Wei, Wolfensberger, 2015), we refined and standardized the method. The preliminary study explored a method to distinguish the individual dynamic process of epistemic involvement in CSCL. Two female bachelor students from a Dutch university participated in seven online collaboration sessions, solving statistics questions in an online text-only chatting room. The unit of analysis was defined as each message emerging at a recorded timeslot. We used a series of equations to arrive at an Epistemic Synchronization Index (ESI). We segmented the total process of problem-solving equally into several time intervals. For each time interval, we calculated the area between individual CEV curve and the baseline. After that, we used the following formula (Figure 1) to achieve the ESI value.

$$ESI_0 = \int_{t=0}^{t} A * |CEV_{S1} - CEV_{S2}| * dt$$

Figure 1. Formula to calculate Epistemic Synchronization Index (ESI)

A is a normalizer defined as, see Figure 2:

$$A = \frac{1}{\int_{t=0}^{t}(|CEV_{S1} + CEV_{S2}|) * dt}$$

Figure 2. Formula to calculate the normalizer A

In order to calculate the A, the polygons of the CEV for individual students were defined as CEVs1 and CEVs2. The integral function was applied in this case with the aim to achieve a more accurate comparison.

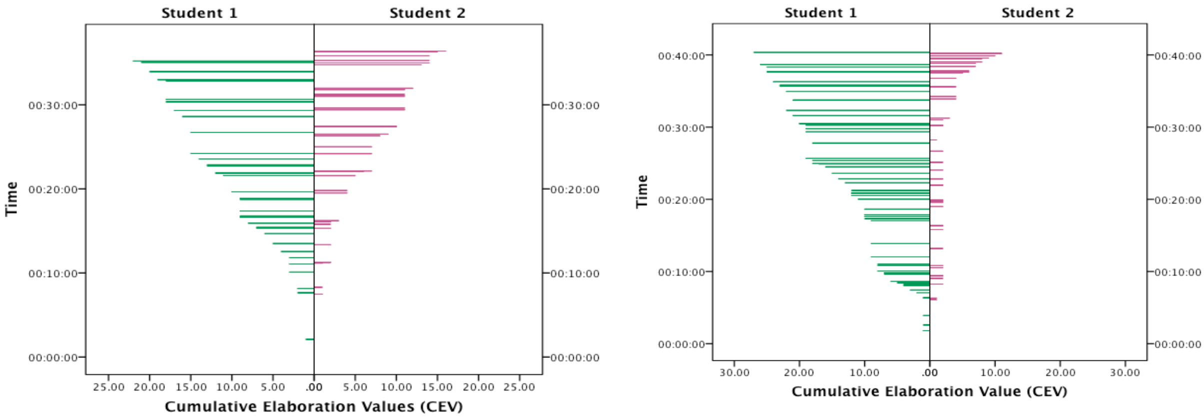
Furthermore, we used following two formulas, see Figure 3, to measure whether an individual student contributes more to the collaboration than his/her partner.

$$ESI_1 = \int_{t=0}^{t} A * max\{0, CEV_{s1} - CEV_{s2}\} * dt$$

$$ESI_2 = \int_{t=0}^{t} A * max\{0, CEV_{s2} - CEV_{s1}\} * dt$$

Figure 3. Formulas to calculate the individual ESI values

Notice that we have ESI0=ESIS1+ESIS2. If ESIS1>ESIS2, the first student makes more contribution than the second student to the collaboration, and vice versa. From the Figure 4, we may distinguish students' knowledge elaboration processes. ESI ranges from 0 to 1. The smaller, the more symmetrical of students' epistemic engagement.



ESI=0.68 ESI=0.84

Figure 4. Sample of visualization of ESI

This methodological exploration will not only contribute to the CSCL theoretical research, but can also be applied into various online learning environments, for example, to provide tailored just-in-time hints to weak students in order to achieve a balance in knowledge elaboration process.

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Using Persuasive Design and Social Learning to Support Adult Learners' Metacognitive Development

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Abstract: Adult learners with strong metacognitive awareness and strategies are more likely to achieve their goals and effectively perform in school and the workplace. However, research is limited on how to support their metacognitive development, so we designed and piloted a sociotechnical system informed by theories of metacognitive development, persuasive design, and social learning. Learners who used the intervention, which involved weekly prompts for reflection on their metacognitive awareness and discussion of their development with their peers online, showed stronger metacognitive development, particularly in their awareness of strategies and tools as well as planning and goal setting. This pilot is part of ongoing research into a new persuasive-social approach to supporting metacognitive development.

Keywords: metacognition, social learning, design

Introduction

Metacognition, or awareness of and implementation of one's strategies for thinking and learning, is a requirement for 21st century adult learners to be effective in any context (Bransford et al., 2000), but further research is needed on how to better support adult learners in their metacognitive development (Justice & Dornan, 2001). Metacognitive support tools exist but are primarily tested on younger learners in specific domains rather than with older adult learners across multiple contexts (Veenman et al., 2006). Thus, our main research questions are: (1) How can we better support adult learners in developing metacognition? and (2) What specific design elements and features aid in supporting metacognitive development for adult learners?

To begin answering these questions, we created and piloted a web-based application, ReflectCoach, with adult learners enrolled in an introductory college course. Persuasive design (e.g. Consolvo et al., 2009) and social learning principles (e.g. Huang, 2002) informed the design of ReflectCoach, which emphasizes the intersection of behavior, identity, and social influence to help users make changes with respect to their metacognition. These elements aid adult learners in understanding how their stories of metacognitive development, which are rich with prior learning and varied experiences, are part of a bigger community and shared story; through reflection on this, learners better understand their metacognition and begin to improve it.

The intervention

ReflectCoach is a responsive web application built using a combination of three key persuasive and social design features to facilitate the metacognitive development of adult learners: (1) Classroom wiki that facilitates social learning through membership and participation in weekly reflection forums with other learners through prompts like, “Share a time you were successful or unsuccessful at using a strategy to achieve a goal."; (2) Weekly self-scoring questionnaires based on Schraw's (1994) Metacognitive Awareness Inventory (MAI) with prompts like "How often do you check that your goals are met?" The results appear on a public scoreboard so learners benefit from iterative weekly self-assessment (persuasive) and competitive group identification as "Rookie, Pro, or All-Star" (both social and persuasive); (3) An automated email agent that reminds learners of weekly progress and recent activity in the system. This encourages a persuasive "habit" of reflection on metacognitive strategies each week and supports continued participation. Learners tell their learning stories and begin to identify with the concept of metacognition in these assessments and discussion forums while tracking and monitoring their own and others' progress via the scoreboard and discussion forums.

Methods

The eight adult learners who participated in this study were enrolled in a section of a required introductory-level 10-week online composition course in a four-year bachelor's degree program for adult learners (age 24 and older). Four learners used ReflectCoach during the course and four learners did not. The average age across both groups was 38. The instructor of the course was aware of the study, but did not know who agreed to participate and who did not. She taught the course as usual. To measure metacognitive development, we implemented: (1) A pre/post test based on Schraw's (1994) Metacognitive Awareness Inventory (MAI), which was analyzed with descriptive statistics; (2) participants' learning portfolios (a standard course requirement), which were scored by external raters on three metacognitive criteria: awareness of strategies and tools, self-evaluation, and planning; and (3) 30-minute interviews with participants, which were analyzed using descriptive coding (Saldana, 2012).

Findings

The control group's pre-/post-course MAI scores showed only a 6% average increase, while the treatment group showed a 16% average increase. While the sample is too small to generalize to a larger population, it suggests that there may be a difference between the groups with a larger sample size. To further support these findings, the portfolio scorers found that treatment groups' learning portfolios demonstrated stronger metacognition across all criteria than the control group: the overall metacognition score was 80.5% for the treatment group and 55.5% for the control group. The treatment group also more often exceeded expectations in their awareness of strategies and tools and planning/goal setting.

Learners' interview responses showed that both groups grasped the concept of metacognition and understood its value. However, the control group tended to simply *define* metacognition while the treatment group *internalized and applied* the concept of metacognition and ways to improve: "Sometimes I get so stuck in work and school and family responsibilities that I don't recognize why I'm doing well or poorly. […]There are actually ways I could make it better, by setting goals and planning stuff out more. And knowing when and how to ask for help." When describing their experience with ReflectCoach, the participants valued the weekly updates and preferred personalized information. Additionally, the questionnaires and scoreboard invoked a competitive spirit for one of the participants: "There was a point where I started looking at everyone else's scores and was like hey, I'm doing okay, but I want to be an All-Star." The public scoreboard was also helpful for self-assessment in a social context: "I liked being able to see everyone's scores and see where I fell on the chart." Finally, some participants were active in the quizzes and assessments, but found value simply lurking in the discussions without actively participating.

Conclusions and future research

While this pilot was conducted with only eight participants, the results suggest that (1) introducing the concept of metacognition to adult learners helps them to internalize it and understand its relevance in the learning process and (2) persuasive-social design elements provide opportunities for metacognitive "habits of mind" in a learner-centered, low-stakes, and informal manner. We will continue to iteratively test ReflectCoach using the methods described above with a larger population. We will also conduct an analysis of the ReflectCoach peer forums to learn more about the ways adult learners characterize and interact with each other about their metacognitive strategies. This research will provide educators, trainers, and other adult learning practitioners with learning design principles that encourage metacognitive habits for adult learners. Additionally, since persuasive-social design is a combination of two existing design principles in the eLearning and app-development industry, we are confident that it can be smoothly integrated into various learning settings.

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Science Classroom Inquiry (SCI) Simulations for Generating Group-Level Learner Profiles

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Abstract: Our previous work demonstrated that Science Classroom Inquiry (SCI) simulations effectively teach content knowledge and authentic science practices. Here we demonstrate that SCI simulations, with their non-linear authentic structure, allow for investigation of the unique inquiry-driven paths generated by students. These paths can be used in conjunction with other metrics to construct learner profiles. These learner profiles provide insight into the cognitive processes students use as they participate in simulated authentic science inquiry.

Keywords: science education, simulations, problem based learning, learner profiles

Introduction

Recent science education calls in the United States have resulted in *Next Generation Science Standards* emphasizing the importance of teaching students science practices, disciplinary core knowledge, and crosscutting concepts (Achieve, Inc 2013, NRC, 2012). Allowing students an opportunity to engage in science inquiry that is grounded in real-world problems *and* that allows authentic, non-linear investigation is expected to foster students' collaborative learning. Simulating such inquiries via computer-based simulations removes many of the typical time and instructional barriers (NRC, 2011, Renken, Peffer, Otrel-Cass, Girault & Chiocarriello, In Prep). Our previous work (Peffer et al, In press), demonstrated that Science Classroom Inquiry (SCI) simulations were effective at presenting an authentic-inquiry experience to students that resulted in student-reported learning gains and alterations in perceptions of authentic science practices. To better understand actual student outcomes when given investigative flexibility, we set out to identify the presence of unique inquiry-driven pathways generated as students worked through a SCI simulation. Preliminary data collection with groups of middle school students indicated that each student group generated its own unique hypothesis and pursued unique testing strategies—generating group-specific pathways. Here we discuss relations between group pathways, initial hypotheses, and conclusions. We also highlight implications for research, design, and instruction.

Methods

Participants

Participants were recruited from students involved in an extracurricular educational activity at a zoo located within a large mid-Atlantic city. Students were first introduced to background information pertinent to completing the simulation and then completed the *Unusual Mortality Events* SCI simulation. The participants included both males and females of mixed ethnicities in grades 6-8.

Design and procedure

Students worked in groups of 2-3 to generate a hypothesis, utilize a testing strategy and make final conclusions. As student groups completed the simulation, the simulation engine automatically recorded their entries and decisions. We analyzed the archived and de-identified data to determine the learner profiles generated by student groups.

Findings

Although all students were presented with the same background and problem, each group of students worked through the simulation in a slightly different manner (Figure 1). Each group's initial hypothesis is shown on the left hand side of the figure, and final conclusions on the right hand side. Black dots represent when a group decided to pursue a particular experiment. Each group's progress can be traced by following the black lines.

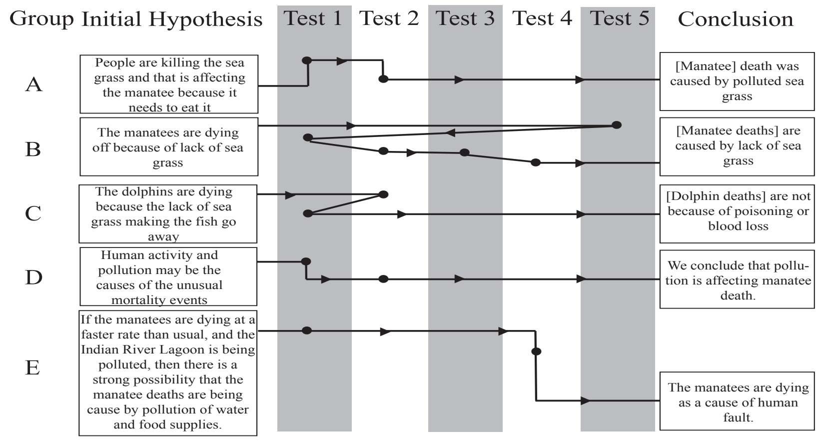

Figure 1. Student group pathways from the *Unusual Mortality Events* SCI simulation.

Conclusions and implications

New technologies, such as SCI simulations, have the potential to revolutionize science education not only by providing enriching, authentic experiences normally not feasible for typical classrooms, but by allowing for flexibility that leads to a more personalized learning experience. The data presented here on group pathways provides preliminary evidence that SCI simulations offer a powerful, real time view of group-level decision-making. Each group generated a distinct profile that contained unique hypotheses and conclusions, as well as the unique path through the simulation. To further delineate the role of collaboration, future work positioning students working in groups each with individual computers (rather than multiple students around a single computer) will allow better assessment of group- versus individual-level work. Analysis of virtual laboratory notebooks yielded insights into the students' decision-making, preferences, and barriers to hypothesis revision. Importantly, these data are obtained in real-time without disturbing the students during the inquiry task. Combinatorial analysis of learner inputs in response to various findings within the simulation and the groups' approaches to completing the simulated inquiry may yield increased insight into students' cognitive models of science practices (Chinn & Brewer, 2001). Understanding these cognitive models will lead to an improved understanding of how students evaluate data in a simulated authentic science inquiry experience. This is especially important given recent calls for a better understanding of the role of technologies, like simulations, in learning (NRC, 2011).

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Exploring How Students Construct Scientific Explanations During a Classroom Discussion after Implementation of an Immersive Virtual Environment

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Abstract: Immersive virtual environments (IVEs) hold great potential for scaffolding scientific inquiry skills in classroom teaching and learning. Effectively integrating IVEs into formal learning environments requires collaboration between teacher and students to make sense of the virtual world experiences. This study analyzed how teachers enabled students to construct scientific explanations through classroom discourse in eight middle school science classrooms after implementation of the IVE, SAVE Science. Teachers shut down opportunities for students to collaboratively make meaning of their experience in the IVE by taking a role as the source of authority for knowledge in the discussion. This research improved our understanding how to bridge the pedagogy of the classroom with the pedagogy of the technology and has the potential to inform the design of professional development.

Keywords: Immersive Virtual Environment (IVE), scientific inquiry, middle school science

Introduction

In the United States, scientific inquiry has been featured in recent curriculum reform in the form of "science practices" (National Research Council, 2012). Emerging technologies, such as immersive virtual environments (IVEs), hold great potential for scaffolding scientific inquiry skills in formal learning environments (Ketelhut, Nelson, Clarke, & Dede, 2010). This study analyzed how teachers enabled students to engage in scientific inquiry through classroom discussion after implementation of the IVE, SAVE Science.

SAVE Science (Situated Assessment using Virtual Environments for Science content and inquiry), a project funded by the National Science Foundation in the United States, has implemented IVE-based modules designed to assess middle school science content and inquiry since 2010 (Ketelhut, Nelson, Schifter, & Kim, 2013). In SAVE Science, students can navigate through the virtual world, converse with non-player characters (NPCs), take measurements, record observations or graph data about the problem they are investigating. Following the completion of the modules, students engage in a teacher-led whole-class discussion. The classroom discussion is designed to show students the multiple pathways to success within each module. A goal of SAVE Science is to impact the way teachers think about and enact scientific inquiry in their classrooms. This study explores one aspect of this—how teachers enabled students to construct scientific explanations through classroom discourse after implementation of an IVE designed for scientific inquiry.

This study seeks to answer the question, "How do teachers enable students to construct scientific explanations through classroom discourse after implementation of an IVE designed for scientific inquiry?"

Methods

Teachers volunteered to participate in SAVE Science, implementing one or more IVE science modules with their classes in public middle schools (Grades 6-8, ages 11-14). This study focused on students who individually completed an IVE module about gas laws and properties of matter (Basketball module), which simultaneously assessed knowledge of gas laws and elements of science inquiry. All activities were performed in school, under the direct supervision of the students' science teachers. Post–implementation, class discussions were video recorded to explore how teachers enabled student construction of scientific explanations through classroom discourse.

The study focused on semi-structured post-implementation classroom discussions with two teachers that had been participating in the SAVE Science program for three years. Teachers attended professional development that focused on scientific inquiry and technology integration several times over the three years they participated in the project, including a specific focus in one year on facilitating the post-implementation discussion.

A total of eight classroom discussions, each following the completion of the Basketball module, were transcribed and open coded for students constructing scientific explanations through classroom discourse.

Findings

The study found that teachers shut down opportunities for collaborative meaning making by taking a role as the source of authority for knowledge. Below is one example. One student asked the teacher why there were multiple objects to measure. This teacher quickly and authoritatively responded that just one measurement in science in insufficient to validate a scientific claim. Interestingly, in this situation, three students attempted to engage in argumentation but the conversation was closed and the opportunity lost by the teacher's response.

Student 1:	Why was there like so many like, do you know how like all the basketballs there was like three on each court?
Teacher:	Um-hum
Student 1:	Like why was that because they were almost all the same? No, they were all the same.
Teacher:	Normally how many, when you do an experiment how many trials do you do?
Student 1:	One
Student 2:	Three
Student 3:	A couple.
Teacher:	Three.
Student 1:	Yeah.
Teacher:	You usually tend to do multiple trials when you do an experiment. And you'll see when we start on the, uh, energy machines in motion. You'll be doing three or four trials for everything, because you want to verify your data. Just one trial is not, uh, good enough. So I think that's what they were getting in that, in that part of it. Why there, why there were three balloons inside or two balloons inside, two balloons outside, three basketballs inside, three basketballs outside. You always want to do more than one trial.

Conclusions and implications

Teachers use their authority and expertise to quickly respond to student inquiries, which shut down an opportunity for students to listen and reason with one another. While the project staff repeatedly suggested that teachers turn a question to the rest of a class, the teachers' approach is in direct opposition to these suggestions. We hypothesize that the teachers in this study may have taken a role as the source of authority for knowledge in classroom discussion either due to their general discomfort with the high degree of student-centered activity in the IVE, or simply because the teachers remained uncomfortable or uncertain with how to facilitate a student-centered discussion despite the practice and discussion of this in the professional development sessions.

As technology becomes more integrated into teaching and learning, there is a need for formal educators to consider how to supplement the affordances embedded in the design of technology and integrate these more fully into classroom practice. This research indicated a need to better understand how to bridge the pedagogy of the classroom with the pedagogy of the technology with implications for the design of professional development.

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"What Would Experts Say About This?" An Analysis of Student Interactions outside MOOC Platform

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Abstract: In MOOC research, many studies examine student learning by analyzing their behaviors on the platform, whereas only few pay attention to their activities *outside* it. In this study, we examined students' off-platform interactions during course implementation with a combination of survey and interview procedures. We found that not many but some students interacted with others outside platform and find some value in it, whereas they were not fully satisfied with their experience. Our analysis identifies three major challenges of *object matching or coordination*, *task structure*, and *expert feedback*, followed by a discussion on potential solutions.

Keywords: MOOC, learning across settings and time, CHAT, script

Introduction and motivation

Research on Massive Open Online Courses (MOOCs) has been active lately given significant criticism by the skeptic for its traditional pedagogical approach (Eisenberg & Fischer, 2014). Grover, Franz, Schneider, and Pea (2013) proposed a conceptual framework for MOOC design and research with four dimensions in which they pointed out the need of design and research for *interactive learning environments* to promote collaborative learning and communities of learners including "offline" learning.

In line with it, we are currently exploring new pedagogical approaches to promote interactive learning and designed two history courses—one with online learning only like regular MOOCs and the other combined with face-to-face collaborative learning on the same course content—on a Japanese MOOC platform "gacco" (http://gacco.org/). During the implementation, we noticed that not many but some students appeared to organize their own study groups and online communities on social media, and these observations interested us to investigate student interactions *outside* the platform. Accordingly, this study examined the ways and nature of student off-platform interactions during the course period.

Analytical framework

In this study, we examined student interactions in the Cultural-Historical Activity Theory (CHAT) perspective (Roth & Lee, 2007). In this perspective, student interactions are framed as the unit of analysis focusing on their cultural backgrounds, objects and motivation, and means and artifacts, and we analyzed student interactions as the intersection of multiple activity systems of diverse learners. In analysis, any contradiction or specific challenges for their practicing study groups and online communities were focused to discuss potential solutions for enhancing the quality of off-platform learning.

Methods

Post-survey procedure

First, a post survey was conducted in which we asked students to describe whether and how they interacted with other students outside the MOOC platform in an open-ended item. Total 58 valid responses were obtained out of 2214 survey respondents (total about 20,000 people signed up for the courses), and 36 students indicated they interacted with others outside the platform. From their descriptions, we identified four major "story stems" (student background, group and community, object and topic, and communication mode and tool).

Post-interview procedure

Next, a post semi-structured interview (15-30 minutes) was conducted with 13 volunteers (all Japanese) from the students above to learn more details about their experience along with the story stems. Specifically, we first asked participants their background including their prior experience with MOOCs and how they came to take our course. After these questions, we asked those who interacted with others outside platform the details of their experience in their group/community, objects/content, communication modes/tools, and the frequency and continuity of their interaction. On the other hand, we asked other students who did not whether they wished to interact with others and the reasons.

Results and discussion

From the post interview, we confirmed that 12 students (eight students in the MOOC-only group and four in the with-face-to-face-class group) interacted with others outside the platform. In the following, we report the two issues that are most salient from their stories to discuss major challenges and potential solutions.

Diverse learner backgrounds and difficulty in coordinating mutual objectives

First, student attitudes to interacting with others differ among students by age. Three students in senior ages mentioned they have some concerns in contact with others or strangers in different generations, whereas two students in younger ages mentioned some positive value in it for "learning different viewpoints." In addition, five students mentioned their realization of diverse interests and commitments through interaction with others. One student told us that she interacted with a student on the course content through his blog for a while, but one day he stopped updating and she felt disappointed by it. Another student told us that he joined a "meetup" event with others to discuss the course content and felt it was fun but not so productive, since each appeared to have different interests. We coincidentally had the interviewee who organized the event, and he told us his struggle to facilitate discussion given participants' diverse backgrounds and interests.

Difficulty in facilitating productive discussions and reaching legitimate conclusions

Related to above, three out of four students who participated in the meetup event told us their experience in the difficulty in reaching legitimate conclusions without the presence of experts. One student told us that he felt hard in discussion when different ideas and positions emerged and that it ended up with participants saying their own thoughts and opinions. The event organizer had a similar impression and told us that it was hard for him to facilitate their discussion in such situation. Both mentioned that they wished to have some comments and feedback from the instructor or experts to reach some legitimate conclusions, even though there would be no single answer. In addition, all the four students told us that they also participated in some online group through Facebook, but their interactions were neither active nor continued. One student told us that there was no specific agenda or topic to discuss even though he was physically connected to others in the online community.

Conclusions and implications

In this study, we found that not many but some students interacted with others outside the MOOC platform, but their experience was not fully satisfying. From our analysis, three major themes emerged to enhance the quality of students' off-platform learning and cultivate learning communities. First, *object matching or coordination* seems a key to match or coordinate mutual interests in study groups. Second, some *task structure* might benefit for students to facilitate their discussion. Last, some *feedback from experts* would be mostly valuable for students to reach legitimate conclusions or implications. To the first challenge, some online app to match or search members by specific interests or questions might help students find others in similar interests or questions. Second, providing some task resources (e.g., forms and rules of discussion) could serve to facilitate students' off-platform learning. Last, although it is unrealistic to provide each study group with continuous access to experts, it would be feasible to provide some FAQ pages by aggregating frequent questions or host some "ask-me-anything" event (e.g., Reddit) where experts answer student questions at some arranged time. Note that all the interview participants were Japanese, and therefore students' reactions and requests could differ in other Asian and Western countries.

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An Emerging Educational Technologist Role in Changing Organizational Structures

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Abstract: This paper explores how schools design and position roles to facilitate teacher collaborative learning of educational technologies, and the possible necessary school-level conditions for these roles to support teachers for successful pedagogical impact. It features two embedded case studies of emergent educational technologist roles' in private international schools in Singapore.

Keywords: teacher education, technology, organizational learning, technologists, coaches

Introduction

Teachers need personal support to change their teaching and learning practices through technology. Formal and informal roles such as "champions" (Hargreaves, 2003), "coaches" (Fishman and Davis, 2006), and "techne-mentors" (Ito, 2010) may facilitate collaborative teacher learning of educational technologies. Literature on teacher collaborative learning roles have generally examined these roles at the level of their working with teachers, without examining other levels of organizational learning and design that makes these coach-type roles successful in meeting teachers and changing their practices. The purpose of this paper is to contribute to theory on the practice to design schools for multi-level system learning, which includes the introduction of educational technologist roles that may facilitate teacher collaborative learning at one level and changes at other school levels. The paper addresses the questions, "How is an emergent educational technologist role positioned to facilitate teacher collaborative learning in the set of conditions that broadly constitute technology integration in a school?" And, "What do an emergent educational technologist role's feedback interactions indicate about the necessary school-level conditions for the role to support teachers in pedagogic innovation through technology?"

Methods

A school is a designed social organization. It consists of structures, which refer to, "The designed organization including formally designated positions, chains of command, departments, programs, and formal organizational routines" (Spillane et al., 2011, p. 588). For instance, structures can be organizational units such as grade-levels, subject areas and administrative departments, all of which conceptually frame and focus interactions or practices among staff. Ultimately, the designs of structures and interactions constitute the variable conditions of a school for learning. This study features two embedded case studies of emergent educational technologist roles, the Digital Literacy Coach (DLC) in School F and the Educational Technology Coach (Edtech Coach) in School G. Data for each case were collected from interviews with selected technologists and other school stakeholders, observations of technologist interactions, school documents and artifacts from technologist interations.

Analysis

Data were analyzed to identify school-level conditions, in terms of the types of structures and interactions for which these roles were designed, and feedback interactions, in terms of participants, formality, techological focus, and outcomes. For each case, I present each role's feedback interactions through selected technological foci.

Findings

The designed conditions and feedback interactions in School F for a Digital Literacy Coach

School F is one of the largest and most prestigious private international schools in Singapore. From the 2011-2012 academic year, School F followed its technology integration strategic plans. The school adopted Apple hardware and software. School F designed a new organizational structure with a new role, the DLC. Computer subject teachers would become DLCs. Each DLC would be assigned to a school section and be responsible for all the grade-levels in the section. The creation of the DLC role from the computer subject teacher role coincided with the termination of computer subject lessons in the junior section. At the same time, School F would design new DLC interactions for digital literacy learning. The representative DLC in this study Sam, unlike other DLCs in the school, negotiated his DLC role and wrote his own job description. He designed his role to be a member of the curriculum team in the primary section. He was assigned to the primary section, which comprises grades two, three, four and five.

Sam began facilitating teacher collaborative learning of video editing through iMovie because of a technology skills matrix, which he used at curriculum team meetings at each grade-level to map technology to selected curriculum units. Sam had designed interactions for him and stakeholders at a grade-level to learn about technology. One designed interaction was Team Time, which involves Sam meeting all teachers in a grade-level during teachers' non-contact time twice weekly. Another designed interaction was Techsperts, which involves Sam meeting two student representatives from each class in each grade-level weekly to train the students to teach their teachers and students about the technological innovation during lesson time. Sam was able to introduce iMovie into curriculum units in all grade-levels, to revise the curriculum units into which iMovie was introduced for the following year, and to replicate his designed interactions in another school section for the following year.

The designed conditions and feedback interactions in School G for an Educational Technology Coach

School G is also one of the largest and most prestigious private international schools in Singapore. From the 2012-2013 academic year, School G followed its technology integration strategic plans. The school adopted Apple hardware and software, as well. School G designed a new organizational structure with two new roles, the Educational Technology Coach and the Educational Technology Coordinator. Computer subject teachers would become DLCs. These roles would be assigned to a grade-level. These roles taught computer subject lessons but teaching load was reduced greatly. School F designed interactions so all Coaches and Coordinators would meet weekly and all Coaches and Coordinators in a school section would meet weekly. The representative Edtech Coach in this study, Steve, was assigned to grade two in the primary section.

Steve met with his primary section Coach and Coordinator colleagues to determine a professional development and performance appraisal goal. The team decided to introduce blogging into grade-two. Steve did not have any designed interactions with grade-two teachers. He created blogs for all the teachers but this produced conflict. Blogging became explicitly voluntary for grade two teachers. Three out of thirteen teachers enlisted themselves and their classes. Steve's principals gave Steve mixed messages about his interactions with teachers. Steve used his discretionary time to resolve many administrative and security dimensions of blogging. Ultimately, students in three, grade two classes blogged during lessons. Steve posted an exemplary student blog post on his public blog. Steve later said that these teachers benefited greatly from the blogs because they could view student blogs to more easily write up student reports for parents.

Conclusions and implications

Both schools enacted strategic plans for technology integration, but the seemingly minor design differences between in each school's plans influene greatly the effectiveness of each school's educational technologist role. The technologist that facilitated teacher collaborative learning of video editing through iMovie was arguably more successful in facilitating systematic teacher collaborative learning because of the scope of his deployment, his association with his school section's curriculum unit, the regularity of his interactions with teachers and his opportunity to design new interactions.

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Drawing on Interactive Tables: Examining Students' Flow, Collaborative Process and Learning Outcomes

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Abstract: This study explores collaborative knowledge construction using interactive tables for an ICT-based drawing task. Thirty-six students worked in small groups on science posters. Results show a significant learning gain from pre- to post-test. Furthermore, significant positive correlations were found between students' science curiosity and pre-test scores as well as between flow and perceived collaboration. Analyses of the video-data suggest that the more successful group displayed higher proportions of domain related talk.

Keywords: collaborative drawing, flow experience, science curiosity

Introduction

The creation of self-generated representations in the form of drawing can facilitate students' translation of information between different representational formats (van Meter & Graner, 2005) in science tasks. Drawing combines particularly well with collaborative learning, during the creation of a joint representation students are expected to exchange domain related information and make decision regarding their drawing. These discussions are associated with positive learning gains (Gijlers, Weinberger, van Dijk, Bollen & van Joolingen, 2013). Unfortunately, some students might get carried away during the activity, focusing on the aesthetic quality of their drawing or a single aspect of the drawing task at the expense of the unity of the learning task. For the learning process it is important that students not only exchange superficial information but engage in domain oriented dialogues and monitor their progress (Malmberg, Järvenoja, & Järvelä, 2013).

Activities where persons are deeply involved in a task, or highly focusing on distinct aspects of a task, are often described with flow (Csikszentmihalyi, 1990). Flow in a collaborative setting, however, is a different phenomenon than individual flow and is often describes as more beneficial than individual flow (Walker, 2010). Within the collaborative groups students may differ with respect to their interests, prior knowledge and skills. Individual differences might lead to uneven levels of participation on various activities within the overall task (Järvenoja, Volet & Järvelä, 2012)). Social flow might occur in a collaborative group only if the situation can be characterized as interdependent, with high levels of agreement and clarity about goals and procedures.

In the present study we explore students' collaborative learning process in a group learning arrangement. The aim of the study is to explore the relation between students' collaborative learning experiences in terms of flow and collaboration in relation to their learning outcomes. We expect that science curiosity and prior domain knowledge are positively related to students' perceived flow. Moreover, we expect that flow is related to collaborative learning experience and students' learning gains. Subsequently, we explore the collaborative learning process of two groups with different group performance scores.

Methods: Drawing task and procedure

Thirty-six Finnish, eight grade students were randomly signed into nine groups of three to four students and participated in the collaborative drawing session on center of gravity. A domain knowledge pre-test and an opening lecture were organized by the researchers in the school facilities. In the following week students were invited to university facilities to perform a collaborative drawing tasks using the SimSketch drawing software (Gijlers, Weinberger, van Dijk, Bollen & van Joolingen, 2013). on interactive tables. Students were instructed to create a poster to explain the center of gravity to seventh grade students. Each session lasted approximately 40-45 min. per group. Before the start of the drawing session students completed a science curiosity scale (7 items $\alpha = .83$). After twenty minutes of working on the task, the students completed a self-report addressing their flow experience (7 items, $\alpha = .90$). After the students completed the drawing task, a second flow self-report (7 items, α = .81) and a self-report on collaboration (9 items α = .83) were administered. The domain knowledge post-test was conducted at the school, after all groups had completed the collaborative drawing session.

Findings

Results of a paired sample t-test indicate that students improved significantly from pre- to post-test $t(29) = 6.32$, $p < .000$, with a mean score of 6.00 (SD=2.18) on the pre-test and 9.17 (SD =2.51) on the post-test. Results of a paired sample t-test indicate that the students perceived flow increased significantly during the session $t(33) = 2.80$, $p < .001$. Significant and positive Pearson correlations were found between students' collaborative learning experience and their perceived flow experience on the first ($r=.428$ $p<.05$) and second ($r=.523$ $p<.01$) self-report. A positive correlation was also found between students' scores on the science curiosity scale and the pre-test ($r=.563$ $p<.01$), suggesting that students with a high science curiosity were more knowledgeable concerning the domain at hand. Students' science curiosity was also positively correlated to their scores on the second administration of the flow self-report ($r=.366$ $p<.05$). Correlational analyses did not reveal the expected correlations between students' learning gain and their perceived flow and collaboration.

Two groups (a high and low performing group with respect to the drawing task) were selected for a closer analysis of the collaborative drawing process. For these groups the equality of group members' participation to the discussions was evaluated by calculating the relevant on-task (i.e. domain, task- , and monitoring) utterances of group members. In the low performing group one of the students was monitoring, and initiating the task related discussion during the entire session. Furthermore, the low performing group engaged in deep-level domain discussions only in the beginning of the learning session whereas the high performing group engaged in deep-level discussions throughout the session. Development over time indicated that high performing group had more situations and a trend to engage more group members to the discussion throughout the learning session compared to the low performing group.

Conclusion and discussion

Correlational results provide no evidence for the suggestion that higher levels of flow are associated with higher learning outcomes. This might be explained by the fact that students can experience a high level of flow during the activity but were driven by activity-oriented incentives and therefore not focused on the goals of the activity. Also, in this study we didn't measure the collectively the social flow experience, rather the focus was in individual interpretations. Furthermore, the first topics listed in the assignment might have been relatively easy for students with a high pre-test score and therefore not challenging enough to experience flow. This idea is supported by the fact that students reported a higher flow experience on the second administration of the flow self-report.

The results of the more detailed video analyses suggest that within the groups participation was not equal on domain related as well as the monitoring aspects of the discussion. Within the more successful group students worked more evenly towards the end of the session. It can be speculated whether the equal participation could be an indicator of the social flow state, where the group members are together engaged in their shared task. Further analysis and research is needed to explore the relation between the role students take on during the collaborative learning experience and the experienced flow and collaboration processes.

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The Potential of Collaborative Mobile Learning: Experiences from a Design-Based Research Cycle in Singapore Schools

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Abstract: This poster presents a cycle of a mobile learning design-based research (DBR) in Singapore schools. A smartphone application was evaluated in terms of how its features, including usage time, badge score, number of experience updates posted, number of answers given, comments given, likes given, comments received and likes received contributed to the student science summative assessment score. The analysis is then used to inform a new cycle of system redesign offering new and updated collaboration features.

Keywords: mobile learning, collaborative learning, learning system design, tablet computers

Introduction

As a part of the Seamless Mobile Learning (Zurita & Nussbaum, 2004; Looi, Wong and Song, 2013) research project in Singapore, mobile learning system SamEx which supports seamless, mobile, self-directed learning activities for primary 3 school students in Singapore (Figure 1) entered into the 5th phase Design-Based Research (DBR) cycle (Barab & Squire, 2004). Although the application was at first developed to support individual collecting, storing and access to multimedia artifacts with no intentional design for collaborative learning, a thorough analysis of how its main features might contribute to the students' learning suggests the need for including more collaboration features.

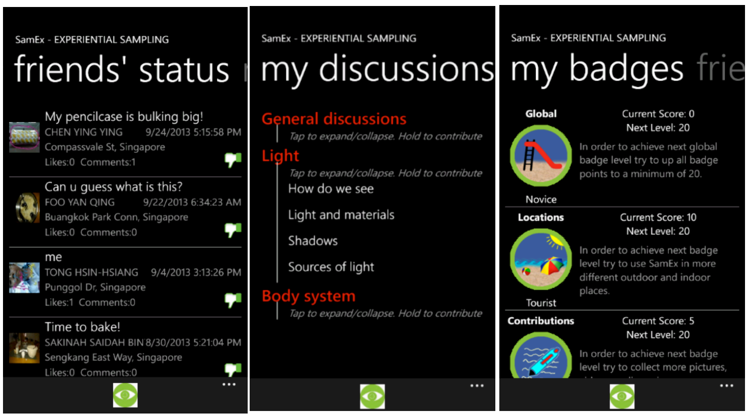


Figure 1. Main SamEx (smartphone version) features (left to right): experience updated, threaded discussions and virtual badges

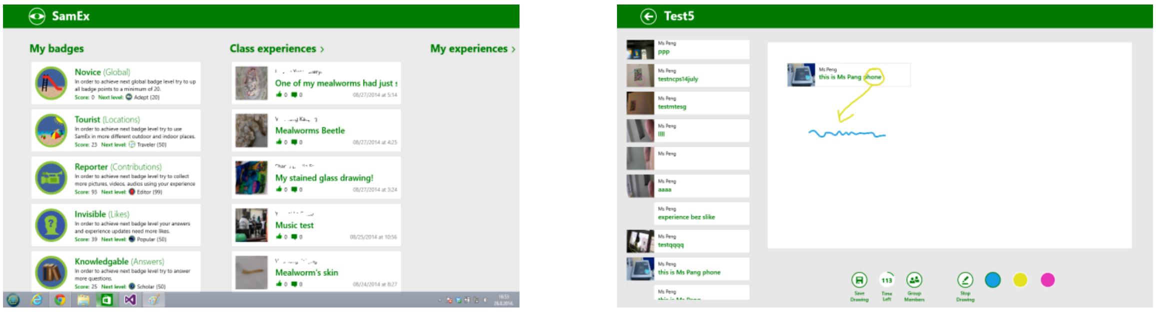
Methods: Identifying key mobile learning software features

Data was collected from 306 students during the 1-year window (mid-2012 to mid-2013) and coded into several categories according to the following software features: *usage time*, *badge score*, *number of experience updates posted*, *number of answers given*, *comments given*, *likes given*, *comments received* and *likes received*. Amongst all potential variables, three of them were found to be correlated with the *students' summative assessment results*: *usage time*, *badge score* and *likes received*.

In the multiple linear regression, answers given and likes received statistically significantly predicted the total assessment score, $F(2, 287) = 20.090$, $p < .001$, $R2 = .117$. Two variables (answers given and likes received) added statistically significance to the prediction, $p < .05$.

Designing for collaboration: New technology affordances

Design of collaborative tasks for each group that have elements of positive interdependence and individual accountability, and that requires interactions, social skills and group processing (Johnson, 2003) are more likely to foster collaborative learning. In the framework for assessing Collaborative Problem Solving, the tests assess personal competencies in taking initiatives (being proactive), in teamwork, in planning, and in coordination of group work (OECD, 2013) and in social and task regulations (Hesse, Care, Sassenbrg, Buder and Griffin, 2014), amongst other dimensions of these skills. Considering that these driving principles for creating opportunities for fostering these competencies are related to collaboration, we envisage future designs that can make use of the affordances of the SamEx platform that allows groups of students to work on a common task to collaboratively co-construct higher-level meaning making, such as like adding and elaborating conceptual linkages between using the artifacts created individually. Therefore, a new collaborative software module for asynchronous small group work was implemented and included into SamEx. Students use the collected experiences (pictures, video, audio and text) to contribute to a group task assigned to them by their teachers using the free from sketching tool to annotate the group artifact (Figure 2b).



(a) (b)

Figure 2. (a) New Windows 8 tablet application main screen and (b) asynchronous group work area

Conclusions

This brief illustration shows that students might leverage standard software features to do collaborative work, even if that is not intentionally set up by its designers or teachers. By themselves, these features strongly correlate with the final assessment results Feedback from the iterative research implementation suggests that the collaboration opportunities can be better supported if the students can work synchronously on the artifacts they created, thus providing more affordances for diverse collaborative learning scenarios.

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The Effect of Task and Collaboration Support on Learning Processes and Learning Results in a CSCL Environment

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Abstract: This study investigates the effect of two types of support (i.e. task/domain and collaboration) on students' learning processes and learning outcomes. Several meta-analyses were conducted. The results show that students who received support for collaboration had higher individual learning outcomes and a better collaborative and cognitive process than non-supported students. Further, students who received support for the task/domain had higher individual learning outcomes and a better collaborative process than students who received no support.

Keywords: CSCL, meta-analysis

Introduction

Learning in computer-based learning environments is often supported by scaffolds. These scaffolds can focus on the task and domain or on the collaboration. Traditionally, the task and domain are supported by cognitive scaffolds. These scaffolds support students in processes such as formulating hypotheses and creating experiments (Gijlers, Saab, van Joolingen, de Jong & van Hout-Wolters, 2009). An example of such a scaffold is a concept-map (Novak, 1990). Constructing a concept map requires students to pay attention to the key concepts of the domain (Nesbit & Adesope, 2006). Besides, various scaffolds are available for collaboration. A popular way to support collaboration is for example offering collaboration or communication rules to students. Mercer and colleagues (e.g. Mercer, 1996) have performed several studies where they provided instructions for effective communication in a collaborative learning setting. Overall the results of the work of Mercer and colleagues showed that the quality of students' conversation or talk improved when they received instruction in effective communication (e.g. Mercer, 1996; Rojas-Drummond & Mercer, 2003).

This study investigates the effect of these two types of support in CSCL environments. The aim of this study is to examine the relation between the two kinds of support (i.e. task/domain and collaboration) and students' cognitive and collaborative learning processes and students' learning outcomes.

Method

Search strategies and criteria for inclusion

For this review, systematic search actions were conducted from May 2014 through August 2014 in three online databases (i.e. PsycINFO, ERIC, and Web of Science). The search was restricted to publications from the years of 1990 through 2014. Examples of keywords we used for this search were *computer supported collaborative learning, CSCL, cooperative learning and computer-mediated communication.* The search generated 15555 publications. First, duplicates were removed and from the remaining 7536 publications we assessed whether or not the study met the predefined inclusion criteria: a) The study had to measure the effect of collaborative learning on cognitive outcomes, b) The study should have a description of the CSCL arrangement, c) The communication should go through computer or face-to-face behind a computer, d) The domain and learning task had to be described, e) At least one form of collaboration and/or one condition requirement had to be investigated, f) The group size should be between 2 and 5 participants, g) The study had to investigate CSCL in students from elementary or secondary education, and h) Each article should contain quantitative data. Two researchers independently reviewed 10.6% of the publications based on inclusion criteria: the Cohen's inter κ rater reliability was .84 (Landis & Koch, 1977).

Coding and analysis

After the application of the inclusion criteria we included 39 remaining studies in the final dataset. Articles from the final dataset were coded with a coding scheme existing of three categories: 1) *Support* (task/domain, collaboration), 2) *Learning outcome* (individual, group, a combination of individual and group, or no learning outcomes), and 3) *Learning process* (collaboration, cognitive, both kinds or no learning process). Two researchers independently coded 22.1 % of the studies in the final dataset by means of the coding book. The Cohen's κ for each category: support .85, learning outcomes .89 and process component .71.

From each study, separate effect sizes for one or more of the four dependent variables (i.e. individual learning outcome, group learning outcome, collaboration process, cognitive process) were extracted. For each of these variables, an effect size (*Cohen's d)* and variance were computed. In total, 85 effect sizes were extracted from the 39 studies.

Findings

Effects of support on students' learning outcomes

Students who received support on the task and domain had higher individual learning outcomes than students who received no support. A small to moderate mean effect size was found, ***d* = + 0.33**, SE = 0.09, k = 18, $CI_{95\%}$ = [0.16; 0.51]; p < .01. However, students who received support on the task and domain did not have higher group learning outcomes than non-supported students. A non-significant, small to moderate mean effect size was found, ***d* = + 0.39**, SE = 0.21, k = 14, $CI_{95\%}$ = [-0.01; 0.80]; p = .06.

Students who received support on collaboration had also higher individual learning outcomes than students who received no support. A small to medium mean effect size was found, ***d* = + 0.31**, SE = 0.10, k = 5, $CI_{95\%}$ = [0.12; 0.50]; p < .01. Finally, collaboration supported students did not have higher group learning outcomes than non-supported students. A weak, statistically non-significant mean effect was found, , ***d* = + 0.12**, SE = 0.14, k = 8, $CI_{95\%}$ = [-0.16; 0.40]; p = .40.

Effects of support on students' learning processes

Students who received support on the task and domain had a better collaborative process than non-supported students. A medium to large mean effect size was found, ***d* = + 0.63**, SE = 0.22, k = 13, $CI_{95\%}$ = [0.20; 1.06]; p < .01. On the other hand, students who received support on the task and domain did not have a better cognitive process in comparison with non-supported students. A small to medium, statistically non-significant mean effect was found, ***d* = + 0.28**, SE = 0.17, k = 12, $CI_{95\%}$ = [-0.05; 0.61]; p = .10.

Students who received support on collaboration had a better collaborative process and a better cognitive process than students who received no support. A medium to large effect size was found for the collaborative process, ***d* = + 0.53**, SE = 0.18, k = 10, $CI_{95\%}$ = [0.17; 0.89]; p < .01 and a small to medium mean effect size was found for the cognitive process, ***d* = + 0.41**, SE = 0.15, k = 5, $CI_{95\%}$ = [0.11; 0.71]; p < .01.

Conclusions

This study examined the effect of two types of support on students' learning outcomes and learning processes. We found that students who received support, regardless which support, scored higher on individual learning outcomes than students who did not receive support. Surprisingly, we found that both types of support had no significant effect on group learning outcomes. Further, support of collaboration had a significantly positive effect on both collaboration and cognitive learning processes while support on the task and domain only had a positive effect on collaboration learning processes.

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Exploring the Limits of Priority Awareness for Improving Performance in Integrative Negotiations

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Abstract: Negotiations between two persons rarely lead to optimal results because they are not aware of each other's different priorities. Fostering Priority Awareness with non-interactive bar charts has been shown to enhance the goal oriented communication of integrating the different priorities and thus improving multiple measures of negotiation performance. This experimental study in progress builds on these findings and tries to expand the range of Priority Awareness: Non-interactive bar charts are compared with interactive bar charts in 33 negotiations each. It is assumed that the interactivity makes the partners aware of more subtle differences in priorities and leads to better negotiation performances than the previous non-interactive bar charts. The advantages of the interactively fostered Option Priority Awareness are especially helpful in situations, where both partners want the same thing but are not able to communicate it and settle with less.

Keywords: priority awareness, knowledge and information awareness, integrative negotiation

Priority awareness in negotiations

Negotiations are important f.e. in work life, when we try to share a common budget between work groups or in learn settings where we have to agree on the solution of a collaborative learning task.

Many times it is not possible to meet in person to agree on a sometimes huge number of issues and for this purpose, web-based collaborative negotiation tools have been developed and studied (Kersten & Lai, 2007). Independent of the use of such tools do negotiations rarely lead to an optimal result, where both parties jointly integrate their individual interests because they lack the knowledge about the other's priorities (Thompson & Hastie, 1990).

The concept of *Knowledge and Information Awareness* has already been presented at the Computer-supported Collaborative Learning Conference (Engelmann, Kolodziej, & Kozlov, 2013). It is the awareness of spatially separated group members about their collaborator's knowledge and the information source of this knowledge. Studies show that fostering this awareness enhances the effectiveness and efficiency of newly formed groups of experts in network-based collaborative problem solving.

These findings are extended by Kolodziej, Hesse and Engelmann (2014) to *Priority Awareness*: The awareness of one negotiation partner about the priorities of the other negotiation partner.

Kolodziej et al. (2014) compare a condition with Priority Awareness with a condition without Priority Awareness. The results show that fostering Priority Awareness creates the opportunity for the negotiation partners to tacitly learn about each other's different priorities in a computer-supported negotiation scenario and achieve a better negotiation performance – like the *joint outcome* and *pareto efficiency* – than the partners without Priority Awareness. This prevented the *fixed sum error* (Thompson & Hastie, 1990), the tendency of one partner to assume that the other has the same priorities of issues, which he/she does not. The *incompatibility error*, where one partner believes that the priorities of options inside issues of the other partner are not compatible with his or her own, even when they actually are, could not have been prevented. In 45% of all negotiations, the partners did agree at least in one of the two compatible issues on an option with a common loss although both favored the same options in these issues.

This experimental study tries to solve this problem by using interactive bar charts instead of bar charts that do not change interactively. The goal is to not only foster *Issue Priority Awareness* like in the study of Kolodziej et al. (2014) but also to make it more salient through the interactivity. This interactivity additionally fosters *Option Priority Awareness* and reduces the number of incompatibility errors.

- **Hypothesis 1 & 2:** Negotiation partners with Option Priority Awareness achieve a different joint outcome (H1) and pareto efficiency (H2) than negotiation partners with Issue Priority Awareness.
- **Hypothesis 3:** Negotiation partners with Option Priority Awareness less often commit the incompatibility error than negotiation partners with Issue Priority Awareness.

Experimental study

132 people (100 female, 32 male) participated in this still to be analyzed study, resulting in 66 negotiations, 33 per condition. The whole experiment took place in an experimental negotiation tool on computers in two separate rooms and lasted approximately one hour.

The negotiation partners first worked individually and were presented some demographic questions and visual understanding tests. Then the car purchase scenario and the individual role as buyer or seller of a company car fleet were presented. It was explained that each party will negotiate for points and that their sole goal is to maximize their individual points. At this stage, the negotiation partners established a recorded audio communication and were forwarded to the maximally 35 minute lasting negotiation.

In the lower half of the negotiation screen, the partners saw eight issues written out (e.g. “Warranty”, “Delivery Date” etc.) and had to agree on one of five of their respective options and corresponding points (e.g. issue “Color”; options “Grey 1200”, “White 900”, “Red 600”, “Black 300”, “Silver 0”). Buyer and seller only differed in their individual points for options and therefore were in conflict over the choice of the “right” option.

The top half of the screen held either the non-interactive and uniformly filled bar charts of the condition with Issue Priority Awareness or the interactive bar charts of the condition with Option Priority Awareness (Fig. 1). Horizontal lines showed the possible states of each option of every issue which were filled up dependent of the made choice. The partners where free to negotiate as they wished, could end/abort at any time and where not instructed to use the Priority Awareness tool, or how and why to do so.

Then the partners worked alone again and answered questions on fairness, satisfaction, honesty, effort and skills with regard to the negotiation, and the other negotiator and also on the utility of the bar chart and the frequency of its usage. In the end, they answered a questionnaire on social value orientation.

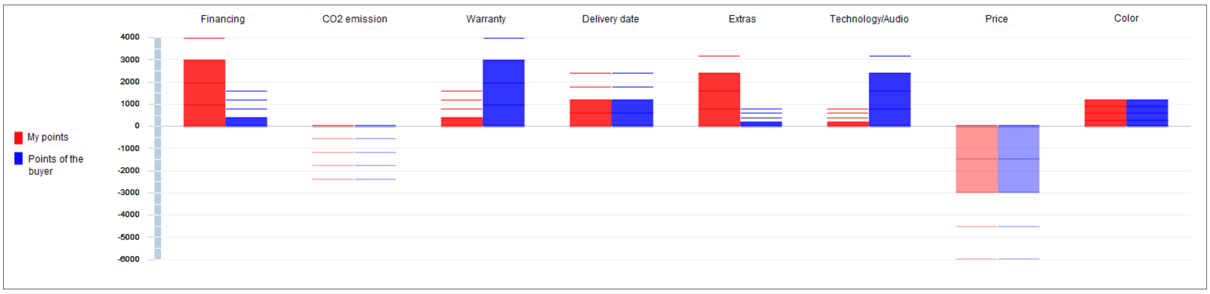

Figure 1. Interactive bar chart of the condition with Option Priority Awareness (exemplary for the car seller). The non-interactive bar chart of the other condition had uniformly filled bars without horizontal lines.

Conclusions and implications

It is unclear if more awareness leads to even higher recognition of integrative issues, more trade-offs and a higher joint outcome/pareto efficiency. We assume that the condition with Option Priority Awareness with interactive bar charts has an advantage over the condition with Issue Priority Awareness with non-interactive bar charts in terms of issues, where both persons actually want exactly the same, fail to communicate this and agree on something that is inferior.

The application of these findings will help stimulate the exchange of different priorities between spatially separated partners who have to collaboratively agree on one set of answers. Being aware of each other’s priorities will lead to a more goal oriented communication and less misunderstandings, which else would result in inferior performance. Future studies will elaborate on the willingness of sharing ones priorities.

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Computer-Supported Collaborative Word Acquisition for Language Learners

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Abstract: Collaborative word acquisition (CWA) is an important pedagogical approach to language learning for L2 learners. As an incidental word learning method, CWA facilitates word learning of learners in terms of their group discussions and negotiation about target words, the effectiveness of which seems to rely to a large extent on the involvement of interactions among learners. In this paper, we propose a framework for computer-supported CWA and compare it with conventional CWA in terms of the effectiveness in promoting word learning. The rationale of this proposed framework is verified by our preliminary empirical results.

Introduction

Collaborative word acquisition (CWA), an important pedagogical approach to incidental word learning (Paribakht & Wesche, 1999), has been widely adopted by L2 language teachers and learners (Pica, 1994; Zheng, Young & Wagner, 2009). It facilitates word learning of learners during their group discussions and negotiation about target words (Keating, 2008), yet it is limited in that its effectiveness mainly depends on whether interactions among group members are active or not. To address the issue of low learning effectiveness of inactive learners, we propose a framework of computer-supported CWA in this paper, the core idea of which is to link target words with social events or news in which the majority of group members are interested through a group recommendation algorithm (Amer-Yahia, 2009). The evaluation of this framework involves empirical comparisons between the computer-supported CWA and conventional ones. The preliminary results verify the rationale of this framework for computer-supported CWA.

The framework for computer-supported CWA

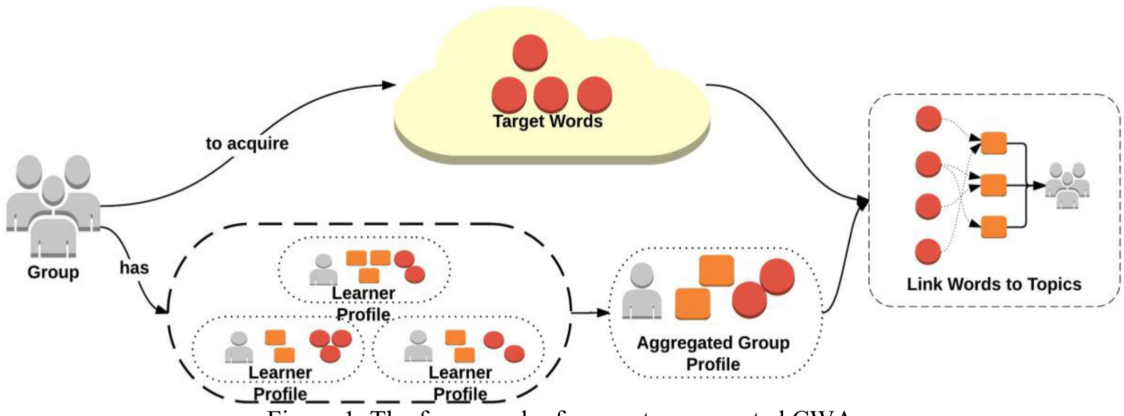

Figure 1. The framework of computer-supported CWA

Learner profile acquisition

The framework, as shown in Figure 1, includes learner profile acquisition, group profile aggregation and word-topic linkage. The aim of learner profile acquisition is to understand potential interested topics that may induce more group interactions among inactive members. Specifically, we invite learners to indicate their preference ratings (from 1 to 10) of 12 pre-defined topics (including political, financial, property, entertainment, sports, traveling, food, education, health, local, and global news). We also investigate the pre-knowledge levels of learners about target words in pre-tests. Based on the interested topics and pre-knowledge levels of each group member, we construct their individual learner profiles and use them to further create the aggregated group profile at the next stage.

Group profile aggregation

The group profile aggregation is constructed by merging individual learner profiles into a group aggregated one, based on which the most interested topics can be identified. To aggregate learner profiles of all group members, we employ the "Least-Misery" strategy to create the group profile (Yu, Zhou, Hao, & Gu, 2006). The selected topics are rated with scores higher than 5 by all members; and the overall score of the whole group ought to be maximized. The pre-knowledge level of the aggregated group profile is determined by learners with the lowest language proficiency levels, thus even such learners can engage proactively in the learning activities.

Word-topic linkage

The last step is to map target words and the aggregated group profile into topics that can be used for group discussions and negotiation in the CWA so as to prompt interactions among group members, especially the inactive ones. To achieve this, a-bag-of-words paradigm and content-based similarity measurement are adopted.

$$Sim(\vec{w},\vec{a}) = \frac{\vec{w}\cdot\vec{a}}{\|\vec{w}\|\|\vec{a}\|}\ (where\ \vec{a}\in t)$$

where $\vec{w}$ is the set of target words and familiar words according to the pre-knowledge levels of the group profile, $\vec{a}$ is the bag of words in a recent news article from a news corpus. The news should be under specific topic *t*, which is selected according to the "Least Misery" strategy for the group profile aggregation.

Preliminary experimental results

We compare the average word learning effectiveness of conventional CWA and computer-supported CWA by pre-tests and posttests as illustrated in Table 1. 24 freshmen whose second language is English are invited and divided evenly into four groups. 20 out of 40 target words, which are identified through pilot studies, are used for pretests, and the other 20 for posttests. The experimental results confirm that the proposed framework can improve the word learning effectiveness.

Table 1: Word learning effectiveness of two groups

Methods	#Group	#Subjects	#Words	Pre-test	Post-test
CWA	4	12	20	62.3	69.4
CSCWA	4	12	20	61.6	70.9

Conclusion and future work

In this paper, we have proposed the framework of computer-supported CWA, which can further assist the interactions among group members. The empirical results further verify the rationale of this framework. In future research, we plan to compare various group profiling strategies in a larger scale.

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Learning Analytics to Support Teachers: Theoretical and Empirical Findings

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Abstract: Teachers increasingly use computer-supported learning (CSCL) in their classrooms to facilitate collaboration among students. Learning analytics (LA) tools, which offer summaries, visualizations, and analyses of student data, can help to decrease the teacher's effort to maintain an overview of students' activities. The goal of this poster is to highlight the two mechanisms by which LA tools may support teachers, illustrated with examples.

Keywords: teachers, secondary education, learning analytics

Introduction

Teachers increasingly use computer-supported collaborative learning (CSCL) in their classrooms to facilitate collaboration among students. Digital learning environments designed for collaborative learning generally integrate tools for carrying out the task as well as a means for communication between group members. Providing these tools, however, does not guarantee that students will adequately finish their task nor a high quality of discussions (Kirschner & Erkens, 2013). It is known that students may experience problems. For example, concerning cognitive activities, the informal character of a chat tool may lead to off-task behavior. An example of a problem with social activities is that some group members may put in less effort than the others. If these problems are not addressed and resolved in time, the collaborative process is hindered. It is therefore important that teachers monitor students' activities and offer help when necessary (Van Leeuwen et al., 2013). During CSCL, students' activities are usually logged and available for review. It can be a challenge for the teacher to keep up with all student activities. The traces left by student activities can be automatically collected, analyzed, and reported back to both students and teachers for the purpose of optimizing learning. These analyses of student data, when fed back to the teacher, are a form of learning analytics (LA). It is hypothesized that summaries or visualizations of student data can help to decrease the teacher's effort to maintain an overview of students' activities. While many articles describe the technical underpinnings of LA tools, not many empirical studies have been conducted yet to study the effects of learning analytics on teacher regulation of CSCL (Chatti et al., 2012). Recently, we performed two empirical studies (Van Leeuwen, Janssen, Erkens, & Brekelmans, 2014; in preparation) to find the answer to that question. The goal of this poster is to bring the results of these two studies together.

Method

To combine an experimental setup with the use of authentic classroom situations, simulation software was created based on an existing CSCL environment called VCRI (Virtual Collaborative Research Institute). The simulation software is able to read student data from previous research and to display it as if students are collaborating real time. This way, all participants could be shown the same authentic collaborative situations. At the same time, two experimental set-ups were realized by creating three versions of the simulation software: the control version, which was essentially the same as VCRI, and two experimental versions, which were enhanced with different types of LA tools, focusing on students' social or cognitive activities. In VCRI, students work on collaborative assignments. They communicate through a Chat tool and work on the assignment in a shared text editor, the Cowriter. In the three conditions of the simulation software, participants were able to follow all students' activities. They could open Chat windows and read the texts that are being written in the Cowriter. Besides these ways to diagnose, participants could intervene by sending messages in the Chat windows. The set-up was thus similar to the way VCRI is normally used by teachers in actual classrooms in secondary education.

Findings and discussion

The dependent variables in the two studies included, among others: diagnosis scores given by teachers to the groups they regulated, the number of teacher interventions, and the focus of teachers' attention (social, cognitive, and regulative activities). We will focus on the general findings from these studies in terms of two mechanisms of how LA can support teachers, which were derived from the overall data.

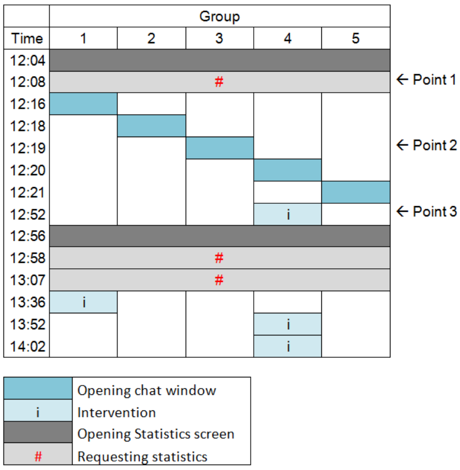

Figure 1. Excerpt showing teacher use of learning analytics

Mechanism 1: Lowering cognitive load

The first way in which LA tools can support teachers is therefore by aggregating time-spanning collaborative events to a visible summary, which eliminates the necessity to observe all student activities to assess the quality of student collaboration. In our studies, we found that teachers were indeed better able to detect problems, in this case unequal participation of group members, when they had access to LA tools that visualize students' social activities. Figure 1 illustrates the way LA were used by the teachers. At point 1, the teacher checks the LA tools for information about participation within the groups. Upon detection of unequal participation, the teacher opens the chat conversations to see what the groups are discussing (point 2). After reading the conversations, the teacher sends a message to this group (point 3).

Mechanism 2: Shifting teachers' focus

The second mechanism concerning LA is that the information shown by the LA tools can steer the direction of the teacher's focus. In other words, when teachers are shown information about an aspect of student behavior that they did not consider yet, their focus may shift towards this aspect. We found this in our study concerning LA tools about cognitive activities. With access to these tools, the focus of teachers' messages to students was more often on cognitive activities than on social activities. By steering the teacher's focus, it means there is an underlying thought of what teachers *should* focus on. When the shown information is not deemed important by the teacher, the teacher might discard or misinterpret the information. For example, teachers were shown how often there was disagreement or agreement within collaborating groups (Shared Space Tool). When there was agreement more than 50% of the time, this was sometimes interpreted as a problem, because it meant that students lacked critical discussion, and sometimes as a good sign, because it could mean there was a positive atmosphere within the group. Next to a difference in interpretation of information, another possibility is that the LA tools are not used at all because they are deemed unimportant. For example, when a teacher is not interested in participation rates of individual group members, it could become redundant information. The presence of redundant information could result in increased cognitive load, which counteracts the intended effect of lowering cognitive load. It is therefore important that it is always examined first what teachers want or need, or to offer teachers a training in the use of the LA that explains how the shown information could support them.

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Developing an Interactive Tabletop Application for ‘Creative Interpretation’ in Art Museums

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Abstract: This paper presents the design and implementation of an interactive application - TACTEC - for multi-touch tables in art museums. With focus on visitor participant experiences we propose an application that promotes visitors engagement through the development of creative activities using interactive technologies.

Keywords: visual art, engagement, design, art museum

Introduction

Gallery interactives integrating multitouch surfaces, games, and kinetic technologies are increasingly introduced as interpretive resources in art museums (Kidd, 2014; Pierroux & Ludvigsen, 2013). The TACTEC application (Pinto, 2013) was similarly designed for casual visitors to explore and interpret art using an interactive tabletop, as a walk-up activity in a large art museum in Portugal, focused on the work of Hieronymus Bosch. In contrast to simple browsing activities, TACTEC aimed to engage visitors in collaborative and creative processes by applying visual arts perspectives on learning and interpreting art to the interaction design. The design was further informed by what is now substantial and mature research on tabletop interactives (Dillenbourg & Evans, 2011; Müller-Tomfelde *et al.*, 2010), including studies of collaboration among casual users in ‘walk-up’ settings in museums and other public spaces (Müller-Tomfelde *et al.*, 2010; Rogers, Lim, Hazlewood, & Marshall, 2009). These studies emphasize the need to balance user guidance with allowing users to interact freely with the interface, supporting naturalness and simplicity in the gesture-based interactions, and providing an aesthetically appealing design that is accessible on all sides and highly visible in the surroundings (Iraola & Romay, 2010; Müller-Tomfelde *et al.*, 2010). Recently, tabletop applications that integrate creative ‘making’ activities are being explored (Smørdal et al., 2014; Liu, 2013).

Methods

TACTEC was tested in a lab Centro de Computação Gráfica (CCG) setting, and in the reception area of the museum Sociedade Martins Sarmento, Guimarães (SMS) (Fig. 1, left). The main feature of the interface was a large canvas with a menu that allowed users to navigate and select among nine categories of images from Bosch’s paintings to create new compositions (Fig. 1, right). Users could then publish and comment on their compositions – as well as those of others – using a *Facebook* plugin. User studies were conducted in lab (two sessions) and museum settings (one session) using a questionnaire, direct observations, and video recordings supplemented by field notes. Usability issues were the focus of the lab studies, with individuals completing a series of closed tasks during a period of 13-15 minutes. Thirteen young people participated in the third session at the museum (SMS), with more open-ended tasks, choosing to spend approximately twice as much time.


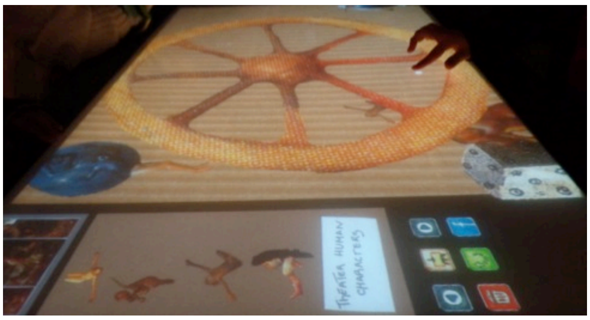

Figure 1. Tabletop in reception area (left) and TACTEC interface (right)

Analysis

Images and posts published by users on *Facebook* were analyzed using methods from the visual arts, e.g., color, form, symmetry, proportion, symbolism, to evaluate the ways in which users may have been sensitive to general issues of composition, and to Bosch's visual language in particular. Users' comments on images posted on Facebook frequently described experiences that were personal and positive, e.g., “"I started by making an image with elements I didn't like very much, it was simple and without an explicit meaning. But the process captured my imagination and I created this image, with more elements that have meaning for me.” Responses to the (same) questionnaire applied in all three trials (n=24) were evaluated on a five point Lickert scale. A total of 39 questions were posed regarding demographics, usability, prior knowledge of Hieronymus Bosch's art, general interests in art, and the interface design. In questions dealing with users' interest, engagement and interpretation of Bosch's work, responses indicated that participants in the study made new observations (4.08), valued the exploratory aspect of the experience (4.3), and were generally positive to the menu design featuring visual elements ‘deconstructed’ from Bosch's paintings (3.5). Participants were in large agreement (4.3) that interaction with the application had provided them with a deeper understanding of Bosch's work, and had created a sense of intimacy between user, content and the composition of his paintings.

Conclusions and implications

Findings from this testing in lab and museum settings informed a new round of development, and interaction studies were conducted with casual users at a walk-up installation of TACTEC in a different museum location. We are currently analyzing these data. Based on the user testing reported in this poster, and on preliminary analysis of visitor interactions in a natural setting, we suggest that interactive tabletops designed with rich visual content, a low level of guidance, and the opportunity to share compositions with others on a social media platform may engage group collaboration in creative activities in art museums.

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Exploring the Relationships Between Group's Self-Regulative Behaviors and Its Collective Performance during Computer-Supported Collaborative Lesson Design Activities

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Abstract: This study investigates the relationships between group's regulative behaviors and its collaborative knowledge work. Participants were 44 pre-service teachers who were engaged in collaborative lesson design activities. Data mainly came from online discussion and group work on the lessons designed. Findings suggest that (1) high-regulative groups were more likely than low-regulative groups to work creatively under the guidance of knowledge building principles; and (2) high-regulative groups were also more likely than low-regulative groups to produce effective technology-integrated lessons.

Keywords: knowledge building, lesson design, technology integration, pre-service teachers

Introduction

Given the fast development of technology in education, there has been an increasing demand for prospective teachers to learn to teach with technology and design technology-integrated lessons (Collins & Halverson, 2010). Unfortunately, typical teacher preparation approaches tend to focus on "scripted teaching" or "direct instruction" by highlighting step-by-step teaching procedures (Adams & Engelmann, 1996; Engelmann, 1980; Sawyer, 2004; Slavin & Madden, 2001). Much less emphasis is placed on cultivating among teachers the required capacity to assume the role of designer and engage in sustained improvement of their teaching practice (Bereiter, 2002).

To help prospective teachers develop design capacity, the present study engage them in collaborative lesson design activities in small groups. Each of the groups was invited to achieve a main learning goal that required them to collaboratively design an effective technology-integrated lesson. In addition, a key knowledge building principle called "Community Knowledge, Collective Responsibility" was employed to guide group's teamwork. This principle highlights that "contributions to shared, top-level goals of the organization are prized and rewarded as much as individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community" (Scardamaila, 2002). Previous studies suggest that group regulation is essential to successful performance of collaborative work (e.g., Goos, Galbraith, & Renshaw, 2002; Dehler, Bodemer, Buder, & Hesse, 2011). Therefore, it is posited that using the "community knowledge, collective responsibility" principle as a guidance would enhance group regulation and accordingly help groups better achieve their learning goal—designing effective technology-integration lessons.

Methods

This study was conducted in a teacher-education class where students (n=44) were assigned into 10 groups and the major assignment for the groups was to design a technology-integrated lesson. To this end, groups were guided to go through 3 lesson design cycles in which they worked collaboratively to improve their lesson designs in Knowledge Forum (KF)--a computer-supported multimedia environment that supports collaborative knowledge building activities. Data sources include groups' lesson design ideas discussed online and each group's 3 lesson design products/prototypes (derived from 3 design cycles). First, cluster analysis was performed by using a coding scheme with three feedback dimensions--i.e. affective, cognitive, and metacognitive feedbacks that were modified from Tsai and Liang (2009; see also Cheng & Hou, 2013). The 3 dimensions were used to analyze all the feedback ideas recorded online in order to identify high vs. low regulative groups. Second, all the lesson design ideas and products were further assessed using the above-mentioned principle (community knowledge) as evaluative criterion to decide whether high regulative groups are more likely than low-regulative groups to be aware of the guiding principle for their teamwork. Third, using the ICT Integration Scale for Elementary and Junior High School Teachers developed by Hsu and Kuan (2011), groups' lesson designs as group's collaborative learning products were further analyzed. In particular, the quality of technology-integration embedded in the lesson designs were examined, and the inter-coding reliability (Spearman's coefficient) was computed to be .76.

Findings

First, cluster analysis was performed with two clusters emerged--high vs. low regulative groups. Four high-regulative groups generated less affective feedbacks, but more cognitive and metacognitive feedbacks. In contrast, the other six low-regulative groups generated more affective and cognitive feedbacks, but less metacognitive feedbacks. Further, to answer the first research question, Chi-square was performed. As shown in Table 1, the results showed that there was a significant positive relationship ($X^2(1) = 5.926$, $p<.05$) between the extent of group regulation and the extent to which the knowledge building principle was referred to during group discussion. High-regulative groups were more likely to be aware of this principle as guidance when engaging in their online discussion and lesson design activities. Moreover, to answer the second research question, another Chi-square was performed. As shown in Table 1, the results suggest that there was a significant positive relationship ($X^2(1) = 15.294$, $p<.01$) between the extent of group regulation and the quality of collaborative designed lessons as learning outcomes/products. High-regulative groups were more likely to progressively and effectively integrate media and technology in their designed lessons than low-regulative groups. The effectiveness of technology integration also implies that students in the high-regulative groups are more effective collaborators under the guidance of the "community knowledge" principle.

Table 1: Relationship between extent of group regulation and degree of principled awareness and effectiveness of technology integration

	Degree of principled awareness			Effectiveness of technology integration		
Level of group regulation	More principled awareness	Less principled awareness	Total	High tech integration	Low tech integration	Total
High-regulative	12	0	12	8	4	12
Low-regulative	5	13	18	4	14	18
# of total lessons	17	13	30	12	18	30

Conclusions

This study suggests that within the same knowledge building environment, different groups may still perform very differently. One possible factor to affect group performance is group's awareness of the underlying "community knowledge" principle as guidance for collaborative teamwork. It seems that when group awareness is high, the extent of group's collaborative regulation will also be stronger. Moreover, it is found that the extent of group regulation is related to a group's collaborative learning outcomes (i.e., lesson designs). Based on the findings, The findings in the present study have implication for the future design of computer-supported collaborative knowledge building environments. Future designs need to take into consideration as to how to develop tools to further help monitor group awareness and regulate group work in order to make group collaboration more effective.

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Reconsidering the Value of Gamers' Experience in the Mathematics Classroom: A perspective of Game Transfer Phenomena

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Abstract: Little research has addressed the importance of what kind of abilities do gamer developed from their gaming experience in everyday practice. The aim of this study was to using Game Transfer Phenomena as a lens to illuminate gamers' knowledge revealed in the problems they posed in elementary math classrooms. Two major categories of gaming community knowledge were emerged: 1) deconstructing gameplay logic and 2) internalizing the trial-and-error strategy.

Keywords: community of gamers, Game Transfer Phenomena, game experience, free problem-posing

Introduction

For "digital native", unidentified abilities are developing. The game generation refers to the generation that grows up with abundant information, rapid technology development and various games, and the influence of these is deeply embedded in their childhood. Nourished by the gaming experience, the gaming generation develops unique abilities, language, and logic to interact with the world (Egenfeldt-Nielsen, Smith, & Tosca, 2008). To be specific, "What unique abilities have been developed?" has becoming the question waiting to be answered and appears to be the hot topic nowadays.

The purpose of this research is to discover to what extent video gaming experience be transferred to daily life. The flexibility of free problem-posing activity was utilized to examine if gamers' gaming experience could be reflected in the problem they posed. In addition, the concept of Game Transfer Phenomena (GTP), developed by Ortiz de Gortari and Griffiths (2011), was used to guide the analysis of "gaming community knowledge". Ortiz de Gortari & Griffiths (2012) defines GTP as "involve the transfer of video game experiences into the real world. These experiences can be triggered by the association between real life stimuli and video game elements." (p.7) They gathering the interview transcripts conducted with dozens of gamers, and self-reported life events directly impacted by video game experience, which were collected from online forum discussion threads with thousands of participants (Ortiz de Gortari & Griffiths, 2012). They then claim that video gaming experience affect gamer's thinking, perception, mentality, and behavior.

Although it is clear that experienced gamers perceive and interpret reality from their gaming viewpoint, GTP is still a phenomenon that could be perceived conceptually but not analyzed empirically. With consistent understanding on the relationship between gaming and real-life experience, it is highly possible that the existence of the GTP can be observed everywhere. If specific methods could be developed to describe the immersed experience beyond flow experience, it would be of great value for more nuanced examination on GTP.

Research methods

Eighty seven participants from a primary school in northern Taiwan (fourth and fifth-grade class) were recruited. There were two phases of free problem-posing activities. The first phase was in-class free problem-posing activities. Led by the research team, 11 stages and a total of 440 minutes of lessons were conducted. The second phase was a school-wide problem-solving contest using all the problems posed by the students during the 3-day contest. The main incentive for free problem-posing was to create a challenging problem through group discussion and peer revision. The students were encouraged to incorporate daily life experiences into their problems with no limitation on any specific units in math textbooks. There were also no instructions on using gaming experience.

Two types of data were collected: 1) the 87 problems the students posed and 2) interviews. Of the 87 problems, nine of them were related to video games. For the selection of the interviewees, three homeroom teachers and more than half of the students were interviewed based on their willingness. Each of the interview lasted for about one hour long.

Nine math problems were analyzed on a thematic/content basis in which underlying meanings were unitized and coded based on phenomenological inquiry (Creswell, 1998). Two analysts extracted significant statements relevant to game community and coded them as units of meaning. They then clustered these units of meaning into themes. After the research team reached an agreement in the team discussion on appropriate thematic grouping, the extracted themes and statements were labeled accordingly. Overall, the inter-rater reliability reached 0.95. Here is an abridged example of the theme-categorizing results: "One's belongings stay at the original place after they die. After resurrection, one has no resources and needs to retrieve them. [Game logic of looting system]"

Findings and discussion

Two major categories of gaming community knowledge were identified: deconstructing gameplay logic and trial-and-error strategy. Due to the limited space, one problem was particularly selected to demonstrate how GTP were embedded in a gamer's composition of his problem.

> Whitey, Teeth, and Gaga are playing Minecraft. They built a house with two sets of wood. There were three sets left, and the three of them divided the resource equally. One day, Whitey fell from a mountain and her wood was taken by zombies. Teeth was burned to death in lava together with his belongings. Gaga went to sleep and never woke up - everything he possessed remained intact. Collectively, how many sets of wood are left? (<u>Note: one's belongings stay at the original place after they die. After resurrection, one has no resources and needs to retrieve them</u>) (problem 01)

Deconstructing gameplay logic: It is a necessary skill for gamers to secure the advantage in games. A video game is usually made up of different functional game logics and gamers need to master them in each sub-system perfectly in order to be outstanding. In problem 01, the gamer's problem statement revealed that the way to acquire resources differs from system to system (e.g. Regular Purchase System, Gachapon System, and Looting System). He also demonstrated his understanding of the looting system by using his own words (shown in <u>underline</u>) at the end of the problem. It is clear that he accurately master the knowledge about such system. Through free problem-posing, the gamer clearly portrayed the essence of the logic and of the mechanism. With his successful experience in deconstructing complicated and intertwined gaming logic and rules, it is reasonable to expect that old-timers in game could adapt proper strategies and adjust to organizational culture in school, comprehensive exam/competition regulations, and react to complex situations

Internalizing the trial-and-error strategy: If gamers fails, they have to try the same level again until it has been successfully completed. Video games always create a safe environment for gamers to make bold hypothesis and examine it with precaution. In our analysis, problem 01 (shown in *italics*) describes specific causes of death. The gamer used to learn and improve his own skills through trial and error by composing the problem with ideas such as "Did one die?", and "How did one die?" If gamers ignore the cause and take death as how it was, death would reoccur after the repeated trial. Therefore, if the gamer can figure out the cause of death, he or she can perform better next time once they return from death. Similarly, when the character dies, it provides a chance for improvement, rather than a hopeless end of the game. Through problem posing, the gamer displays soundly the spirit of trial and error. Moreover, the relatively responsibility-free place of games has made it a perfect environment for cultivating the trial-and-error strategy and developing a scientific mindset towards hypothesis building. Internalization of such strategy might lead to positivity, perseverance, and decisive decision-making. Such aspiring students with a passion for learning and persistence are exactly what the society is looking for.

In conclusion, GTP was vividly revealed in problems generated from free problem-posing activities in an elementary math class. Whether gaming experiences could lead to more innovative, delicate, and complex thinking and behavior deserves further empirical examination.

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Towards a Teaching and Learning Model for Transition in the Pre-Service Teaching Community

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Abstract: Individual undergraduate pre-service teachers are in constant contact with their past as they develop essential skills for the future. It is important to consider the role that past experiences have in the learning process. 'Give Your TWO-CENTs', a teaching and learning model, supports students in a collaborative biographical exploration of the history of education. This paper discusses the initial application of this model and suggests a new role for the history of education.

Keywords: Initial teacher education, history of education, CSCL, design-based research

Introduction

Engagement with the history of education in initial teacher education (ITE) programmes has declined over recent decades as pre-service teachers focus on methodology, subject knowledge and educational technology. (McCulloch, 2011; Kerr, Mandzuk & Raptis, 2011) This research project explores how engagement with the history of education can be enhanced by sharing biographical experiences when supported by educational technology in an undergraduate ITE programme. Participants in such programmes are in constant contact with their past as they develop essential skills for the future. Engaged with all sectors of education, this tacit relationship leaves neither the participant nor the learning environment unchanged. (Alheit, 2009) 'Give Your TWO-CENTs' is a design-based research (DBR) (Barab & Squire, 2004) intervention inspired by social constructivist thinking which asks participants to collaboratively create a digital artefact by recording a history of education unique to their peer group. Participants are encouraged to ask questions about their past experiences, their contemporaneous position and the role that they may play in the history of education not yet written. This paper gives a brief account of the initial application of this model and suggests a new role for the history of education in undergraduate ITE programmes.

Theoretical context

Engagement with history of education is a prerequisite for professional registration in the Republic of Ireland. Internationally, engagement with this area of ITE has been in decline over recent decades. Pre-Service Teachers (PSTs) find the discipline difficult to reconcile to the practice of teaching as socio-economic demands undermine the necessity to understand the processes of education. (McCulloch, 2011) As ITE programmes across Europe embed educational technology into their curricula, this project asks if a collaborative exploration of the history of education can help PSTs transition into tertiary education and towards professionalism when supported by educational technology. This research draws on the theory of *'biograhicity'* (Alheit, 1999) and the role our tacit past plays in any intraspective examination and suggests that all historical experiences of education can be explored as a process that leaves neither the participant nor the learning environment and those in it, unchanged. (Alheit, 2009) As part of this process, the development of intersubjective dialogue may challenge preconceptions about how relevant the history of education is, as a foundational study, to the profession of teaching.

Methodology

Key to answering the central research question was the development of an environment that could facilitate the real-world complexity of ITE. A design that would facilitate an in-depth qualitative exploration of the central research question through the multiple interdependent variables (MIVs) - collaboration, engagement, narration and technologies (CENTs) was required. The history of education, as a non-elective modular component of ITE, was therefore viewed as a project based DBR intervention. (Barab & Squire, 2004) The model was designed and administered by the researcher over a period of twelve weeks. Ethnographical data was supported by survey data, focus groups, a submitted artefact as part of assessment requirements and short reflective essays. The triangulation of this qualitative data supported by nominal and ordinal quantitative data, was then analysed through the lens of the multiple interdependent variables. The cohort of students identified as a purposive sample were new entrants to a four year duration undergraduate Bachelors Degree in Mathematics and Education. (n=21) All participants were engaged in tertiary education for the first time.

Situating the design model

The physical learning environment needed to be conducive to face-2-face collaboration and adequately resourced with educational technology (in this case iMacs). The design model required a CSCL environment which was accessible, mobile and effective in supporting the needs of the participant group processes during the study. (Stahl, Koschmann & Suthers, 2006) The initial design phase focused on identifying what might make the history of education personally significant to PSTs by linking the theoretical foundations of education to the practice of teaching. CENTs would act as a lens through which the intervention could be informed for subsequent iterations. The module content was aligned with pertinent issues in ITE such as methodology, subject knowledge and educational technology. The duration of the intervention, twenty-four hours, was split equally between historical content and construction of an artefact. Participants investigated the history of education in four distinct areas - primary, second level, tertiary level and postgraduate education and began a collaborative story building process in groups of four. Integrating mobile educational technology would ensure mobility for participants, supported by a CSCL environment, reflecting the real-world pervasiveness of such technologies. Participants were asked to construct a representation of their collective experiences at each level of education and disseminate to the cohort in a digital format (in this case an iBook), their histories of education.

MIVs at work

Participants welcomed the structure of the module however, when they had exhausted all of their efforts in exploring the history of primary, secondary and tertiary level education the groups stagnated. They had no personal experience of postgraduate education. The design model had anticipated that this may force participants to re-examine their collaborative story sharing for evidence of postgraduate influence. Participants instead asked each other what postgraduate education meant to their future careers and began to look to their future roles as professional educators. The participants had collaborated in order to make sense of their transient position in the history of education and the teaching profession through the story building process. Transition had emerged as a new design variable.

Conclusion

The design model has clearly enhanced participants engagement with the history of education and the story-building process was effective in making the module content personally significant. Participants initially engaged as individuals until they were faced with confronting their future as professional educators at which point they transitioned from being co-operative members of a group to being collaborative members of a pre-professional community. The design variables identified collaboration as the variable that underpinned this development. The emergence of a new variable within the design justified the selection of DBR as a research methodology. While the focus for this project remains enhancing engagement with the history of education, the role that the design model plays in the transition of undergraduate PSTs toward professional status must become a more central concern of the research project.

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Gaze Awareness in Collaborative Problem Solving: An Approach for Gaze Sensitive Interaction and Analysis

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Abstract: This paper presents an approach to utilize eye-tracking technology for interaction and analyzing to understand complex collaborative competencies that are subsumed under the term learning to learn together (L2L2). Our analysis uses automated computation of gaze measures, domain activities, and qualitative manual coding to find differences between certain gaze visualizations. We present our results on an empirical lab study of a collaborative puzzle-solving activity in different conditions of gaze awareness between the collaboration partners.

Introduction

In today's information society the requirements in the job, schools and university go beyond the mere acquisition of domain-related knowledge and skills. The term 21st century skills entails and stresses the importance of a wide variety of skills "needed to survive and thrive in a complex and connected world" (Trilling & Fadel, 2009). While we accept the importance of the standard skills promoted by more traditional systems, our work is motivated by the importance of moving beyond domain-specifics skills and focusing on the collaborative competencies associated with group learning that today's complex, fast-paced environment demands (Scardamalia et al., 2011), i.e. a subset of 21st century skills that is especially relevant for CSCL research. In the Metafora project (http://www.metafora-project.org) we designed a pedagogical approach to encourage students to engage and learning those skills. This is subsumed under a frame we call "Learning to Learn Together" (L2L2) that focuses on the meta-level of how students learn from and with each other and includes interacting behaviors as follows: Distributed Leadership, Mutual Engagement, Help-seeking and -giving and Reflection of the group learning process (Dragon et al. 2013). Relevant for our study is the integration of eye-tracking as one input sensor. Studies in CSCL settings (Schneider & Pea, 2013) showed that providing awareness of the focal point of learning partners on the screen supports the coordination of learning partners within a group task and the development of a common understanding of the learning content. For our study we use the INKA-Suite (Kienle et al., 2013) that directly connects the eye-tracker's gaze data stream and the CSCL system and identifies the areas of interest at runtime, regardless of size, shape and position. We will show how low-level gaze and operation information can be combined with high-level L2L2 category coding to get a richer picture of L2L2 in practice. And how different gaze visualizations infect those L2L2 behaviors.

Methods

The experiment consisted of collaborative puzzle where each participant used a separate computer. The puzzle is a collaborative adaptation of the turtle puzzle (see Fig. 1, left) which requires matching heads and bodies of turtles across 2 adjacent puzzle cards and that has been used in a similar way in CSCL studies before (e.g. Mühlenbrock & Hoppe, 1999). The turtle puzzle consisted of nine pieces and accepted just one valid solution, which was automatically detected by the system. As shown in Fig. 1, there were nine drop zones for solving the puzzle, as well as nine stack zones, which initially held the puzzle pieces. Every dyad had the same initial piece distribution. It was implemented as a "What-You-See-Is-What-I-See" real time web application, which transmitted every drag and drop. Conflicts like dragging the same piece or using the same drop zone was prevented by the system. Participants were assigned to a color, which was used to highlight drop zones and gaze indicators. It was also used by the experimenter to refer to participants via the collective voice chat.

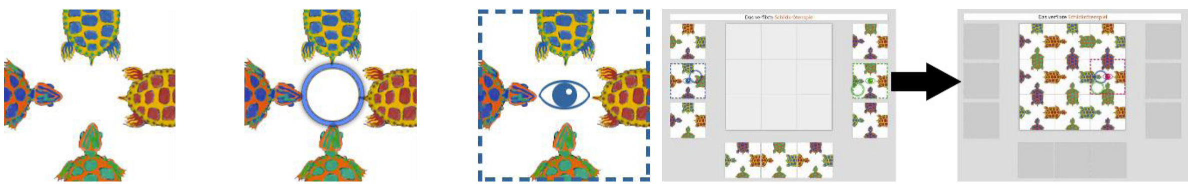

Figure 1. Turtle puzzle game board (left) and gaze conditions (right)

In this experiment we used three conditions in a between-subjects design. Those conditions were divided by the support of gaze (see Fig. 2, right). The first group had no gaze support at all, the second group was supported by a mutual gaze cursor and the third group used a gaze enabled application, which highlighted the visible elements on the screen while fixating it without showing a gaze cursor.

Findings

In this study we used computational methods to derive gaze-related information. These automated methods have been complemented by extensive manual coding on a subset of the dyads that created a balanced spectrum of the different conditions and quickness of the solution (both quick success and maximum duration without success). The explicit coding of L2L2 behavior (four independent coders; code was established when coded by at least three analysts) and the parallel inspection of captured gaze properties and domain actions helped us to identify potential patterns at the different levels of observations that can guide the inspection of the full set of dyads. Mutual engagement is established in the different conditions in different ways. While the shared gaze in conditions gaze cursor and gaze awareness helps to create joint attention, this information is lacking in the no-gaze condition and has to be compensated by audible references or referential gestures within the tool. In the investigation of L2L2 behaviors in the dyads we coded manually, we detected a typical pattern of audio-gaze combination with an optional action taking place afterward in the two gaze conditions, while in the no-gaze we detected a typical voice-action-gaze pattern before joint attention was created (see Fig. 2). Similar characteristic patterns can be identified for Distributed leadership.

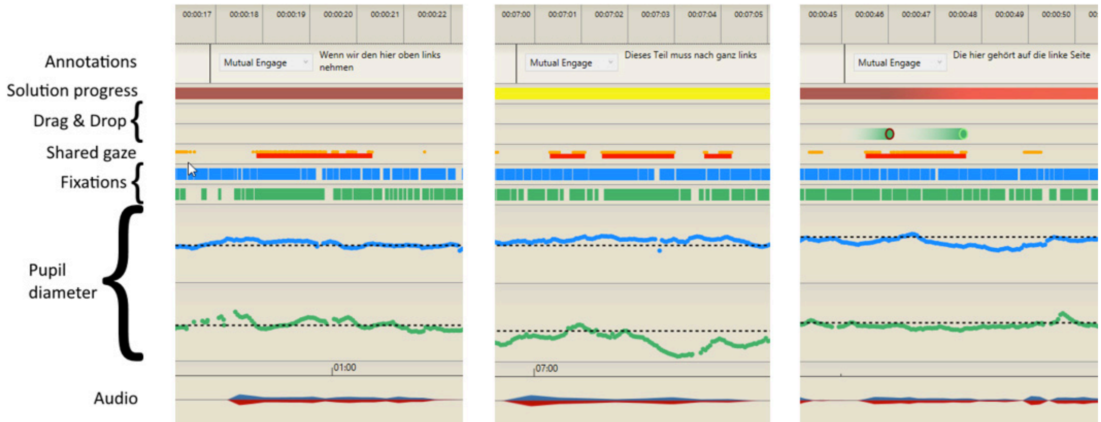

Figure 2. Analysis application with annotated Mutual Engagement

Discussion and conclusions

To conclude we utilized eye-tracking technology to investigate the presence of L2L2 behaviors in problem-solving activities. Our assumption that the sharing of gaze information can help to establish mutual engagement and distributed leadership was supported in our experiment. The analysis of our two different gaze conditions (i.e. replication of the gaze cursor vs. highlighting an area of interest as gaze awareness) brought a slight advantage of our awareness condition, yet no significant differences at this stage. We will have to explore in more depth if more complex learning scenarios will create clearer results. Useful for this analysis was the integrated and synchronized visualization of all relevant information inside the INKA-Suite.

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University Students’ Learning Culture Concerning Collaborative Tools in the Net

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Abstract: This study investigated university students’ learning culture concerning the Internet. Students´ attitudes especially regarding the collaborative tools such as wikis and blogs in the Net were examined. The participants of the study were higher education students (n=126). Online survey was used. The findings indicate that the Internet is an important part of students’ learning culture e.g. for knowledge search. Collaborative knowledge production seems not to be part of the learning culture of the students.

Keywords: Learning culture, collaborative tools, internet, student learning, higher education

Introduction

The purpose of this study is to investigate university students’ learning culture. Culture can be seen as social practices and can be operationalized by how people act and what kind of attitudes concerning knowledge do they have (Bourdieu 1990). In this study culture is considered from three aspects: technology, knowledge and learning. Technology refers to the Internet and especially the collaborative tools offered in the Internet such as Wikis and Blogs are in the focus. Although ICT-technology offers a good deal of knowledge building possibilities, the Internet is often not an integrated part of the learning culture (Biermann 2009). Internet has provided solutions offering enormous potential for an active participation in knowledge creating and sharing. Theories like "wisdom of crowds" (Surowiecki, 2007) deal with learning as participating and knowledge creation in collaborative community.

When talking about culture the concept of knowledge is always in the background (Bourdieu 1990). Students’ concept of knowledge can so influence the practice of using collaborative knowledge services in the Internet. Students perceive and interpret their learning environment by applying their individual epistemological beliefs (Harteis, Gruber & Hertramph 2010).

Students can also perceive their learning environment with different orientations towards learning. Hence, conceptions concerning learning can be seen as an important. Learning was measured by LSI model (Vermunt 1994) as external and internal learning orientation.

The research questions of the study are: What kind of Internet learning culture do the students have? What kind of factors can be found in this culture which might have an impact on the use of the Internet and especially collaborative tools in the Internet? How students use Internet and collaborative tools?

Methods

Participants of the study were 126 university students from different disciplines and from three universities in Finland. The data was collected via online-survey which consisted of Likert like statements. Mainly a 5-point Likert scale was used from 1 (very strong agreement), 2 (agreement), 3 (neutral), 4 (disagreement) to 5 (very strong disagreement). The usage of the Internet was measured by the scale 1 (daily) to 5 (never). The questionnaire was carefully piloted.

Findings

The results indicate that the Internet is important for the students because they use the Internet every day (98%). Most of the students use the Internet mainly as a search engine (97%) and as a communication tool (98%). Also Facebook is important for managing everyday communication (77%). Whereas only a minority of the students actively uses Internet solutions like Wikis and Blogs (range between 7% - 9%). For most of the students the permanent accessibility into the Internet is not very important (67%) neither to access the Internet with an own device (53%). The main use of the Internet seems to be a tool for arranging and organizing the daily life regarding time and data management plus fostering social contacts.

In the learning context the result indicates mainly a similar pattern, the Internet for organizing the learning is highly accepted, such as searching scientific knowledge (77%) or using learning environments like „Moodle“ (67%), but only a minority uses the Internet as provider for learning content, e.g. only 38% uses e-books. And even only a minority uses collaborative tools, e.g. blogs (8%). Facebook as a learning tool is only considered important by a minority (13%) of the students.

Concerning the attitudes towards the Internet the results are ambivalent. On the one hand as the daily use suggests the Internet is considered very important in the life of the students, even more important than TV (78%) and in developing future society (63%). On the other hand the majority of the students have no or a weak trust on the Internet, especially in terms of data security (2%). And the vast majority (86%) finds Internet dangerous.

For most students knowledge has collective characteristics (70%) and has to be shared in a group (93%). However students' attitudes towards collaborative Internet solutions like wikis and blogs are not very positive. Only a minority of the students accepted collaborative knowledge concepts (range between 17 - 21%). For only 28% of the students Wikipedia is a competitive encyclopedia. Furthermore 40% has the opinion, that the internet solutions mainly strengthen the users' own opinion. In sum, the Internet and especially the collaborative tools are mainly not accepted as a support in the learning process.

Most of the students have an internal learning orientation (61 %) only 28% are external oriented. Students have learned to use the Internet on their own (95%) via an informal way and not in a formal way e.g. by taking courses. However, the majority of the students evaluate their Internet skills good (64%). It can be considered that the students feel comfortable using the Internet with their own manner, using the tools, which they can proper handle.

Conclusions and implications

Internet seems to play an important role in the learning culture of the university students. Searching information, communicating and organizing the learning content within a learning environment seems to be very crucial for the students. However, the use of the Internet seems to be very one-sided. The use of collaborative solutions is far behind expectations. The reasons for this can be very complex.

The concept of knowledge seems not to be an obstacle for using collaborative tools. The students have basically a shared knowledge concept, but knowledge concepts like "wisdom of crowds", "wisdom of friends" are not generally accepted.

Whereas the attitude towards the Internet is mainly positive, the students have the opinion that the internet is also very risky. This could be an obstacle for the students for active participation. The lack of trust towards the Internet should be taken into account when developing learning environments.

Furthermore, the students' informal "learning by doing" learning style for learning to use Internet might have an impact on the learning culture, especially by using the Internet. The students evaluate themselves mainly as good skilled users regarding the Internet. So the learning style "learning by doing" might not help them to develop these kinds of skills on its own. The use of collaboration tools seems to require other learning and teaching styles in higher education. The future challenge could be to develop a teaching culture which supports active collaboration and building of the „community of practice" learning culture in higher education.

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Relating Entrainment, Grounding, and Topic of Discussion in Collaborative Learning Dialogues

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Abstract: In conversational dialogue, *grounding* refers to the joint activity of speakers and listeners establishing common ground—a shared understanding of their mutual knowledge, beliefs, and assumptions. Grounding is a critical component of successful collaborative interactions and plays an important role in collaborative learning. In this work, we investigate grounding utilizing acoustic-prosodic entrainment. Acoustic-prosodic entrainment occurs in spoken dialogue when speakers adapt their tone, loudness, voice quality, or speaking rate to that of their partner. We explore the relationship between grounding and acoustic-prosodic entrainment within on-task and off-task dialogue, and we find that grounding behaviors in both on-task and off-task dialogue are differentiated by how speakers entrain.

Keywords: collaborative dialogue, acoustic-prosodic entrainment, grounding, off-task discussion

Introduction

Effective conversational grounding is a critical component of successful collaborative interactions and collaborative learning tasks (Baker et al., 1999). From a cognitive perspective, grounding in problem-solving dialogue enables people to coordinate knowledge and co-construct solutions, playing a critical role in the learning process (Clark & Brennan, 1991). From a social perspective, grounding may aid in the development of rapport with one's collaborator (Semin & Cacioppo, 2008). These social attributes have in turn been shown to be predictive of learning (Ogan et al., 2012).

In this work, we explore how properties of speech relate to how students are engaging in these critical grounding behaviors in problem-solving conversations. Specifically, we investigate the phenomenon of *acoustic-prosodic entrainment*, when speakers adapt their tone, loudness, or voice quality to that of their partner. Previous works in non-collaborative dialogues have shown that entrainment correlates with grounding behaviors such as backchannels (Levitan et al., 2012). In addition, acoustic-prosodic entrainment has been shown to be positively correlated with cognitive and social processes that grounding is thought to facilitate (Gweon et al., 2012; Lubold & Pon-Barry, 2014). We focus on grounding behaviors within different topics of conversation, investigating: *How does the interaction between grounding behaviors and topic of conversation influence the ways in which students entrain on each other's speech?*

Method

We collect a set of eight 30-40 minute dialogues from 16 undergraduate college students. The students work together in pairs as peers and were randomly assigned to their partners. We give each student a tablet containing a version of the Formative Assessment with Computation Technologies (FACT) application (http://fact.engineering.asu.edu/). The application encourages collaborative interaction through the use of a shared workspace. Each pair works together to solve two math problems using the tablets. We record high-quality audio data using unidirectional microphones and we manually label dialogue turns.

Entrainment, known also as accommodation or adaptation, occurs when participants adapt their behavior to each other during an interaction. We explore acoustic-prosodic entrainment where speakers adapt their tone (pitch), loudness (intensity), or voice quality (jitter and shimmer) to that of their conversational partner. We extract these features using OpenSmile (Eyben, Wöllmer, & Schuller, 2010), obtaining the mean for each feature. The dynamics of social and knowledge coordination occur at a turn-by-turn level so we measure entrainment on a turn-by-turn basis, adapting an approach from Thomason, Nguyen, and Litman (2013).

To analyze grounding, we label our corpus with common ground features based on Nakatani & Traum (1999). Grounding contributions are contributions which are defined as specifically adding, confirming, or updating mutual knowledge. In grounding contributions, a turn is labeled as grounding if it is relevant to the preceding turn. We define how it is relevant by analyzing whether it contains the response to a question or if there is a clear reference to repeated content from a previous turn by the other speaker. Grounding behaviors were coded by two annotators and average inter-rater agreement was calculated with Cohen's kappa at 0.74.

While much research in the past has focused on the benefits of on-task dialogue, recent research has found that off-task discussion has rapport-building potential. We analyze the grounding and entrainment across *problem-solving*, *social*, and *activity-related* dialogue. In problem-solving dialogue, students are actively working on the problem. Social dialogue pertains to social, off-task conversation. In activity-related dialogue, students are specifically discussing the application or activity itself.

Results

We perform all analysis using regression. Analyzing grounding and entrainment in problem-solving, social, and activity-related dialogues, we find that controlling for differences between dyads, entrainment on voice quality (i.e. jitter and shimmer) is a pertinent feature of grounding. In problem-solving dialogue, shimmer contributes significantly in discerning grounding from non-grounding behaviors, and in social dialogue jitter approaches significance. Jitter is defined as variations in pitch; shimmer consists of variations in loudness. Table 1 depicts the parameter values for the regression models of grounding with acoustic-prosodic entrainment.

Table 1: Parameter values for modeling grounding in on-task/off-task dialogues with entrainment

Type of Dialogue		**Dyad**	**Intensity**	**Pitch**	**Jitter**	**Shimmer**	**Chi-square** (overall model)	**p-value** (overall model)
Problem-Solving	*B*	-0.04	-0.08	0.45	-0.09	-0.67*	7.968	0.158
Activity Related	*B*	-0.01	0.10	0.17	-0.09	-0.27	0.239	0.77
Social	*B*	-0.29*	-1.55	1.73	-1.75*	2.35	11.69*	0.04

(*) indicates $p \leq 0.05$

Discussion and future work

We found that within different topics of conversation, entrainment on voice quality can be helpful in differentiating meaningful grounding behaviors. Our results suggest that people entrain more when engaging in social dialogues, and that, within both social and problem-solving dialogues, grounding turns have higher entrainment. Future work will use these findings to develop an automatic entrainment detector that assesses grounding in real-time. These methods will allow us to better understand the quality of student collaborative processes without needing to depend on inaccurate speech recognition technologies.

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A Learning Analytics Framework for Practice-Based Learning

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Abstract: The role of the PELARS Learning Analytics System (LAS) system is to collect information from students performing project-based tasks, reason on such information and provide visualization to teachers and students, that is usable for understanding the learning process. The information collected by the LAS comprises pieces of information collected directly by the Students, and other collected by the System automatically. In this work we will provide a comprehensive description of the framework and the motivations behind the various decisions. The software framework will be described starting from the broad vision of the context and then the different components will be described in detail.

Keywords: learning analytics, action recognition, Arduino, Kinect, software framework

Introduction

This paper has two main objectives. The first one is to provide a description of the PELARS software framework architecture, the second a preliminary description of the Learning Analytics concepts and metrics that can be addressed by the framework. The core idea of the system is to process the raw data acquired in the learning environment that a server will collect to produce learning traces that, based on the identified metrics, can be empolyed, by the teacher, to better understand the learning process and, by the students, to document their work. Students will work in small groups on a fixed task using Arduino components. Previous related work has shown promising results (Christodoulopoulos, 2007).

Software framework

The framework has been designed by first defining the system context with the involved entities, then defining objectives and requirements and finally proceeding with the use cases. This initial analysis allowed then to define the system components and their interactions.

Requirements

The basic system requirements are: (1) the integration of different sensors in the Learning Environment (LE) to acquire information about the ongoing learning process; (2) the support of flexible curricula and configurations; (3) the collection from multiple sites at once; (4) the extensibility for supporting new components that extract learning traces and performance indicators; (5) easy to be understood visualization for the students and the teachers; (6) the support for real-time and deferred visualization and evaluation of the acquired Learning Metrics.

General architecture

Provided the above description in terms of Context and Requirements it is possible to identify the high level view of the Pelars LAS. The LAS contains a subsystem called LE that corresponds to the location where the students are working on a project. In this location the following elements have been identified: the furniture in which the LAS will be integrated; the Arduino Kit for the experiments; a Collector, which collects all the information gathered by the LAS and the Sensors, which analyze the scene and extract relevant information about objects and actions. The final results are available for the Teachers through a Web Interface. A more general framework in which adaptation is present can be found in (Bienkowski, 2012).

Learning environment

The LE comprises a series of elements that contribute to the learning experience while, at the same time, collect information about the activity of the students. The sources of information for the LAS are constituted by sensors embedded in the furniture. In the following sections the details of the different blocks will be described, together with their interconnections.

Programming IDE

The programming IDE is the tool used by the students for interfacing with the code and developing the projects. The main IDE used in Pelars will be the Arduino IDE with variants developed in the context of PELARS to extract information about the programming tasks in the form of packets sent to the Collectors.

Desk and vision sensors

Desk sensors will be used to track the position and number of hands active in the LE. The Leap Motion Sensor (Guna, 2014) represents a possible solution [3], which is able to acquire in real-time the position of each hand segment inside a fixed volume. Each Sensor can capture around four hands, but without the knowledge of hand pair, meaning that each hand is a separated hand. Possibly more sensors will be embedded in the LE to cover the majority the working area. Position sensors, like RFID, will help to track the position of Arduino components inside the system.

A Vision Sensor is intended as a RBG-D camera, which is able to capture a 3D image of the environment. It will be used to gather knowledge of the relative and absolute position of Arduino components and other used instruments in the LE and to track the movement of the components.

Collector

The Collector is a piece of software responsible of acquiring the information produced by the different sensors and of elaborating the data in order to extract the Learning Metrics. The collector will be a stand-alone application which collects and processes information from the various sensors (Vision and Desk) and the Arduino IDE. All the information extracted by the Collector will be sent to the Server deferred, or in real-time.

Server

The Server will be a dedicated machine hosting a Web Server and a database. Inside the Web Server three Applications will be executed: the Acquisition App that receives data from the Collector and stores into the Database, the LA Core App that performs computations over the acquired data and a Web App that provides the front-end to the user. The Web App provides mainly two types of services: the Administration of the LAS and the Visualization of the learning traces in the form of dashboard or custom visualizations.

WebApp

The Web Server will export a web interface, accessible from any computer, for Teachers that will be able to manage the collection of data from learning sessions and visualization of data. The Visualization is based on two concepts: the Dashboard that allows the users to visualize the key elements about a group of students, and a Traces Visualization that presents the information collected for a given user along.

Conclusions and implications

It is important to notice that the Learning Analytics Framework is in a preliminary stage and needs further development based on the Learning Analytics Metrics, which are currently researched. The structure has been developed trying to maintain it modular and expandable, but also able to scale well with the possible increase of concurrent LEs and new Learning Analytics Experiment Kits. How to evaluate the results of the test is still in development topic and will be researched during the development of the framework.

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Promoting Sustainability: Learning New Practices through ICT

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Abstract: The purpose of this paper is to promote sustainability as an important research topic within the computer-supported collaborative learning (CSCL) community. CSCL can play a crucial role in the achievement of sustainability, which is paramount for the well-being of current and future generations. While CSCL brings formal educational settings to mind, computers and cooperative learning should be considered in a wider perspective since learning also takes place in and through people's everyday practices. This paper considers two on-going research projects outside mainstream CSCL research, to illustrate ways that technology can lead to changed practices for the benefit of increased environmental and social sustainability. The projects concern children's online practices and social sustainability, and information and communication technology (ICT) and practices in sustainable agriculture, respectively.

Keywords: CSCL, ICT, learning, practices, social sustainability, environmental sustainability

Introduction

The purpose of this paper is to promote sustainability, and we argue that CSCL research should place sustainability up high on the research agenda and prioritize research questions embarking on the difficult, but imperative, undertaking to facilitate learning that fosters maturing of sustainable human practices.

A keystone of the sustainability movement is the United Nation report from 1987, "Our Common Future". The sustainability discourse is commonly based on the idea of three overlapping areas, or pillars, covering environment, economy, and society (Boström, 2012). The well-being of our planet and its present and future inhabitants is a global challenge of vital necessity, and it is inevitably highly multi-dimensional – in its intrinsic characteristics as well as potential paths towards it. A generic path is to stimulate people to change towards more sustainable practices, which can be cultivated by, e.g., formal as well as informal learning (Marsick, 2009), but also to address sustainability aspects in the design of interactive technology with a focus on everyday practices and routines (Pierce et al., 2013). ICT is part of people's daily lives, and hence it offers a possibility to integrate, e.g., features into applications that can stimulate change in practices and behaviours.

CSCL is concerned with "how people can learn with the help of computers", but much of the research focuses on institutional settings and formal education (Roschelle, 2013). However, technology is becoming ever more ubiquitous, and computer supported learning takes place within broader environments, across different contexts and media (Dillenbourg et al., 2009). A consideration of the wide-spread use of technology and broader learning environments, brings an opportunity to affect people's everyday practices and sustainability.

This paper describes two different on-going research projects, outside the mainstream CSCL focus. One of them concerns social sustainability and prevention of risk behaviours in children's leisure online activities. The other concerns environmental sustainability and sustainable land-use. These projects serve as examples of collaborative learning supported by technology. The intention is to demonstrate that CSCL can have an significant impact on sustainability if the field embraces new lines of thought, and widens its scope to consider the highly complex and vital challenge of sustainability.

Two cases of learning new practices through ICT

A current research project, concerned with decreasing the risk for children to become the object of online sexual grooming, aims for children to learn new practices through ICT, in this case, a cooperative computer game. The aim is to raise young children's awareness of potential consequences of their decisions and online behaviours, for the benefit of their well-being and social sustainability. Children are immersed in technology-related leisure activities (e.g., online gaming and social networking), but learning in such activities tends to be overlooked since it is outside formal educational settings. Some ICT is also being misused, e.g., for online sexual grooming, i.e., communication and socialisation where a potential offender seeks to gain a child's trust in order to prepare the child for sexual abuse (Martellozzo, 2012). According to Piaget, reasoning processes in children aged 8-10 years are characterised by being content-bound, tied to available experience, and logic is limited to solving tangible problems that involve concrete objects. Consequently, they also have difficulties in reasoning about hypothetical problems or future events (Wadsworth, 2004). Then, from around the age of 11-12, children's reasoning processes mature and they can reason about the past, the present, and the future, and hypothetical problems. The cooperative computer game will transform abstract phenomena (possible consequences of online interactions) into a tangible object, thereby bridging the differences between reasoning processes in 8-10 year olds, and the reasoning processes required to understand and cope with hypothetical risks and consequences.

Another project concerns ICT, practices, and the challenges facing sustainable agriculture. Agricultural ICT can contribute significantly to long-term sustainability, but currently it does not meet all the raised demands. One identified reason is the lack of knowledge on farmers' daily practices, and more focus should be spent on shared learning experiences and the actual use of agricultural ICT (Thorburn et al., 2011). The crop farmer in this study has, together with the neighbour farmer, recently invested in an N-sensor, which is a tractor-mounted precision agriculture (PA) technology; PA technology enables monitoring of soil and crop conditions and targeting treatment, and it permits fields to be considered as *heterogeneous* entities where selective treatment can be applied, instead of *homogenous* entities. A major challenge in PA is how to change current farming practices so fields are treated as heterogeneous entities (Aubert et al., 2012). The PA technology allows farmers to measure a crop's nitrogen requirement as the tractor runs across a field. In this study, the instant feedback from the N-sensor's display initiated questioning of the current framing practices, and the farmer realized that the variation in the fields and the soil quality was much larger than he had believed. The farmers started to discuss the outcome of using the N-sensor, which in turn initiated other forms of collaboration and changes in their work practices. Their positive collaboration and learning experiences have then spread to other farmers, which is a beneficial development since larger areas of fields come to be viewed as heterogeneous. Thus, agricultural ICT brought changes to the farmers' practices, which contribute to sustainable farming.

Concluding remarks

In summary, sustainability is a complex but necessary issue when considering the well-being of present and future generations, and CSCL should place sustainability up high on the research agenda. Considering that the boundaries between computer-supported collaboration and other forms of collaboration are disappearing, and that learning takes place within formal educational settings as well as informal settings, CSCL research should embrace a wider scope of technology use and learning environments. CSCL, with its interest in collaborative learning and technology, has a great opportunity to significantly contribute to various aspects of sustainability, such as sustainable practices, and to inform the design of technology for that purpose. The two research projects described in the above section, illustrate different ways technology can support collaborative learning and sustainability. A sustainable society ultimately depends on the human resources it can muster, and changed practices is an important means towards the goals of sustainability. Yet, sustainability cannot be transferred to, or induced upon, learners – it has to come from 'within', through people embracing sustainable practices, and CSCL has a great opportunity to significantly contribute to fostering sustainable practices.

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Student Experiences with Social Annotation Tools in a MOOC Course

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Abstract: Collaborative annotation tools create new possibilities in educational technology, both by allowing for easier and more natural interaction with online course content, as well as by facilitating meaningful collaborative activities. This paper presents preliminary results from an exploratory study using annotation tools within a Massive Online Open Course (MOOC) contexts. HarvardX produced media-rich annotation tools that allow different levels of interaction with learning materials. The annotation tools were used in a ChinaX module, using both text passages and a detailed illustrated scroll. An experimental mixed method design was used to test the effects of guidance on students' subjective experiences with annotation tools. This is one of the first studies that investigates using annotation tools in MOOCs and highlights opportunities and challenges for student learning and engagement.

Introduction and background

The widespread use of online lecture materials requires innovative pedagogies to engage students with an inherently passive media format. Some methods commonly used include discussion forums and video comment boards (as found on the YouTube platform). While many Massive Open Online Courses (MOOCs) use similar strategies, they are often less integrated with learning materials. They direct students to a separate discussion page rather than allowing comments to be linked and in close proximity to the materiel. This project explores an alternative way of engaging MOOC learners with content: encouraging the use of annotation tools.

Recent research in the development of annotation tools is rich (e.g., Chen, Hwang, & Wang, 2012). Only small fractions of these studies report learner experiences with these annotation tools (e.g. Su, Yang, Hwang, & Zhang, 2010). Overall, there is a lack of understanding on how to best use different types of annotation tools to increase students' engagement and learning outcomes. For instance, after conducting a literature review of using social annotation tools for educational purposes, Novak and her colleagues (2012) found mixed results on the impact of using annotation tools to improve student learning and engagement. It is not clear whether the results from these studies are generalizable to MOOC environments since MOOC students need to learn and use the annotation tools as a self-regulated learning activity. These mixed results highlight the need for further studies to understand how learners perceive different types of annotation tools. Such studies can examine how different ways of using such tools impact learner perceptions of feasibility and usefulness of the tool in learning environments, both distance learning and in-person classrooms.

In 2013-14, HarvardX produced three interoperable, open source, media-rich annotation tools (Desenne & Reis-Dennis, 2014). The tools allow commentaries and tagging on text passages, video clips and high definition images. All annotations can be aggregated under one section of the platform. Students can browse and review their own notes, as well as the instructors' and other students' contributions. The annotation tools were built using widely adopted open source technologies for annotation (e.g., Annotator, http://annotatorjs.org/)

The instructional team of the ChinaX course (https://www.edx.org/course/china-harvardx-sw12x) developed two annotation tool exercises. The pedagogical goals for the exercises included deeper analysis of the text and image as primary sources to gain a better understanding of the High Qing period. Text passages were from the novel commonly known as *The Scholars.* The image was a digitized 30ft long scroll. Both were created in 18th Century China. ChinaX team created step-by-step video and image/text based tutorials for students to train them how to use the annotation tools to annotate text and the scroll.

This abstract presents preliminary findings on learners' subjective experiences with the social annotation tool. It is part of a larger study that aims to use qualitative and quantitative methods to learning experiences of using annotation tools with different types of educational materials. Below, we summarize the implementation of a novel image annotation tool in a ChinaX module and aim to answer the following research question: What are the learner experiences with and attitudes towards image annotation tools?

Methods

Participants were learners in the ChinaX course. A between-subjects design was used and learners were randomly assigned to one of three groups: No annotations (Group A), instructor annotations (Group B), learner annotations (Group C). All three groups interacted with the annotation tool after the assessment test and before the annotation experience survey. The number of participants in each group varies due to attrition.

Surveys aimed to capture participants' experience with the annotation tool using 5-point Likert scales; (6 questions; e.g., How much did you enjoy the annotation task?) including their attitudes on the usefulness of six different aspects of the annotation tool (e.g., How useful did / you find the following aspects of the annotation tools? - Highlighting), scroll task motivation (5-point Likert scale; 4 questions; e.g., How much did you pay attention to the scroll?). In addition, participants answered questions about the scroll and the reading on course discussion forums. Students' interactions with the annotation tools (e.g., number of features they used, number of annotations they created) were captured to objectively measure student engagement.

Findings

User experiences with the annotation tool

Participants' subjective experiences were not significantly affected the group (Group A = 169; Group B = 137; Group C = 92). Median values of outcome variables for all participants are: $m_{enj} = 2$, $m_{challenge} =4$, $m_{utility}= 2$; $m_{desire} = 3$; $m_{distraction}= 4$; $m_{intuitiveness} =3$. The most used aspect was tagging. 81.5% (n=339) of participants reported that tagging was useful for their learning. The least used aspect was adding media to their comments with 53% (n=220). The median usefulness was either 2 or 3 for a given annotation tool aspect. Overall, participants did not find the annotation tool very useful.

No significant differences were found on the main effect of group for any of the four questions (i.e, enjoyment, attention, challenge, motivation) on Scroll task motivation (Group A=160; Group B=135; Group C=157). The median task enjoyment, felt challenge, and attention were 4. The median rating of participants' desire to learn with similar tasks in the future was 3.

Annotation practices

Annotation data from the ChinaX Scholars module revealed high participant engagement with the texts and image. Over 800 learners in the course generated over 22,000 annotations on the text passages and the scroll over a span of five weeks. On average, students were very active, creating over 2,000 annotations a day during the first week of the module release tapering to about 500/day towards the end of the period.

Conclusion

Although ChinaX learners used the annotation tools, they did not find them valuable for their learning. Non-significant results reported in this study should not be taken as a counter argument for using annotation tools within MOOC environments. It is likely that students had negative experiences because the annotation tools are still rudimentary (i.e. had glitches), and students were unfamiliar with the tools' functionalities.

Overall, this project is one of the first that aim to measure the educational value of image and text annotation tools in specific ways at large scale, with MOOC learners. We expect that the further analysis of the learner annotations and discussion forum participation after the course closes will give further insight into the *learning impact* of image and text annotation tools. We will be able investigate how learners used the annotation tools, which is a significant gap in the existing literature.

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Bedside Manner Experience Development (BedMED): Supporting the Development of Bedside Manner through Game Design

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Abstract: Nurses interact with patients in a number of different settings, and these touch points require that nurses have well-developed "bedside manner." However, nurses receive very little, if any, education around acquiring and developing bedside manner while in nursing school, and the hectic environment and increased use of technology and patient-load often make it difficult to develop those practices once on the job. Bedside Manner Experience Development (BedMED) is an online game designed to develop and improve the bedside manner capabilities of pre-service nursing students by simulating the patient care experience so that pre-service nurses can acquire, understand, reflect on, and develop their ability to engage with patients in more caring and meaningful ways.

Keywords: subject matter, teachers, technology, student learning, design

Significance and relevance of topic

In the United States, there are more than 2.7 million nurses practicing in the healthcare field, with the U.S. Bureau of Labor Statistics reporting that the projected job growth for registered nurses (RNs) will increase 19% by 2022 (2014). Overall, the projected job growth for nurses is increasing at a faster rate, on average, than all other U.S. occupations (U.S. Bureau of Labor Statistics, 2014). Nurses interact with patients in a number of different settings, from checking vital signs, to administering medications, to taking care of the hygienic needs of patients, especially if they are admitted into the hospital. All of these touch points with patients require well-developed interpersonal skills as patients are constantly re-assessing their healthcare experience and the level of service they are being provided. In other words, nurses must have extremely good "bedside manner." While the term bedside manner is well known, the actual articulation of what bedside manner is has not been agreed upon (Person & Finch, 2008). We define bedside manner as the way a doctor or nurse behaves with a patient (Merriam Webster, 2014).

Nurses receive very little if any education around acquiring and developing bedside manner capabilities and practices while in nursing school, and the hectic environment of medical offices and hospitals, large number of patients, and increased use of technology often make it difficult to develop those skills once on the job (Hagabaghery, Salsali & Ahmadi, 2004; Person & Finch, 2008; Jain, 2008). As a result, bedside manner has received little in-depth attention in the literature, especially from the perspective of nursing students or in the context of game design. The objective of this research is to develop and improve the bedside manner of pre-service nursing students through the development of an online game called Bedside Manner Experience Development (BedMED), which simulates the patient care experience so that pre-service nurses can acquire, understand, reflect on, and develop their ability to engage with patients in more caring and meaningful ways. In particular, this research explores the following questions:

1. What factors and practices have the greatest impact on the development of pre-service nurses' bedside manner?
2. What opportunities do these students have to acquire and develop bedside manner capabilities and practices? In what ways do faculty support that acquisition and development?
3. What difficulties do pre-service nursing students face as they are developing their bedside manner capabilities and practices?
4. What do those difficulties suggest about supporting that acquisition and development in the context of an online game?
5. How effective is BedMED at supporting the on-going development of bedside manner capabilities and practices among these students?

Poster content

This poster will describe results from the on-going analysis of data for the BedMED project. We are in the very beginning stages of the project. As such, the poster will describe the BedMED project, including the significance and relevance of the problem, research design, methodology, and findings from on-going data analysis. In particular, the poster will present findings and insights gleaned from semi-structured interviews with advanced practice nurses (i.e., nurses with 5+ years of experience) as well as School of Nursing faculty to both identify the factors that impact patient perceptions of bedside manner as well as articulate authentic user scenarios that will inform the design of the online game. In addition, the poster will present artifacts created during the design of the game (e.g., storyboards, images of the physical prototype, images and of playtesting sessions, etc.) as well as findings with respect to the effectiveness of BedMED at supporting the on-going development of bedside manner capabilities and practices among pre-service nursing students (Fullerton, et. al., 2008).

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Changing Patterns of Knowledge Compartmentalization, Social Organization and Power Structures to Promote Interdisciplinary Learning

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Abstract: We suggest rethinking three traditional practices in higher education instruction: (1) compartmentalization of disciplines, (2) traditional pedagogy, and (3) traditional hierarchies. We developed a model that harnesses technology to break boundaries between disciplines, learners and organizational levels of hierarchy. Findings indicate that 34 undergraduate students who participated in an online course that implemented the model, significantly improved their interdisciplinary understanding of the course contents.

Keywords: interdisciplinary understanding, technology-enhanced learning community.

Introduction and background

This study explores interdisciplinary understanding, and suggests technology-enhanced means for supporting it in higher education. Our "high level conjecture" (Sandoval, 2014) was that interdisciplinary understanding entails deep understanding of disciplinary ideas and connections between them, and that these abilities are gained through meaningful dialogue and exposure to a diversity of ideas and ways of thinking. In order to promote interdisciplinary understanding, we developed the "Boundary Breaking for Interdisciplinary Learning" (BBIL) model that harnesses technology to address three traditional practices in higher education instruction: (a) from the *curricular perspective*, it addresses the traditional compartmentalization of disciplines; (b) from the *pedagogical perspective*, it addresses the traditional focus on individual learners; and (c) from the *organizational perspective*, it addresses the traditional academic hierarchy based on levels of expertise. This study assessed students' learning outcomes, with respect to interdisciplinary understanding, following their participation in an academic course that implemented the generic model.

According to the theoretical framework of *Interdisciplinary Learning as a Pragmatic Constructionist View* (Boix-Mansilla, 2010), interdisciplinary learning is a process by which learners integrate information, data, techniques, tools, perspectives, ideas, concepts and theories from two or more disciplines to create products, explain phenomena, or solve problems in ways that would have been unlikely through single disciplinary means. Another framework to explore integration of ideas is *Knowledge Integration (KI)*, which offers a conceptual and practical lens for understanding knowledge integration processes, for evaluating them, and for supporting their emergence using instructional and design principles (Linn & Eylon, 2011). The current study combines the two.
We also relate, as described in our "high level conjecture", between interdisciplinary understanding and meaningful dialogue among people who hold various ideas. Such dialogue can be promoted in a learning communities educational approach, which emphasizes the social-cultural aspects of learning. A core characteristic of a learning community is the diversity of expertise among its members, who are valued for their contributions and are given support for personal growth and development (Bielaczyc, Kapur, & Collins, 2013). Technology has been shown to have an added value in supporting these processes (Kali, Levin-Peled & Dori, 2009). When considering learning within a community that brings together learners with different levels of expertise, the notion of cognitive apprenticeship (Collins, 2006) becomes very relevant. The goal of cognitive apprenticeship, as a pedagogical approach, is to assist novices in gaining mastery in a certain skill or concept.

Design and methods

Based on the three perspectives reviewed above, we defined the following "pragmatic design principles" (Kali, Levin-Peled & Dori, 2009): (1) Boundary breaking between disciplines; (2) Boundary breaking between learners; (3) Boundary breaking between organizational levels of hierarchy. The BBIL model (Figure 1) was derived from these pragmatic design principles and includes features designed to promote interdisciplinary curriculum focused on a cross-cutting theme, cultivation of a learning community, and interactions between graduate and undergraduate students, while using a cognitive apprenticeship approach (Collins, 2006).

The BBIL model was employed in the current study for designing a set of two technology-enhanced semester-long higher education courses (undergraduate and graduate levels) in which students studied similar interdisciplinary contents adapted to their level of expertise. The courses also shared a similar title - Learning In a Networked Society (LINKS) - and involved six knowledge domains each: learning sciences, science communication, health sciences, cognition sciences, media and communication, and information sciences. Both courses were taught simultaneously to enable interactions between students in the two courses (Figure 1).

We used "conjecture mapping" - a technique for representing conjectures in design-based research (Sandoval, 2014). Our high level conjecture, as described above, was embodied into design through a set of technology-enhanced features that employ the three pragmatic design principles. Our design conjecture was that these features would enable learners to participate in meaningful dialogue and be exposed to various ideas and ways of thinking, which will support the emergence of connections between ideas from different disciplines. We also expected that cognitive apprenticeship processes (modeling and coaching), embodied into the design, would promote deepening disciplinary ideas as well as developing interdisciplinary thinking. Our theoretical conjecture was that due to these mediating processes students will develop the ability to analyze a cross-cutting theme in a coherent and logical way using arguments that represent knowledge integration of ideas in different disciplines.

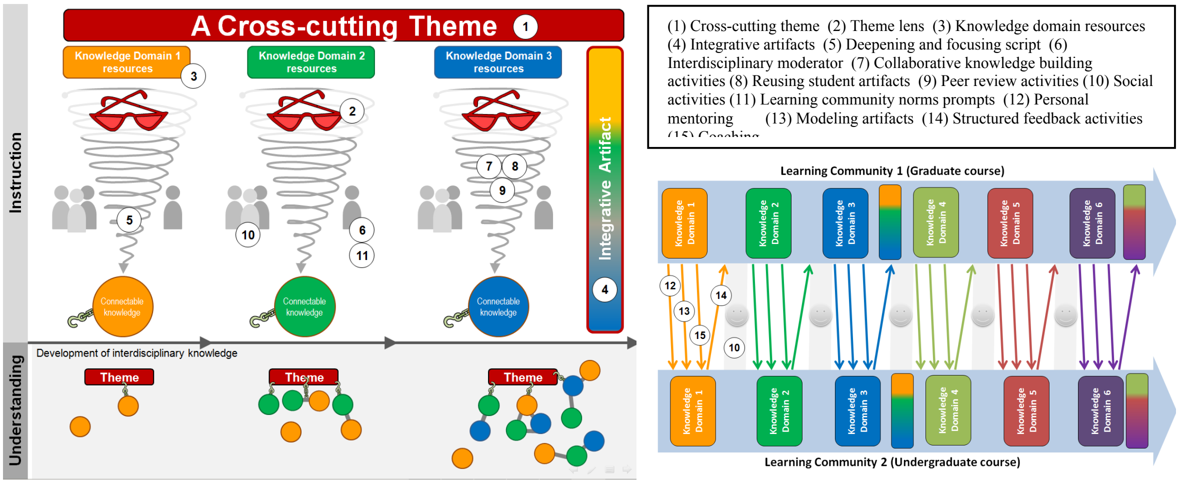

Figure 1. The BBIL model: the "within" (left) and "between" (right) learning communities features

To evaluate the development of interdisciplinary understanding, we analyzed assays written by 34 undergraduate students in the middle and at the end of the course. In these essays (up to 1000 words) students answered an open-ended question in which they were required to integrate ideas from three knowledge domains. Interdisciplinary understanding was evaluated through the lens of the KI framework (Linn & Eylon, 2011).

Findings conclusions and implications

The analysis and comparison between final and mid-term essays indicates that students who participated in the LINKS undergraduate course significantly improved their interdisciplinary understanding of the cross-cutting theme [$t(31)=2.96$, $p<.01$] between the assays that they wrote in the mid-course assignment ($M=67.2$, $SD=29.4$) and those they wrote in the final assignment ($M=82.5$, $SD=22.0$). Thus, this research illustrates how careful design, based on theoretically-based design principles, can lead to interdisciplinary understanding, despite the challenges in achieving such understanding, as described in the literature (e.g., Boix-Mansilla, 2010).

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Obstacles Supporting Expansive Learning

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Abstract: We discuss key findings inspired by concepts of expansive learning theory by illustrating results from empirical research on technology-mediated cross-border collaboration in an educational setting. The study reports from a three-year school development project and aims to examine what factors that influence expansive learning and how we can design for it.

Keywords: expansive learning, activity theory, cross-border collaboration, technology-mediated

Introduction

The digitalization of schools enables new forms of teaching and learning and demands major shifts in teachers' professional practice. Thus professional development needs to be redirected from refining established practice (Higgins et al. 2007) towards pervasively transforming practice (Mishra & Koehler, 2006). A transformed teaching practice requires comprehensive learning towards the notion of expansive learning (Engeström, 2001). In expansive learning the subject of learning is transformed from an individual to a collective or a network of activity systems. Engeström's (2001) concept of expansive learning belongs to the third generation of activity systems theory where two interacting activity systems and its interrelated elements: subject, object, tool, community, division of labour, and rules, is the minimal unit of analysis. An activity system may be an organisation, or a group of people working together in order to solve a task and eventually begin to question the existing order and logic of their activity. The aim of this study is to examine and understand which factors that influence teachers' expansive learning by studying a situation where different activity systems collaborate as part of the project design, thus results in expansive learning. We address the following research question: *How can we design for expansive learning in technology-mediated cross-border collaboration?*

Empirical case and analytical framework

We report from a school development project, where researchers and practitioners collaborated in an action-oriented approach to develop innovative cross-border teaching models between Scandinavian school systems. Since the project design rely on distance collaboration teachers were put in a new situation where traditional forms of teaching is not an option since using technology is a necessity to mediate the geographic distance. In addition, the teachers were speaking closely related, yet distinctive languages. Hence they were facing obstacles related to technological and linguistic difficulties due to the project design. During the project teachers were working in transnational teams, referred to as "class-match groups", consisted of teachers, their students, and researchers from the respective countries. Within the class-match groups cross-border didactical design were planned, implemented and evaluated in a virtual classroom. A didactical design refers to a pre-planned sequence of lessons with specified learning objectives. The investigation involved 22 mathematical teachers and 600 students from 9 middle and upper elementary schools. A variety of data such as; classroom observations, chat logs, video productions, video calls, shared images and documents on mutual accessible forums, interviews and content analysis of teachers' planning and reflection notes provides the basis for our analysis along with activity theory as an analytical framework.

In the empirical case, the class-match group can be seen as two local activity systems, each consisting of national teams of teachers, researchers, and students, together with their local classrooms, equipment, and school policies. These two local activity systems interact and collaborate with each other in a cross-border, technology-mediated context. Even though the national teams try to be aligned with the overall rules and division of labour defined by the Nordic virtual classroom as such, they still need to submit to the local national rules, division of labour and the tools defined by their local team or school organisation. Differences in conditions may cause tension between the teams.

During the analysis, our attention was drawn towards obstacles or difficulties of different kinds. We came to recognize obstacles as playing a crucial role in the project, since they continually arose, were tackled and overcome. It seemed that these contradictions originating from slight cultural differences, language barriers and differences regarding rules and tools constituted a key element in providing opportunities for expansive learning to occur. In the planning phase, conflicts originated for example from different teaching philosophies regarding levels of student governance or varying ambitions. In the implementation phase, difficulties arose for example when technology shut down and failed to support the collaboration resulting in a somewhat chaotic learning situation.

Evidence of expansive learning

We have identified two sources of evidence supporting that expansive learning did occur during the project both from an outer perspective (the researchers) and from an inner perspective (the teachers).

The first source of evidence is supported by an analysis regarding progression of didactical designs complexity and pedagogical value (Willermark & Pareto 2015). In this analysis we focus on the innovation process involving all teams and didactical designs, where we identified four distinct phases of the process. These phases cover all seven steps in the cycle of expansive learning, where 1) contradictions are identified, 2) analysis of the organizations' histories are made, 3) models are constructed, with new and improved procedures and 4), the new models are tested in the in the organization, and 5) are implemented in daily work. Finally 6) reflection on the process is carried out and 7) the new practice consolidated (Engeström 2001).

The first phase is characterized by a "*Practitioner-driven initial innovation*" where the researchers deliberately resisted from intervention in order to allow for innovation driven by the teachers. However, the teacher teams focused on how to organize the collaboration, rather than the learning content. This led to the primary contradiction (step 1), where the teachers started to question the value in conducting cross-border teaching. This led to the next phase "*Researcher-invention of a new boundary object*" in which the researchers tried to meet the growing doubt from the practitioners: Here the researchers worked on designing a tool to support the planning of new didactical designs, where the issue of didactical value is addressed from start. This phase corresponds to step 2 in the expansive learning cycle, where doubts in some members are reflected in more questioning and further investigations related to the overall objective. The third phase was characterized by a "*Researcher-supported collaborative innovation*" where practitioners explored new didactical designs with support of the new boundary object and the researchers as active participants in the design process. This phase corresponds to step 3-5 in the expansive learning cycle, where a new approach towards didactical design innovation is discovered, modeled, and implemented in the activity systems. The forth phase was characterized by a "*Practitioner-driven informed innovation*" where the practitioners have internalized and adopted the new thinking and approach from previous phases, as evident from their autonomous and confident acting through the planning, implementing and evaluating their final didactical designs. This phase corresponds to the last two steps in the cycle, the reflection on the entire process and consolidating the new practice.

The second source of evidence is the teachers' reflections. Teachers reported numerous examples of obstacles during the project e.g. how different teaching philosophies had to be negotiated between teachers from different countries, as illustrated by: "We *wanted different things*" or how the cross-boarder collaboration was hard to handle due to technological failure, as stated by: "*There were a lot of technology related difficulties*". However teachers also described how they gained knowledge about the teaching profession in general, but also how they developed subject-specific competences when collaboration with their Nordic colleagues, as illustrated by: *"We gain a lot as we tested each other's theories and thoughts*." Furthermore, they described how they both developed technology skills and practiced their general problem-solving ability.

Conclusions and implications

Obstacles could serve as catalysts for innovation and change, and consequently expansive learning, even though they often imply disturbances and conflicts. We argue that three types of obstacles, despite being sources of frustration and sometimes despair, were the main reasons for expansive learning to take place: 1) language difference, which became an obstacle as the mean of communication, but also made teachers reflect over conceptual meaning; 2) contextual difference, which became an obstacle as the frame of reference differed due to national or cultural variations and thus made teachers reflect on and re-evaluate their own practice; and 3) distance collaboration, which became an obstacle since technology sometimes failed, lagged or had inadequate sound, which resulted in teachers developing their communication skills by becoming very explicit, clear and concrete and by developing a flexible mind-set and innovative ways to cope with the situations.

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Investigating Recognition Systems in a Collaborative, Programming-Oriented Affinity Space

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Abstract: As part of a study of digital badges in online informal, interest-driven learning contexts, we investigated the relationships between discussions of credibility, trust, and the presence/absence of recognition systems in StackOverflow, a premiere programming oriented online space. Based on a content coding of 652 posts, we identified strong correlational relationships between certain badges and discussions of credibility/trust. Systems that recognize participation on the site (upvoting, downvoting, accepting answers) may provide consequential means for participants to transfer their social contributions into long-term resources for the community.

Keywords: affinity spaces; digital badges; computational thinking; informal learning

Introduction

The present rhetoric around the promise of digital badges to support learning has often skewed toward discussions of design: How do we design better digital systems that can capture evidence of learning, promote participation in online learning environments, and credentialize the skills and practices gained through these spaces? And yet, there is increasing interest in understanding the relationships between practices in informal online contexts for learning, especially learning as found within the online "affinity space" (Gee, 2005; Duncan & Hayes, 2012), or computer-mediated context within which *ad hoc* communities of interests form around practices and media artifacts. How do informal, online affinity spaces (Gee, 2005) embed relationships between recognition systems and social immersion?

Method and findings

Data was drawn from a larger study of online affinity spaces and digital badges, using content coding methods developed by Steinkuehler & Duncan (2009), further iterated to better capture information sharing practices (Gunawardena, Lowe, & Anderson, 1997; de Laat, 2002). Textual data was randomly sampled from the programming-oriented website StackOverflow during September, 2014. Data were "threads" (or unique discussions on the site), often including multiple "posts" (individual contributions) per thread, with sampling conducted at the level of "thread" in order to maintain intelligibility for qualitative coding purposes. 652 posts were sampled (by 344 unique posters), representing over 8% of the active threads from the previous two weeks. "Social interaction" codes were applied, addressing social banter, discussions of participation in online communities, offline communities, the discussion of credibility/trust, and the overt discussion of recognition systems. Four experienced programmers were trained as qualitative coders, reaching an interrater agreement of 93.29%. Raters independently rated each post in the context of each thread, assessing the presence/absence of each of the codes. Phi-coefficients were calculated between all pairwise combinations of codes to assess the co-occurrence of codes within the scheme. After initial coding was completed, data was reorganized by poster in order to isolate the relationships between codes and the presence/absence of badges. Due to space limitations, we focus our findings on the last of these analyses, addressing the ways that social interaction interrelated with the presence/absences of badges on StackOverflow.

Given the highly task-specific discussions on StackOverflow, we expected relatively low coding saturation for the social interaction codes. They were, in fact, uniformly low, with *Uncodable/Ambiguous* coded higher than any of social interaction codes other than *Social Banter* and *Online Participation*. Much of the communication within StackOverflow stayed tightly on task around computer programming, addressing solutions to posted bugs. *Credibility/Trust* was coded quite sparely (.92% of the entire data corpus), though recoding by *poster* captured individuals' activities with this code. In Table 1, below, we present six strong phi-coefficient results between *Credibility/Trust* and explicit badges on StackOverflow, all of which were highly significant ($p < .01$).

Table 1: Selected significant correlations between *Credibility/Trust* and StackOverflow badges (** p<.01)

Research Assistant = .707**	Synonymizer = .496**	Publicist = .707**	Beta = .496**	Booster = .345**	Marshal = .345**

Badges strongly correlated with *Credibility/Trust* included "Research Assistant" which indicated the editing of entries on StackOverflow's collaborative wiki resources, and "Publicist," which indicated a high number of unique IP addresses visiting a link that was shared by the individual. Though *Credibility/Trust* was not coded highly, it seemed that there was evidence that editing the *collaborative resources* of StackOverflow (the Wiki, shared questions) had some potential relationship to this code. However, it was unclear whether these relationships indicated discussion of the credibility and trust of digital badges or other factors within the discussions on the site. We chose to isolate all posts where *Credibility/Trust* as well as presence of *Recognition Systems* were coded to identify the specific moments in which *Credibility/Trust* and *Recognition Systems* co-occurred. This yielded *four* posts drawn from three threads, with one thread featuring an exchange between two posters regarding the nature of credibility that evolves from the use of recognition systems on the site.

> **Post 19-9:** "Glad to help. Actually, there are no requests for exceptions. An exception could only occur as a result of a request. If everything goes OK, then a response will be the result. Otherwise, the exception will be handled and logged... Anyway, *you should upvote the answer. It is very important for other users navigating to your question to be able to identify a useful answer…*"
>
> **Post 19-10:** "Sure I will *upvote when i find an answer which works for me*, thanks for your help." (Italicized emphasis added by researchers, not found in the original posts).

There is no discussion of badges here and, in fact, for all of the posts coded *Recognition Systems* that were drawn from the StackOverflow sample, *none* of them overtly discussed badges. Of course, other recognition systems may have been important, but it seems that the up-voting of responses on StackOverflow as well as the "accepting" of an upvoted response (validating a proposed solution as the one the original poster used) served a greater role in StackOverflow than originally suspected. Our assumption that recognition systems would be discussed with *Credibility/Trust* was partially confirmed, but in ways that were unexpected.

Conclusions and implications

While digital media and learning research has focused quite a bit on digital badges in recent years, our preliminary results indicate that instead of badges, more prosaic recognition systems (upvoting, the acceptance of answers) may be of greater use in supporting a collaborative learning environment on StackOverflow. There are clearly relationships between the presence/absence of some badges and discussions of Credibility/Trust, but upon deeper inspection, these do not appear to be consciously engaged with by site participants. Badges may be less salient to participants in the site that the post- and thread-level recognition systems, such as upvoting and the accepting of answers. It is intriguing that the recognition systems discussed with regards to *Credibility/Trust* were those that could transform a user contribution into a *resource* for others. By upvoting responses and accepting other posters' responses, users may translate contributions on the site into "answers" for future programming problems. While badges may capture depth of participation within the site's collaborative resources, simpler tools such as upvoting and acceptance of posts may be worth further investigation.

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Supporting Transition between Personal and Collective Activity through a Tablet-Based CSCL System

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Abstract: This paper describes the design of XingBoard, a tablet-based tool that supports a bi-directional transition between personal and collective activities in the learning process. For this purpose, this system provides a shared space for discussion comprised of multiple, connected tablet terminals and allows users to move post-it like idea cards from one terminal to another. In addition, the system can copy cards from a shared space (i.e., connected tablets) to each learner's tablet for personal work, which consists of reflection on or revision of the results of the group discussion.

Keywords: tablet terminals, personal-collective activity, transition, system development

Introduction

In collaborative learning, it is not common to put a personal activity after a collective activity. Usually, collective activity is considered as the last phase of the class activity through which different views are integrated and the summary of the class is produced. However, the authors believe having learners engage in a personal activity after a collective activity is effective for better learning. One reason is the effect of reflection (Moon 2004), the other is appropriation of learning contents (Voloshinov 1973).

Collective and distributed learning model

The authors propose the model of "Collective and distributed learning" by expanding Nussbaum's learning model (Nussbaum et al. 2009). Our model consists of "gathering," in which the ideas of various individuals are collected for discussion in a group, and "bringing back," in which each learner brings the results of the group work back to his/her own personal study to re-examine it individually. These two types of activities are repeated in a cycle. Figure 1 shows the model of collective and distributed learning.

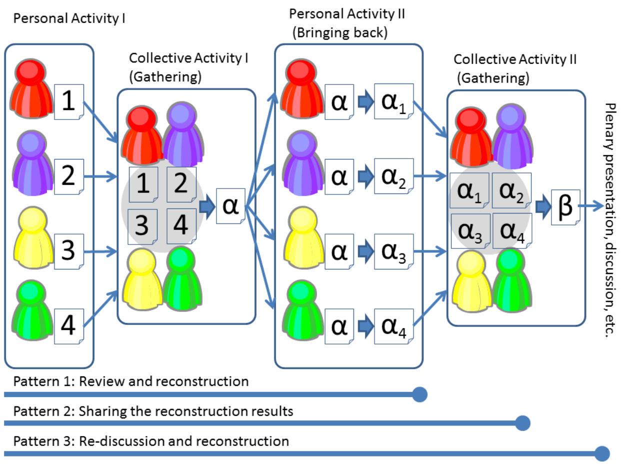
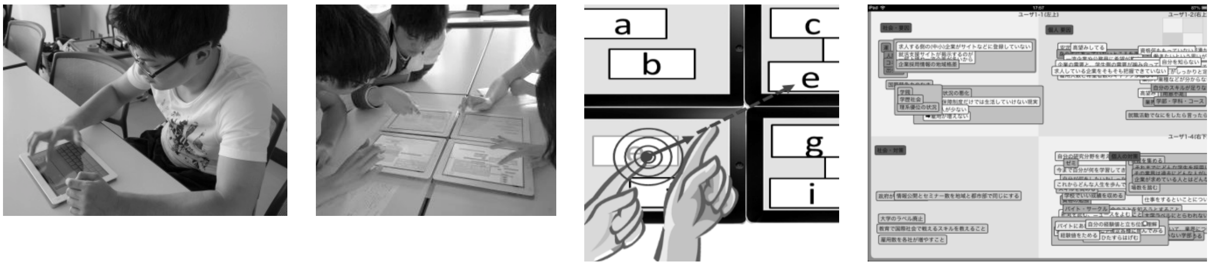


Figure 1. Collective and distributed learning model

The learning process begins with "personal activity I" (Fig. 1). Here, each learner develops his/her own idea individually but keeping in mind forthcoming group work. This gives learners a sense of accountability. In "collective activity I (gathering)", multiple viewpoints and values are compared and as a result developing new ideas is facilitated. In Personal activity II, they can re-examine the results of the gathering discussion by bringing back it into their individual context and language. If the learners meet again to share the results of their individual reflection in "Collective Activity II, they will consider the ideas from multiple viewpoints, thereby arriving at a deeper understanding of the theme.

XingBoard: A tablet-based system for collective and distributed learning

XingBoard (Crossing Board) is a system that uses cards, similar to sticky notes, to share ideas in order to support collective and distributed learning. This system is configured as a client-server type. The development environment for a tablet terminal on the client side is Mac OS 10.6 and Adobe Flash CS6.0. It is an AIR application; therefore, it is possible for the system to be published as an iOS application and an Android application. In the section below, the functions of the system are explained by following the learning flow.



(a) (b) (c) (d)

Figure 2. XingBoard system

Personal activity I

Each learner is given a tablet terminal to record ideas and results obtained from his/her individual work (Fig. 2(a)). The ideas can be written on a "card," which resembles a sticky note. The cards can then be organized or summarized.

Collective activity I

The learners discuss the results of their personal activity in a group by placing their tablet terminals side by side or end to end (Fig. 2(b)). They can create a summary of the group results by moving and editing cards. Learners can move a card from one terminal to another using sliding motion as shown in Figure 2(c). It is possible to move a card from one screen to another in a diagonal direction and even to move grouped cards. Using this function, learners can organize the cards on their own terminals and then integrate them with other group members' cards.

The results of this activity are to be recorded on a sheet of domain which is composed of four tablet terminals. "Copy distribution" is a function that copies the output of the group work onto each tablet terminal so the group members can examine it during their next personal activity. Figure 2(d) shows a screenshot after a copy distribution. Note that copy distribution is possible only when all four group members agree to it.

Personal activity II

Each learner reviews the results of the collective activity individually and can make additions or revisions based on his/her own understanding.

Conclusion

A model of collective and distributed learning and the design of XingBoard, a tablet-based tool that supports transition between collective and distributed learning were discussed. The preliminary evaluation showed that this tool is easy to use and aids the transition between the two activity types: the personal and collective. Evaluation in classroom setting is our further study.

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Bridging the Cultural and Pedagogical Gap with Seaweed

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Abstract: Students from John Abbott College and the Cégep de la Gaspésie formed collaborative teams to solve "real-life" problems within a laboratory environment although the two colleges were 950 kilometers apart. Teams of two members from each college used a Wiki to create a formal lab report using chat, forum, and Google Docs tools. Students reported favorable perceptions of the PBL laboratory exercises, especially the importance of acquiring skills in using online collaborative skills.

Keywords: Problem Based Learning, Case Study, Science Education, Distance Education

Introduction

Problem-based or Project-based Learning (PBL) is a student-centered pedagogical approach whereby students work in a collaborative manner to solve a specific problem Problem-based or Project-based Learning (PBL) is a student-centered pedagogical approach whereby students work in a collaborative manner to solve a specific problem. Unlike traditional instruction, PBL actively engages the student in constructing knowledge. This case study describes the implementation of PBL pedagogy, specific for laboratory implementation, across two colleges (one urban and the other rural) which were 950 km apart.

Problem-based Learning (PBL) had its start in the late 1960's at McMaster University (Neville, 2009) and was initiated in the medical faculty to increase student participation, motivation, deeper learning, and relevance to real-world situations. The PBL approach has been implemented in other disciplines, architecture, business, engineering, physics, etc. with much success (Woods, 2005). Since the mid 1990's, PBL activities been partially implemented in chemistry courses and laboratories (Laredo, 2013). Our goal was to implement and evaluate the effectiveness of an online PBL chemistry laboratory assignment across two very different colleges whereby students would have to use online collaborative tools.

Methods

Participants

Forty students participated in the PBL assignments; 14 from Cégep de la Gaspésie et des Îles-de-la-Madeleine (GIM), and 26 from John Abbott College (JAC). The colleges were located 950 km apart; John Abbott College is located near Montreal and Cégep de la Gaspésie et des Îles-de-la-Madeleine is located in a rural environment in the Gaspé.

Implementation

The PBL implementation consisted of a dedicated website designed to help students navigate the various tasks, access the required documents, deliver eLessons, facilitate communication among team members located across the two colleges, etc. The first scenario required students to determine the iron content of broccoli or spinach or in seaweed taken from the Gaspé seashore. The second scenario required students, supposedly working for Health Canada, to investigate the fraudulent production of antacids by pharmaceutical and naturopathic companies. Within the scenario description, students were presented with the objectives of the work, a list of available equipment and chemicals, as well as guidelines to the chemical analyses. Two types of groups were set up. Some groups (homogeneous) of four students consisted of students only from JAC. Other groups (heterogeneous) consisted of students from both JAC and GIM. Students were required to complete the following four components: eLessons, preparation of an experimental protocol, experimental verification, and a formal laboratory report.

Findings

Students were surveyed on their perceptions of their PBL experience. Students reported favorable perceptions of the PBL laboratory exercises, especially the importance of acquiring skills in using online collaborative tools, especially Google Docs. They also thought that these would become important in the workplace. Figure 1 shows the distribution of the scores for each college. The distribution of JAC Students' responses was positively skewed compared to those of the GIM students.

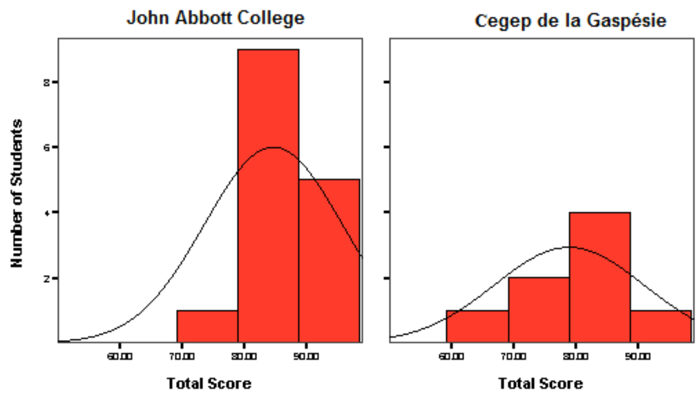

Figure 1. Distribution of student responses on their perceptions of PBL

There was a significant difference in the students' responses from the two colleges for four items. Students from GIM reported that the PBL exercises increased their motivation to do well in the lab significantly more ($F = 4.1$ $df = 1, 37$ $p = .05$) than did students from JAC (mean score of 4.2 and 3.6 for GIM and JAC students, respectively). Significantly ($F = 4.1$ $df = 1, 37$ $p = .05$), students from GIM agreed to a higher degree with the statement that the PBL exercises increased their ability to learn in other courses (mean score = 3.0) than did JAC students (mean score = 2.3) . Students from GIM reported that they liked the idea of using Google Docs significantly more ($F = 5.3$ $df = 1, 37$ $p = .03$) than did students from JAC (mean score of 4.5 and 3.5 for GIM and JAC students, respectively). Lastly, students from GIM reported that they thought video-chatting tools such as Skype, Google HangOut, FaceBook, etc. or others, facilitated communication significantly more ($F = 7.8$ $df = 1, 37$ $p = .01$) than did students from JAC (mean score of 3.8 and 2.7 for GIM and JAC students, respectively)

Conclusions and implications

All student groups reported favorable perceptions of the PBL experience but did admit that this type of laboratory experience involved more "work" than a traditional laboratory experience. Nonetheless, students appreciated learning about authentic problems and developing online skills and tools that may be transferable to other courses and experiences. They also appreciated the need to gain expertise in the collaborative tools suitable to the workplace in the 21st century.

JAC and GIM students in heterogeneous groups did significantly better on the first PBL assignment than did the JAC students in homogeneous groups. For JAC heterogeneous groups, this was not surprising as the relatively stronger academically GIM students mentored the JAC students. Surprisingly, although the JAC heterogeneous group outperformed the JAC homogeneous group in the second PBL as expected, the GIM group performed more poorly. This decrease in performance was primarily due to the late timing of this PBL, higher teacher expectations, and possible student disillusionment that their JAC counterparts were so weak academically.

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Lernanto:
An Ambient Display to Support Differentiated Instruction

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Abstract: This paper presents Lernanto, an ambient display designed for secondary school classrooms, aimed at supporting teachers in challenging each student at his or her own level, i.e. differentiated instruction. Lernanto displays real-time information about the progress of each individual student such that teachers can perceive it at a glance during their lessons.

Keywords: peripheral interaction, ambient display, classroom technology, classroom orchestration

Introduction

Today's classrooms are characterizing by a growing diversity among students. Classes tend to increase in number of students, while at the same time there is an increasing social emphasis on and appreciation for excellence. Teachers are therefore encouraged to challenge each student at his or her own level, i.e. differentiated instruction (Ysseldyke and Tardrew 2007). Addressing this trend, adaptive educational software that adjusts its learning material to the individual student is being introduced in various schools. When using such software, students are thus working on different exercises depending on their level. This raises new challenges for teachers (Ysseldyke and Tardrew 2007): they have to divide their sparse time and attention without having a clear overview of the current progress of each individual student. Particularly in secondary schools, where teachers provide lessons to multiple different classes and thus to up to hundreds of students, it is difficult to be aware of individual levels and needs.

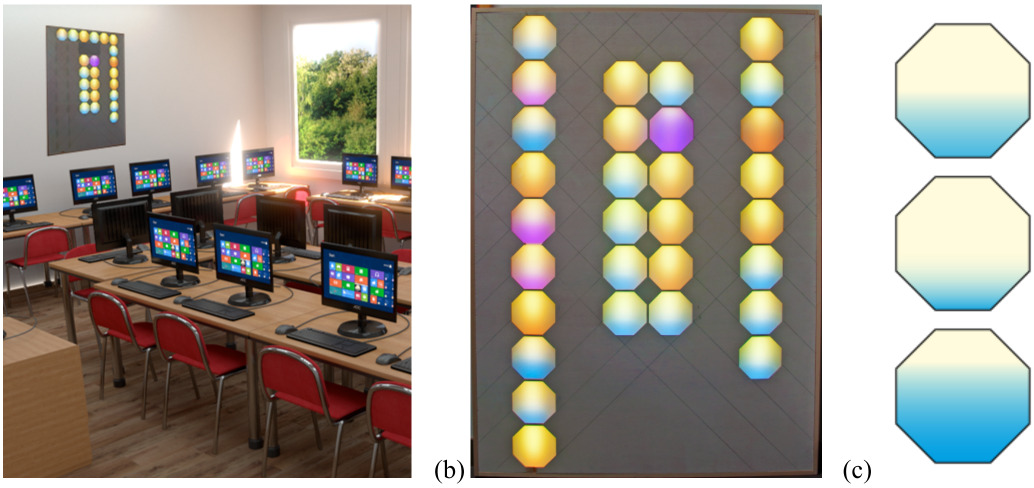
Lernanto aims to support teachers in providing differentiated instruction and structuring teamwork by leveraging data from (adaptive) educational software. This paper presents Lernanto's design and discusses the evaluation setup of an in-progress field study.

Related work

Most (adaptive) educational software includes a "dashboard" (e.g. www.knowre.com), which displays the real-time performance of each individual student by means of graphs or tables on the teacher's computer. To access this information, teachers thus need to focus their attention toward the screen during lessons, rather than towards their students, which may reduce the time available for instructions. However, real-time progress information can majorly support the teacher in providing differentiated instruction: it allows them to spend more time on individual instructions and enables them to better meet the individual student's needs (Ysseldyke and Tardrew 2007). An alternative approach to access such information involves *peripheral interaction* (Bakker et al., 2013) or *ambient displays* (Hazlewood et al., 2011); presenting useful information in a subtle manner such that it can be perceived with minimum attention. FireFlies (Bakker et al., 2013), for example, displays information such as division of turns, on primary school children's desks through light, which teachers can perceive at a glance. Lantern (Alavi et al., 2009) is a light object on students' desks that presents information about the current exercise they are working on. Lernanto adds to this existing work by using an ambient display to flexibly display real-time information to teachers during lessons in the context of differentiated instruction. Different from the mentioned related designs, Lernanto is located on the classroom wall rather than on the students' desk. As a result, the presented information is readily available to the teacher, while distractions for students are minimized. However, the information is still visible to students. The effects of this on the student's experience are not known from related work; we intend to evaluate this when deploying Lernanto in a school.

Lernanto's design and evaluation setup

Lernanto is a display at the back-wall of a secondary school classroom (see Figure 1a) consisting of several octagon shapes that can emit colored light, each representing one student. The aim of Lernanto is to subtly display information about the real-time progress of each individual student, supporting teachers in gaining quick insight in which student might deserve their attention. This insight is expected to relieve the teacher's cognitive load, as the need to remember this information is taken away. Indicators chosen to represent the progress of students are the assignment or domain a student is working on (indicated by color) and the pace of work (indicated by the 'fill' of the octagon, see Figure 1c). The pace of each student differs depending on his or her level. Pace is therefore presented on a personal scale, relative to the individual expected level, which is determined by earlier achievements. When a student is performing as can be expected, the octagon is equally filled, while unequal fill indicates performance slower or faster than expected, see Figure 1c.



(a) (b) (c)

Figure 1. (a) Illustration of Lernanto situated in a (hypothetical) classroom (image source: blenderartists.org); (b) the prototype version of Lernanto; and (c) the pace indication for individual students: at expected pace (top), below (middle) and above (bottom) expected pace.

To make sure the teacher can quickly and easily interpret which student is represented by which octagon, Lernanto's 2 dimensional space is mapped to the physical location of students in the room. To evaluate Lernanto's usefulness as a support tool for teachers, we have developed a working prototype (see Figure 1b). We are currently running a field study with Lernanto. The prototype uses data from an adaptive educational software system (www.got-it.nl), which is being used during an arithmetic course. At the start of this course the students take a test to determine their level concerning arithmetic skills. During the field-study, the results of this test are used to determine the expected pace for each individual student. The software provides assignments fitting the needs of each individual student in one of four different domains within arithmetic (e.g. numbers, geometry), which are represented by four different colors in the prototype. Lernanto thus provides the teacher with real-time information about both the domain of the current exercise and the current pace of each individual student.

Conclusions

This paper presents the design of Lernanto, an ambient display to support differentiated instruction and teamwork. Lernanto presents real-time information about the progress of individual students and the subject they are working on, designed to be perceivable at a glance. This information is intended to help teachers in identifying, at any moment during the lesson, which students might need or deserve their attention. It also intends to help teachers to group students working on the same subject for instruction or teamwork. Thereby, this paper contributes an alternative approach to provide teachers with real-time information during lessons, which is to blend into the environment such that part of the teacher's cognitive load is relieved.

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Digital Materiality as the Fabric for Socio-Temporal Organizing of Learning: A Case Study of Open Source Software Development

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Abstract: The proliferation of digital materiality – through services, devices, and content – is re-organizing learning across socio-temporal scales allowing learners to follow a personalized learning trajectory. Through a case study of two open source software (OSS) participants I illustrate how digital materiality provided a socio-technical infrastructure that allowed them to participate in a meaningful activity, enhance their personal and professional skills, and engage in lifelong learning, starting in high school and continuing through their professional career.

Keywords: digital materiality, socio-technical infrastructure, learning across scales, OSS

Introduction

Digital materiality underlies almost all aspects of CSCL – devices, data, and interactions. This confluence of devices, content, and access has resulted in a new 'materiality of learning' (Sorensen, 2009) and a new empirical focus on understanding it. These changes are evident not only in 'designed' learning environments but in opportunities available across life-wide activities (Barron, 2010). These new configurations are critical elements of the learning ecosystem that we design and expect learners to traverse (Lemke, 2000). Overall, they signal a shift from formal institutions organized for efficiency in the delivery of instruction (Callahan, 1964) towards a more self-regulated learning environment for learners.

In this paper I use one such loosely-networked but organized activity, open source software (OSS) development, as an exemplar for better understanding the changes brought by digital materiality. By breaking down traditional boundaries between school and work, by creating virtual apprenticeship infrastructures, and by integrating learning and working within professional practice, OSS development showcases the future of what learning might look like across a range of professions in the future (Johri & Teo, 2012).

Case studies

To empirically examine socio-temporal aspects of learning, I present case studies of two open source software developers: Roberto and Bruno. They started contributing to open source projects when they were in high school and built a reputation among other contributors. This helped them land an internship while they were still in their undergraduate programs. Subsequently, they joined the firm full time while still completing their degree.

Case 1: Roberto

Roberto was originally from Spain and had moved to Ireland when he started his internship. Roberto was hired as an intern largely because of his open source experience and to help the firm with an open source project. He stated that by active participation he meant "people know me and they know what I've contributed." He started out as a lurker and slowly moved to a helping position, improving his English all the while. Roberto talked about the importance of visibility. He had started working on open source software when he was fifteen years old, in high school, and had been contributing in some capacity for the past 9 years. When he started working on open source software he first starting by reading software code and messages on discussion forums associated with the OSS. He said that he realized that it was important to make a visible contribution to the OSS and bring something new to the community. He started making small contributions and then blogging about it and posting it on mailing lists. Slowly he started to get credit for his work and became recognized with the community. He learned to work across time zone using virtual technologies. He collaborated with developers across the globe including France, UK, US, Germany, and Canada. Over a 15 year period, he had worked in four countries, four companies, multiple open source projects in addition to these formal positions, and developed skills both technical and professional.

Case 2: Bruno

Bruno started out in open source by working on the Gnome project and then became a regular contributor to Ubuntu. Bruno studied in an American school in Spain and then spent his sophomore year of High School in Denver, Colorado, USA. He was from a small town in Spain and after starting at a local university he moved to Madrid after his first years. He was still finishing his classes. He had been working on open source projects for the past five years. He got started by reading documentation about the project and the examples and codes. Once he made a contribution if he ran into trouble he posted on the list and got a lot of help. He started looking at Debian packing when he started out and after three years he became an official Ubuntu developer. He had significant experience with packaging, integrating, and porting software and liked working on multimedia related applications. When he found out that there was a new project in Ubuntu looking for multimedia integration he started making contributions; subsequently, the project leader stepped down due to other commitments and Bruno took over the project leadership. He had learned that making a useful contribution to OSS was hard and has noticed that many people get started but cannot stick round for long. He found this analogous to playing the guitar – the cost of participation is low but very few people stick around; people have to be self-motivated and learn the basics, such as reading music, well before making any meaningful contribution. He said that he had learned how communities work and how one can participate in them and he was using his knowledge to support newcomers to the community.

Discussion

Learning is as much a material activity as it is socio-cognitive (Sorensen, 2009). Through the case study of two youths participating in open source software communities, in this paper want to draw attention to the significant shift brought on by digital materiality. These case studies illustrate how different affordances of digital materiality are leveraged across the OSS ecosystem, particularly from a learning and knowledge perspective. Even though software does not have properties we commonly associate with physical materials, it has properties akin to a material such as the ability to respond to our interaction with it, prevent us from taking action (some might argue it has *agency*), and facilitating or preventing us from engaging in everyday practices. Many researchers who have examined software argue that it can be described in terms of its materiality (Leonardi, 2007). Yoo et al. (2010, 2012) alert us to other ways in which digital materiality impacts us. As digital capabilities are increasingly embedded in physical artifacts these artifacts acquire new properties including programmability, addressability, and traceability (Yoo, et al. 2010), increasing the inseparability of artifacts' digital materialization from social and physical interactions. The effect of digital capabilities (Yoo, 2010) is at the core of OSS. It allowed contributors to create new software, extend existing solutions, blog about it, post if on mailing list, thereby creating a reputation for themselves. It is easy to see how the affordances of digits to allow programming and software development are critical for OSS. But we can also see other ways in which materiality played a part. The practical instantiation of materiality in terms of policies and norms is central to organizing within OSS. It can also been seen as material in the way of the environment of OSS – from tools for bug tracking to repositories of code. These are not physical material but have material implications nonetheless. Finally, findings from this study also illustrate the central role of tasks in organizing the division of labor and power structure within the community and its importance for learning. In open source software projects power relationships emerge through expertise of team members and not their seniority in terms of tenure. In a typical classroom, a teacher is the central character and holds both power and expertise and the responsibility for knowledge sharing and learning. Invariably, the teacher is also older than the students. We observed in the open source projects that often teenagers were the leaders of modules and other contributors were senior in terms of age but not in terms of experience and expertise.

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Collaboration in the Age of Personalised Mass(ive) Education

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Abstract: In this poster we explore a number of issues we believe challenge some current notions of collaboration. We explore tensions arising from the increased interest in personalised open learning, and how this challenges, but also offers new ways of conceptualising collaboration towards group-organisations that are more nomadic entanglements of shifting participation.

Keywords: pedagogy, collaborative learning, nomadic entanglements, individualisation

Introduction

In this poster we explore what we see as challenges to the notion of collaboration as it has often been conceived within CSCL, and more generally within some strands of online open learning. The notion of collaboration we refer to is that which has focused primarily on closely-tied types of collaboration (Stahl et al. 2006a), .We believe that there are two main challenges to such notions of collaborative learning. The first stems from the rising interest in personalized learning and the notion of the self-directed, self-programmed autonomous student. This can be seen as a wider educational and political challenge to collaborative pedagogies. Secondly, we find that there might be a need to conceptualise collaborative learning from a perspective where collaboration in small-groups or teams is transitioning from that of a stable or familial group to one of changing or nomadic groups.

The structure and characteristics of groups in today's digital world

Stahl et al. (2006b) suggested that CSCL requires a focus on the meaning-making practices of collaborating groups and on the design of technological artifacts to mediate interaction, rather than a focus on individual learning. Further Stahl et al. (2014) point out the dialogical perspective provides an important theoretical framework for CSCL However as they also remind us measuring the effectiveness of dialogue or collaboration, even in small collaborative groups, is not a straightforward affair and efforts to support dialogic collaboration remains an on-going challenge in CSCL. We believe the rising interest in personalized learning and the notion of the self-directed, self-programmed autonomous student can be seen as an even wider educational and political challenge to CSCL research and collaborative pedagogies.

The present day online learning landscape is providing learners with a myriad of different and contradictory material conditions and learning spaces that offer a potentially confusing array of opportunities, challenges and issues that sits between a broadcast and discussion view of online learning. What Weller (2007) terms the broadcast view of open learning could be described as that which includes a focus on personalized and individualised learning, self-paced materials (learning objects, OERs), flexible learning, learning on demand and student as consumer or a self-programmed learner; an approach that offers wide, flexible access to materials and/or self-paced activities. This, in a positive reading, as a means of providing access to education for the widest possible group of people, but in a more critical reading can also be associated with austerity politics and as a means to reduce costs or privatise education (Jones, 2014). In contrast, what Weller terms the discussion view is about collaboration, dialogue and critical inquiry with peers and with tutors, in supportive and facilitated online environments or learning spaces. There is a greater expectation of interdependence, co-learning and social sharing of the responsibility for learning.

The recent emergence of personalized or individualized learning, where the individual is not 'held back' by collaboration, but can roam freely around in the open education market raises we believe some interesting issues.. While this particular notion of open learning is not new, MOOCs, obviously, have pushed these concerns to the foreground. Where the student is more likely to be viewed as consumer or self-programmed learner; choosing to take MOOCs or join a P2PU (Peer to Peer University) course or other online communities. The format oriented towards providing wide, flexible access to materials and/or self-paced activities as a way of providing access to education for the widest possible group of people. Arguably, fulfilling some of the aspirations of Illich's (1971) vision of Deschooling Society but not others! Illich's vision was towards learning webs that democratized knowledge and the co-education of society in ways that retained the importance and relevance of dialogue and critical inquiry. His was not a vision of simply making educational artefacts and resources more freely available between people to satisfy their personal learning and individualized interests or objectives. In addition, as Ponti (2013) comments in her discussion of P2PU, while the ever-growing body of resources provides opportunities for learners to access and increase their knowledge, this provision can also be overwhelming, particularly for the inexperienced learner entering a new area, knowledge community or domain for the first time. Interestingly, what has come to be known as cMOOCs are often foregrounded as building on more social and interactional premises than the later xMOOCs. However, connectivist principles as explored by Anderson & Dron (2010) stress autonomy and the importance of personalised networks over more strongly-tied groups and collaboration (Ryberg, Buus, & Georgsen, 2012). Plus often suffer from inexperienced learners finding the online format chaotic and overwhelming.

Novel and emerging forms of collaboration

On the other hand, it has been argued that the networked and weakly tied organization of learning groups or personal networks can be a powerful means of learning that offers serendipity, autonomy, flexibility, independence, ephemerality, and spontaneity (Anderson & Dron, 2010). Further, that these are dynamics that we might overlook if focusing too much on the strongly-tied collaboration within groups, rather than exploring how these might benefit from the weakly-tied traversing of personal learning networks (Jones at al., 2006, Ryberg et al., 2012). Engeström (2008) suggests that learning and collaboration in work teams, more broadly, are under transformation, as they are becoming less stable entities that are characterised instead by fluctuating membership, shifting foci and tasks – what he terms knotworking. We could equally view it as 'nomadic entanglements' where project work, group work or work teams are not fixed entities, but rather knots connecting lines, traces or paths, and coming together in certain places over time to accomplish common tasks and then disperse again. As such we might be seeing the contours of small-group work changing, where there are continuous shifts in membership, but also in the intensity of the work e.g. with periods of intense collaboration and inwards orientation, but also periods of dispersion and outwards movements. Thus we could speak of pulsations between collaboration and more loosely-tied organisations of the work, however, with fierce interdependence becoming a necessary condition to complete the work and to gain new knowledge and learning.

We are wondering whether these pulsations and transitions between different collaborative orchestrations have to date received too little attention from the perspective of the issues identified and explored in the CSCL community and similar areas of research. For example are we paying sufficient attention to the dynamics or influences upon these nomadic entanglements and temporary "coming together" to learn and create new knowledge? Do we know and understand if this changes our current understanding and ideas about collaborative group work?

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Maps, Mobile Tools, and Media Boards: Digital Technologies for Learning About Pawnshops

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Abstract: This paper describes how a suite of digital technologies can support the potential of a critical, place-based perspective in mathematics. The poster focuses on a curriculum that uses technologies to investigate pawnshops, with an emphasis on mathematical understanding, spatial/quantitative, subject/cultural, and social justice dimensions. The technologies include interactive digital maps, mobile data collection, and synthesis tools. The poster describes the role of these technologies, as well as affordances and challenges.

Keywords: mathematics education, instructional technology, social justice

Introduction

Critical pedagogy of place (CPoP, Gruenewald, 2003) in mathematics integrates themes of critical mathematics education (c.f., Gutstein, 2005) with perspectives of space/place (Tuan, 1997). Mathematics can be used to question, elucidate, and communicate issues of social justice, and such explorations can be considered in geo- or socio-spatial terms. Essential characteristics of urban spaces – their density and traversability – make them especially conducive for CPoP. This research explores the role of technologies in leveraging the potential of CPoP in mathematics, with a specific focus on high schools in underserved, urban neighborhoods in the United States.

By encompassing data literacy, quantitative reasoning, and modeling, secondary mathematics is a natural disciplinary fit for analyzing "discriminatory geographies," or spatial justice (Soja, 2010). Digital technologies like mobile devices (c.f., Trouche & Drijvers, 2010) or global positioning with mapping software that can readily represent geospatial data (c.f., Enyedy & Mukhopadhyay, 2007) open up possibilities in terms of how critical-spatial themes can be engaged with mathematics. In contrast with the way that technology can be assumed to be a "quick fix" for urban schools (Philip & Garcia, 2013), in this project, we explore and make explicit the affordances and challenges presented by technologies. This poster addresses the research question, what role can digital technologies play to support learning in a CPoP curriculum?

Background

The City Digits project develops and studies innovative resources for high school students' learning of mathematics with a CPoP perspective and is comprised of iterative cycles of design, testing, and revision, in collaboration with teachers. Findings from implementation lead to new insights and questions, and this fuels additional iterations of the design-based research cycle. This poster describes findings from the second iteration of the cycle with the project's second module, *Cash City*.

Four dimensions of a phenomenon guide the development of CPoP curriculum and technologies. The first is that mathematics is essential for understanding the phenomenon (how does it work?). Second, the phenomenon must have a spatial (where does it occur?), quantitative dimension (how much/ how often?). Third, the phenomenon must also include subject and cultural dimensions (who is involved and how do they participate?). Finally, the fourth dimension is that there must be potential to explore sociopolitical and social justice ramifications (who is impacted, who makes the decisions, and is it fair?). A project goal is to provide students the opportunity to connect understanding the mathematics of a phenomenon, in socio-spatial context, to questions about social justice that might carry personal significance. The project has developed analog supports to pursue the conceptual understanding of mathematics and in collaboration with MIT's Civic Data Design Lab, created custom digital tools to support the spatial/quantitative (digital maps), subject/cultural (mobile tools to support field research), and social justice dimensions (synthesis tools).

Findings and challenges

Spatial/quantitative patterns of New York City demographics were shown on a series of zoomable, digital maps, shaded according to data by neighborhood, with overlays of geolocated markers for banks and alternative financial institutions (AFIs). A "Create a Map" feature allowed students to color the map according to the strength of a ratio between two selected variables. For example, students could select the ratio of banks per AFIs, a ratio that is a relative comparison of the frequency of one institution to another. The digital maps provided a platform for students to explore patterns in data about neighborhoods and financial institutions in a visual, accessible way. A key finding was that spatial representations, even of their own city, were unfamiliar to students, which limited the full power of the maps to help them make connections to place, especially at the neighborhood or city scale.

To investigate the subject/cultural dimension, students conducted field research supported by mobile technologies to explore the location and distribution of financial services in their school neighborhood. The mobile tools enabled students to take photographs, conduct and gather audio interviews, and record data. The GPS functionality of the tools geo-located and published this media on an aggregated, digital map, challenged by wifi-connectivity and operating system compatibility issues on mobile devices. Students took ownership of collecting data, and showed enthusiasm for the field research component and associated technology. Many pawnshop employees were amenable to students' visits and open to answering questions about their business. Banks were less welcoming to students and presented corporate policies against photography. Students' experiences around these two kinds of institutions possibly reinforced the notion of banks as unwelcoming to low-income people, especially in contrast to AFIs.

Students used synthesis tools to generate opinions around the distribution of financial services based on the class sessions and the field research. Students were asked to select and organize media from their field research framed by their understandings about spatial patterns in the digital maps to create a blended media opinion. The goal of the opinion product was for students to communicate, in web-published form, their perspectives about social justice of the local, spatial distribution of financial institutions. The potential of student formulation of a data-enriched opinion about the local distribution of financial services was not fully realized in the short span of this curriculum; students struggled to author opinion statements and justify opinions within the available digital artifact.

Conclusions and implications

Digital technologies are promising for mediating between students' mathematical understandings, out of school experiences, and critical thinking about a locally relevant phenomenon. The *Cash City* digital tools enabled students to investigate an issue at multiple levels of scale, from local streetscapes to neighborhood comparisons to trends across the larger city, but greater attention is needed toward supporting students' spatial literacy, especially at the macro levels of scale. Further exploration of integrating a place-based perspective with critical mathematics might benefit from beginning with the micro or street level of scale and extending outward.

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Knowledge Community and Inquiry about Big Data among High School Students with Interactive Orchestrated Learning Space

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Abstract: In this study students engage in learning about Big Data in a Knowledge Community and Inquiry curriculum. Using a design based approach, a three week statistics unit was developed to allow students in a 12th grade mathematics course to explore advanced concepts in Big Data, using interdisciplinary themes. Learning trajectories were guided by an Interactive Orchestrated Learning Space (IOLS), inspired by recent smart classroom and knowledge community approaches (Slotta, 2010; Slotta, Tissenbaum & Lui, 2013).

Introduction

Current developments in data science offer new opportunities for Mathematics, Science and Social Sciences – disciplines that commonly use statistics to analyse data and interpret experimental results. For example, tools for global watch and collection of data through social networks illustrate the growth of data-driven decision-making and the increased awareness for ideas about big data (Agrawal et al., 2012). Yet any applications of big data in statistics education are still in their early stages, typically occur in tertiary education, and almost never at the high school level. Nonetheless, there is growing awareness of the need for students' basic literacy with such data, and the corresponding need to develop frameworks to guide their learning (Philip, Schuler-Brown & Way, 2013). This paper presents our efforts to further the discussion about the role of big data in 21st century learning applications. While it is an evolving area, Beyer & Laney (2012) characterize "big data" according to the four V's: Volume, Velocity, Variety and Veracity (i.e., level of uncertainty of data). Our study incorporates those aspects of big data, adding a perspective of application or usage, to reveal the incredible potential to advance human knowledge while also raising some moral considerations. As high school students could find the analysis of "real" big data to be challenging, we provided various technological scaffolds that served to represent data through visualizations and analytic tools, focusing on the use of mid-size data and illustrative movies.

Our curriculum emphasized knowledge building and design, using a theoretical framework of Knowledge Community and Inquiry (KCI – see Slotta & Najafi, 2013), with three interrelated phases: (1) establishing a community identity; (2) developing shared knowledge through collaborative inquiry; and (3) advancing and interconnecting shared knowledge through further inquiry. Students' inquiry products must also allow for assessment of learning in the targeted domain. We employed a technology-enhanced learning environment to orchestrate students' collaborative and collective activities in the physical classroom space (Slotta, 2010; Slotta, Tissenbaum & Lui, 2013). Following Stahl's insight that CSCL designs should support group meaning making through activities that cross social planes (Stahl, Koschmann & Suthers, 2006), we designed an interactional space to support small group and whole class knowledge building where students can observe one others' reasoning (Coopey, Danahy & Schneider, 2013).

Methods

Our study addresses the topic of how high school students reason about big data concepts and the role played by Interactive Orchestrated Learning Space (IOLS). The research employs a design-based methodology (Brown, 1992), aiming both to develop theoretical aspects of learning about big data and design principles for of learning environments (Design-Based Research Collective, 2003). We ask what types of activities and forms of collaborative knowledge construction are suitable to support KCI curriculum in topics of big data for high school students, and how to support teachers in an orchestrated interactive learning environment, using generic technological platforms. The IOLS approach strives to take into account the classroom as a physical space (Slotta, 2010) as well as a learning community by Community of Learners (Brown & Campione, 1994). We developed a technology infrastructure aimed to tap into the connectivity of the internet and big data resources, using generic collaborative platforms (e.g., Google Docs) for communication and knowledge building that capitalize on the use of intelligent agents, with limited applications of data mining and learning analytics.

Our curriculum focused on reasoning about big data and covariation, consisting of five activities over three weeks, moving between students' *investigations of* mid-size data of a global scale (e.g. Gapminder) to *learning about* big data. Here, we focus on the second activity, which spanned four disciplinary contexts, blending the spatial and interactive aspects of a large classroom space to promote collaboration. The IOLS

(Figure 1) included one Smart board 14 student laptops and eight large (i.e., projected) displays where small groups were orchestrated through a visible 'shared construction of meaning' (Stahl et al. 2006). Students progressed through four distinct interdisciplinary stations: Health, Social networks, Ecology and Surveillance & privacy, interacting with the content using laptops, discussing and taking notes in Google forms, embedded in the unit website.

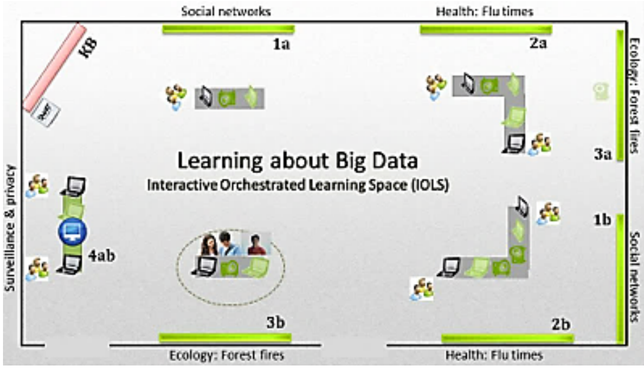

Figure 1. Interactive orchestrated learning space (Activity 2)

Results

This paper reports our approach to introducing big data concepts to high school students, within an Interactive Orchestrated learning Space (IOLS), as guided by the KCI model. The IOLS scaffolded students to add knowledge and engage in media-enhanced activities that crossed digital, physical and social planes, revealing social and ecological applications and ethical considerations. The Smart board showed the accumulating knowledge base from all stations, allowing students to rely on peers' contributions, according to KCI. Our poster will present students' pre-post gains in understanding, as well as the curriculum itself. .

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Peer Feedback Content Quality:
The Added Value of Structuring Peer Assessment

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Abstract: The present studies examined the added value of structuring the peer assessment (PA) process for the peer feedback (PFB) content quality in a wiki-based computer-supported collaborative learning (CSCL) environment in higher education, by firstly investigating a varying structuring degree in the peer feedback template (study 1) and secondly, by further structuring the role of both the assessor and assessee in the PFB process (study 2). Results of the first study revealed that structuring the PA process could be advantageous for the peer feedback content quality, while the results for study 2 are underway. The main aim of this poster presentation is to illustrate the impact of instructional interventions in which we further specify the role of the assessor and/or assessee, in order to enhance the content quality of peer feedback messages.

Introduction

Being a common method of formative assessment and an example of a more complex learning task, which requires high-level cognitive processing, PA is a process in which students assess a peer's performance, which results in numerous cognitive rewards for the assessee as well as the assessor (Topping, 1998). PFB can be seen as a constructive technique for enhancing students' learning, such as enhancing the quality of the students' writing. As the power of peer feedback heavily depends on its content (Cho & MacArthur, 2010), it is important to reflect on what exactly defines peer feedback content quality. A growing body of research suggests that the content of effective feedback should provide for example two types of information: verification and elaboration (Narciss, 2008). Recently, research emphasizes on the need for structure and support to ensure effective feedback (Poverjuc, Brook, & Wray, 2012). As high-level PA processes hardly happen spontaneously, previous literature recommends the use of collaboration scripts, as they focus on socio-cognitive structuring (Kollar, Fischer, & Hesse, 2006). However, finding the accurate level of scripting appears to be difficult (Dillenbourg, Järvelä, & Fischer, 2009). The instructor could structure the PA process by providing more detailed instructions on expected performance (Kollar, Fischer, & Slotta, 2007), e.g. by providing guiding questions to support the assessor while providing peer feedback. One remaining question, however, is how detailed the script should be and what level of structuring is the most appropriate. In the context of the present studies, we especially want to investigate to what degree the role of the assessor and assessee in the PA process should be structured to have an impact on the quality of the peer feedback content.

Methods

Quasi-experimental research was conducted, in which first year university students, enrolled in an educational sciences program (N=168 and N=125, for the first and second study respectively) were divided into groups (respectively N=37 and N=27) of five. For the two studies, each group member was asked to write three abstracts based on provided articles on the wiki. For each student, one fixed group member was assigned the role of assessor and had to provide PFB on this draft version in the next phase. Based on the feedback, students revised the draft version and constructed the final version of the abstract. At the same time, assessees wrote an evaluation of PFB they received. In the first study, all students received a varying degree of structure in their particular PFB template with a list of criteria, resulting in a no structure condition, basic structure and elaborate structure condition. In study 2, the assessee in the request condition had to formulate on which particular aspects they require PFB. In the content checklist condition, the assessor had to complete a checklist with relevant article content, which served as an input source for formulating PFB on the draft. This study applied a 2 x 2 factorial design, which resulted in four conditions namely a control, a request, a content checklist and a combination condition. All conditions used the same structured PFB template. As an overarching ready-to-use content analysis scheme fitting our needs did not exist, both studies employ a developed coding scheme (as presented at the CSCL 2013 conference in Madison), which attempts to identify variations in the peer feedback content quality, by concentrating on the peer feedback style, type, and focus. Therefore, the first study attempts to find an answer on the effect of a varying structuring degree in the PFB template on the quality of the PFB content. In the second study, all students use an identical structured PFB template, but the role of both assessee and assessor in the PFB process is additionally structured. For this reason, the following hypotheses are put forward. For study 1 and 2, we hypothesize that students, who receive more structure in their PFB template (study 1) or in the PFB process (study 2), are more likely to provide peer feedback content with a significant higher proportion of: (H1) elaborations, (H2) negative verifications, (H3) general verifications that are focused on particular criteria (H4) suggestive elaborations, and (H5) general elaborations that are focused on particular criteria.

Findings

Regarding study 1, the findings reveal that the elaborate structure condition had a significant higher number of segments per student, compared to the no structure (p<.001) and the basic structure condition (p<.001). Concerning PFB style, all conditions provide a reasonably balanced proportion of verifications and elaborations in their PFB messages. In more detail, students in the basic structure condition have a significant higher proportion of elaborations (59%) (p=.002), compared to students who receive no further structure (48%). Following, results indicate that students tend to provide substantially more positive than negative verifications. In more detail, only the elaborate structure condition had a significant higher proportion of negative verifications compared to the basic structure group (p=.015). As well, the elaborate structure condition has a significantly higher proportion of general verifications that are focused on particular criteria, compared to the no structure condition (p<.001) and the basic structure condition (p=.001). Regarding elaboration type and focus, research claims that feedback should not only include feedback, which refers to the past performance (informative), but should also include valuable feed forward to augment the quality of future performance (suggestive). Although no significant differences were found between the conditions, results reveal that all students provide slightly more suggestive than informative elaborations (more or less 60%). Similar to verification focus, students who receive an elaborate structure have a significantly higher proportion of general elaborations focused on particular criteria, compared to the no structure condition (p=.030) and the basic structure condition (p=.043). Currently, the data of study 2 is being analyzed and the results will be reported at the CSCL conference in Gothenburg.

Conclusions and implications

These studies attempt to illustrate how an instructional intervention in the peer feedback process can increase the potential impact of peer assessment and boost students' learning in higher education. Based on the findings of the first study, a varying structuring degree in a peer feedback template during the PA process can have an impact on the specific peer feedback content. A practical implication of our study is that we propose the use of a peer feedback template for classroom practice, both online and face-to-face, when instructors consider engaging students in peer assessment.

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Pioneer Valley Citizen Science Collaboratory: A CSCL Approach to Designing Citizen Science Projects

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Abstract: The recent explosion of citizen scientist (CitSci) projects has led researchers to call for their broad use as a tool for improving science learning (Bonney, et al., 2014; Wals, et al., 2014). We highlight the CSCL design features of our PVCS Collaboratory and outline a research program for measuring CitSci's understanding of the nature of science, content knowledge changes and shifts in Science 2.0 practices as participants move from novice data collectors to competent practitioners.

Keywords: citizen science, Science 2.0, technology integration, authentic science collaboration

Introduction

Involving the general public in scientific data collection efforts has occurred for over 100 years. In the past 15-20 years, these efforts, often called citizen science (CitSci) projects, have exploded in popularity (Bonney et al., 2014) under the guise of opportunities for science learning and engagement for social change. However, scholars recently highlighted the need for leveraging theoretical perspectives of learning and engagement if we wish to truly move from citizens as data collectors to citizens as creators of new knowledge who can effectively address socioecological challenges (Wals, et al. 2014). Important to the CSCL community, these scholars call for leveraging technology tools toward these ends. We describe a new CitSci platform, the Pioneer Valley Citizen Science Collaboratory (PVCS), that leverages theoretical constructs from the collaborative learning literature, innovative integration of technology tools and existing CitSci projects and seeks to teach participants deep environmental conservation concepts. This platform engages CitSci participants in Science 2.0 practices such as real-time data, geospatial mapping, the use of social networking tools, and collaboration across time and space. Our work combines research on best practices for teaching nature of science (NOS) ideas, community knowledge construction, and the design of mobile (Zimmerman, 2011) and web-based (Peters & Slotta, 2010) technology platforms for promoting deep content learning.

Several CSCL researchers have begun partnerships with CitSci projects as a context for their research. Polman studied citizen science journalism as a way of engaging students with infographics and peer critique (Polman, Newman, Farrar, & Saul, 2012). Martin and Barron (2013) investigated a CitSci project that networked schools and teachers as an example of "mass collaboration." Price & Lee (2013) examined CitSci participants' understandings of the nature of science (NOS). However, the *design* of an integrated CitSci platform, driven by research on learning, is lacking. We designed for learning opportunities by combining crowd sourced materials, peer review and feedback, public engagement in Science 2.0, and distributed technology environments, all guided by the CitSci, CSCL, environmental and science education literature.

Methods

Participants

In the spring of 2014, the PVCS Collaboratory, began through a partnership between Hampshire College and the Hitchcock Center for the Environment (Hitchcock Center), a local environmental education center. The Hitchcock Center provides environmental education programs for in-school K-12 students, homeschoolers, families, and the general public all seeking to increase participants' environmental literacy. Included are training and opportunities for engagement in CitSci projects. From this original partnership, more partnerships developed allowing for a greater number and variety of participants across a greater geographic range and set of demographic (age, ethnicity, economic class, etc.) categories.

Materials

The PVCS portal features both public and member-only spaces and is designed to be the primary location where citizen scientists can learn about the PVCS collaboratory and, if interested, register as members and participate in local CitSci projects. Each local PVCS project contextualizes science through four environmental issues: climate change, biodiversity, habitat loss, and invasive species. These issues frame PVCS and its projects, emphasizing the convergence of citizen science, environmental issues, and Science 2.0 practices within the collaboratory (see Figure 1). This deliberate emphasis reminds participants to link their data collection efforts to underlying environmental issues, scientific practices and community knowledge.

PVCS projects are the main venue for citizen scientists' involvement in data collection and/or analysis. PVCS projects are often seasonal and run for a specific time frame each year. Scientific data collected in each run, however, can be accessed for analysis, comparison, and visualization after the run is complete, thus, expanding citizen scientists' opportunities for involvement beyond the actual active period of the projects. Current projects include: Salamander Watch; Neighborhood NestWatch Springfield; and Leaf Drop and we are in discussion with project managers for local versions of Firefly Watch and Monarch Watch.

PVCS fosters collaboration through integrated CSCL tools both embedded within data collection webforms (see Fig. 1) and the PVCS web portal. Participants needn't switch between individual platforms (e.g., data collection) and collaborative platforms (e.g., separate social networks; shared data) but can fluidly work individually and collectively toward both individual and collective goals with local and/or global significance, lowering barriers to entry and incentivizing collaboration. Iteratively-designed data collection webforms for the Salamander Watch, Neighborhood NestWatch, and Leaf Drop projects that will run for the first time on a large scale in 2015.

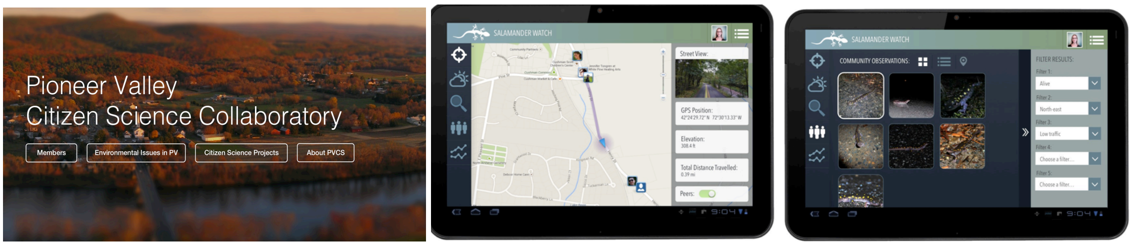

Figure 1. From left, PVCS portal; Salamander Watch mobile collaborative geolocation tool; Salamander Watch mobile community observation collaboration tool.

Findings and implications

Starting spring of 2015, we will collect data on participants' incoming, in-progress and follow-up notions of Science 2.0, target species (e.g., salamanders), environmental issue, ideas about NOS, and shifts from mere data collectors toward knowledgeable practitioners. We will present preliminary findings at the CSCL conference.

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Enculturating Enculturation: A Meta-Synthesis of the Learning Sciences' Discourse and Designs

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Abstract: Enculturation is a central and defining concept of the learning sciences. However, the concept may be under-theorized. In this study, we have reviewed and synthesized how enculturation, both in researchers' discourse and when designed for in practice, has been taken up by learning scientists. Based on the findings of our meta-synthesis of relevant literature, we propose three different types of enculturation discourses. We provide illustrative examples from past learning sciences research and discuss several relevant phenomena. Such findings can help the learning sciences reflect upon its own research.

Keywords: authentic-simulated; enculturation; learning sciences; meta-synthesis

Introduction

This study has been motivated by our personal experiences as emerging learning scientists. Despite the fact that the term "enculturation" has been expressed widely as a foundational idea within learning sciences discourse over the past 25 years (Lee, Ye, & Recker, 2012), we felt there was a great deal of ambiguity around researchers' intended meaning of the term. For example, is enculturation uni or bi-directional? Is the process in societies-at-large the same as within a classroom? We have problematized these issues in table 1. In this study we aimed to review the way that *enculturation has been expressed within learning sciences research.*

Table 1.:Comparison of typical settings that may impact the conceptualization of enculturation

	Typical setting of… Culture-at-large	Formal education
Number of people	Very large membership, making the individual-to-culture ratio high. For example, the ratio of an individual to the American culture is approximately 1:300,000,000.	Small membership, making the individual-to-culture ratio low. For example, the ratio of an individual to a school can be 1:500; and to a classroom, 1:30.
Continuity	Membership changes rotationally. Members enter, often stay for a lifetime, then leave.	School membership changes rotationally. Members enter, often stay for several years, then leave; Classroom membership begins and ends together, for a greater part of a year.
Age	Often disregarded and is not limited by age	Schools are broken into three sub-groups (elementary, middle, high schools); Classrooms are limited to age groups within one year.

Background

Enculturation is originally an anthropological term that was appropriated by learning scientists in the late 1980's when the "socio-cultural turn" took place (Brown, Collins, & Duguid, 1989). However, even in anthropology, there has been considerable conceptual ambiguity and disagreement about what exactly the enculturation process entails (Shimahara, 1970). Given the modern socio-cultural context of the learning sciences, we take a discursive perspective based on the view that communication and thinking are two variations of similar phenomena (Sfard, 2008). As such, by investigating the way people talk about enculturation, we can reveal the different meanings of the term. We asked the questions: How do learning scientists talk about enculturation in their research? How are different views of enculturation expressed within research designs?

Methods

We performed a meta-synthesis of learning sciences discourse on enculturation based on the complete corpus of *JLS* and *iJCSCL.* This included 39 articles and 144 instances of the term.

Preliminary findings

We have found three unique types of enculturation discourses of which the predominant one (and due to lack of space the only one presented here) is "authentic-simulated-traditional discourse". This discourse on enculturation refers to the context of schooling. Researchers draw a distinction between authentic cultures and those that are in school which attempt to duplicate them, what we call "simulated" versions. For example, "Students must be enculturated into the ways of making sense that are characteristic of scientific communities" (Rosebery, Warren, & Conant, 1992, p. 67). In addition, they distinguish between these and traditional education, to which we refer as non-simulated.

In their designs, researchers discuss various "forces" that move the simulated closer to the authentic culture. The figure below represents different approaches that learning scientists take to do this. These forces include interactions with participants who are either the authentic practitioners or representatives of a culture. Other forces include symbolic systems, artifacts and tools. An additional force is time, which differentiates the relatively short-term duration of simulations in comparison to practitioners' full-time career engagement.

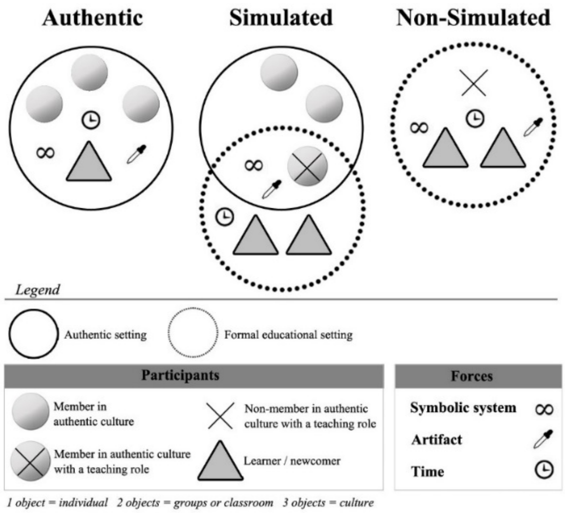

Figure 1. Visual representation of authentic-simulated-traditional discourse

Discussion and conclusions

Our findings indicate that predominant enculturation discourse and design are based on three ways to talk about learning culture: authentic, simulated, and traditional. Out of all the forces, participants and time appear to pose the greatest challenges to overcome the unbridgeable gap between formal schooling and professional practice.

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Developing a Framework to Enhance Creativity and Creative Collaboration via Video Self-Reflection

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Abstract: We offer a novel conceptualization for creativity, reflection, and collaboration. Viewing these three cornerstones of learning as inter-dependent parts of the way science produces knowledge, we suggest a design-based research approach that can investigate these phenomena jointly. Our main intervention, a unique variation of video self-modeling, will be enacted in three iterations. Expected results include a conceptual framework that can explain the role of reflective collaboration on creativity and creative collaboration.

Keywords: creative collaboration, creativity, design-based research, reflection, video self-reflection,

Introduction

In recent decades, the idea of creativity has been re-defined. No longer an individual trait, creativity has been viewed based on the model of scientific practice, such that the complex interactions of process, product, person, and place – the 4 P's of creativity – lead to creative emergences. Seen this way, creativity has been broadened to include learners at all levels and in all disciplines, rather than gifted students primarily in the arts. Recent investigations of creativity have therefore focused on the small "c" of creativity, which occurs as part of everyday life, versus big "C", i.e., eminent contributions of a large magnitude (Kozbelt, Beghetto, & Runco, 2010).

The reconceptualization of creativity as part of a complex system has both contributed to, and is a product of, changes in the way learning is viewed. In recent decades, both the ideas of collaboration and reflection have become cornerstones of the new learning sciences (Sawyer, 2006). Similar to multi-dimensional views of creativity, researchers have taken socio-cultural viewpoints on collaboration and reflection so as not to 'factor out' the complex processes involved (Nathan & Sawyer, 2014).

In this proposed research, we take the view that creativity, reflection, and collaboration are all inter-related aspects of the way that scientific practice produces knowledge. Within this system, we focus on the role that reflective collaboration has on individual creativity and creative collaboration (see Fig. 1). Although creativity is a popular construct and a widely studied educational trend, previous research has not addressed these issues empirically. Our overarching goal is to achieve a conceptual framework that can explain it.

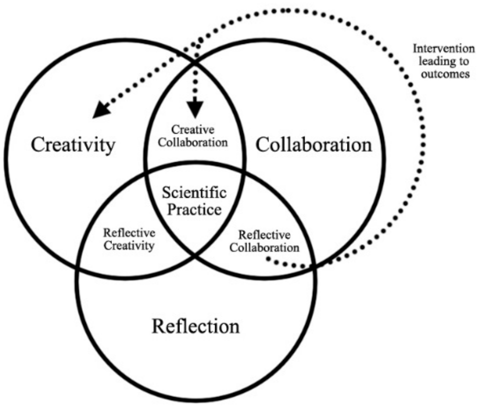

Figure 1. Intervention leading to gains in individual and creative collaborative outcomes

Methods

Consistent with our overarching goal and socio-cultural perspective, we will employ a design-based research (DBR) methodology to answer our research questions. DBR, a cornerstone of the learning sciences, aims to develop theory-in-practice through extended, iterative interventions in naturalistic settings (Cobb, Confrey, Lehrer, & Schauble, 2003). The objectives of this study include:

1. **Design:** To plan, implement, and analyze a pedagogy that promotes reflective collaboration;
2. **Describe:** To characterize the creative collaborative learning process;
3. **Evaluate:** To assess the impact and role of reflective collaboration on individual creativity and the creative collaborative learning process.

These specific objectives together lead to the study's overarching goal:

4. **Infer:** To propose a conceptual framework that can explain the role of reflective collaboration on creativity and creative collaboration.

Participants
Participants in the first two iterations will be 20-30 graduate students, aged 25-55 years, who are enrolled in the Educational Technologies Program at the University of Haifa and who will be registered in an elective course on Collaborative Learning. To investigate the generalizability of the learning principles for creative collaboration as given and refined during the two iterations of the Collaborative Learning course, a companion course, Collaborative Learning for Clinical Rehabilitation Teams, will be enacted as the third iteration.

Intervention procedure
In the proposed study paradigm, we will enact an innovative pedagogical intervention which is based on our definition and conceptualization of reflection, collaboration, and creativity. The basic thrust of our pedagogy, which we aim to refine and generalize as an objective of this study, is for students to record and watch themselves carry out relevant collaborative learning tasks, then reflect upon their learning in an ongoing process of deepening, enriching, and more intensive collaboration. This approach, called REFLECT (Reflective Learning for Creative Collaboration), is a variant of video-modeling (Bellini & Akullian, 2007). What distinguishes REFLECT is that rather than taking a cognitive or behavioral approach, we focus on building reflective, collaborative groups.

Analysis
Each of the study's outcomes will be analyzed using appropriate quantitative and qualitative methodologies that will allow us to provide evidence-based responses to our research questions.

Expected results
The results of this study are expected to make contributions that are theoretical, methodological, and practical. Theoretically, the conceptual framework will clarify processes involved with creativity within complex learning environments. Methodologically, the DBR approach will offer new ways to look at creativity, particularly as we are investigating it using various data collection procedures, instruments, and analytic methods. Finally, the use of DBR will yield a pedagogy that can be implemented across disciplines and ages to make a practical contribution for educational practitioners seeking to promote creativity.

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Automating Detection of Good Reflective Responses in Discourse

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Abstract: In this paper we demonstrate the successful implementation of a learning theory-based computational technique to capture students' abilities to engage in reflection-on-action. Grounded in Epistemic Network Analysis, we operationalize reflection-on-action in discourse in terms of connections between important concepts within a given domain. We also demonstrate that we can use the detection of connections between concepts to determine the degree to which students rely on group discourse as a scaffold for reflection-on-action. We argue that these results will enable CSCL environments to accurately provide on-time and continuous monitoring of student learning.

Keywords: reflection-on-action, learning goals, high school students, college students, Epistemic Games

Introduction

Efforts have been made in the CSCL community to provide educators with real-time information on student learning. One important form of learning is reflection-on-action, a skill that is fundamental to being a professional within a given domain (Schön, 1987). One way to capture reflection-on-action is through the use of epistemic network analysis (ENA) in which learning is conceptualized as a set of connected domain-specific concepts in discourse (Shaffer, Hatfield, Svarovsky, Nash, Nulty, Bagley, E. Franke, et al, 2009). This method has been used in previous research to describe the development of reflection-on-action in professional practica (Nash & Shaffer, 2013).

For novices, group discussion may facilitate the development of reflective competence in the sense that the group can identify relevant connections better than any individual on her own. Further, relative expertise in a domain may affect how much individuals rely on group discussion to scaffold reflection. We may therefore be able to use ENA connections at the level of individual utterances and at the level of the group discussion to determine how much students rely on group discourse as a scaffold for reflection-on-action. Our research questions, then, are:

RQ1: Does automated coding capturing the connections between specific epistemic frame concepts predict a human coder's evaluation of a good reflection response?

RQ2: Can we use ENA connections as a way to model the role of collaboration in the development of the professional ability to reflect-on-action?

Methods

The "Land Science" internship

"Land Science" is an epistemic game (Epistemic Games, 2012) which takes the form of a virtual urban planning internship. The game includes pre-written scripts to initiate reflective conversations. The data analyzed here are students' responses and discussions to the following prompt: "So, planners, you just conducted a virtual site visit. What did you find out about your stakeholders?"

Participants

The participants were 117 students enrolled in an introductory urban planning course at a large Midwestern university and 69 high school students. For our analyses, the college students were considered to have more expertise in the urban planning domain than the high school students.

Definition: "Good reflection responses"

We defined "good reflection responses" as *responses in which students refer to the game's stakeholders and the stakeholders' social and environmental concerns*. These were first coded at the level of the utterance and then at the level of the group discussion.

Automated coding scheme

We developed seven codes that were considered to be most relevant to the topic at hand for the analysis, which were validated with a human rater at $K > 0.60$ ($p < 0.001$). A human rater marked 200 randomly selected utterances and 54 group discussions as either fully meeting the reflection goal or not fully meeting the reflection goal. The interrater reliability for two human raters was $K = 0.71$ ($p < 0.001$).

Results

RQ1: Specified code combination as predictor of good reflection responses

A logistic regression analysis was conducted to predict whether an utterance was considered an appropriate response to the reflection question. These results indicated that specified code combinations were good predictors of good reflection responses and could therefore be used to automatically detect good reflection responses in group discourse (see Table 1).

Table 1: Logistic regression analysis of good reflection response

Independent Variable	B	SE B	Wald	Sig.
Intercept	-3.097	0.362	-8.567	0.00
Specified Code Combination	5.736	1.096	5.231	0.00

RQ2: Collaboration in reflective discussions

College students were significantly more likely than high schoolers to have at least one utterance in the conversation that fully made the specified code combination, $t(49.02) = 2.387$, $p < 0.05$, while high schoolers were significantly more likely than college students to make the code combination over several turns in group discourse, $t(40.65) = -2.45$, $p < 0.05$.

Discussion

The results show that the automated detection of ENA code combinations can reliably predict good reflective responses at the level of the utterance and group discussion. The results also show that we can use specified code combinations to determine how heavily students rely on group discourse as a scaffold for reflection. These findings imply that automated learning assessment can be operationalized in terms of connections between important concepts within a given domain. Such techniques become increasingly important to handle large amounts of learning data, and providing on-time assessments to human or AI mentors becomes essential.

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Learning with Friends: Exploring Socially Motivated Participation in a MOOC

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Abstract: Students choose to enroll in In Massive Open Online Courses (MOOCs) for a variety of reasons. So that we may better plan for successful learning experiences, we need to understand those reasons and their implications for learning in the course. In this study, a subset of students in a MOOC reported that they were enrolling in the course in order to learn together with colleagues or friends. We examined measures of engagement, learning, and satisfaction. We found that although learning outcomes in the course were similar across all participants, socially motivated students reported more satisfaction than their classmates.

Keywords: MOOC, motivation, social, learning outcomes

Introduction

The development and study of Massive Open Online Courses (MOOCs) have reignited a conversation about the variety of reasons individuals choose to engage in a learning experience. The high rates of attrition in MOOCs from initial enrollment to completion have prompted discussion about the motivations, or lack thereof, which students bring to the experience. Kizilcec, Piech, and Schneider (2013) argue that "Learners in MOOCs who do not adhere to traditional expectations, centered around regular assessment and culminating in a certificate of completion, count towards the high attrition rates that receive outsized media attention" (p. 171). We seek to better understand those learners. Exploring the variety of reasons for engaging in online learning experiences will give us a better understanding of how to design a variety of learning experiences for diverse learners.

One of the interesting alternative motivations for participation in a MOOC is the intention of engaging with other learners. Early exploration of MOOC experiences have suggested that participation in a MOOC is more successful when participants complement the online learning experience with an in-person social interaction (Blom, Verma, Li, Skevi, and Dillenbourg, 2013). Yet the majority of participants in MOOCs are likely to see their learning in the online course as an individual endeavor, where "lurking" is an acceptable mode of interaction (Kop, Fourier, & Mak, 2011).

In this study we seek to understand how the intentions students bring to the course relate to their learning experience. It is quite possible that a socially motivated MOOC experience could lead to more "sampling" or "auditing," (Kizilcec, Piech, & Schneider, 2013), with a resultant higher attrition rate and lower scores on exams. On the other hand, participants might find the social accountability of participation with a friend or colleague to be more motivating, leading them to a higher satisfaction and more learning. We explore the relationship between a social motivation for engaging in a MOOC and several different measures of engagement, satisfaction, and learning.

Methods

The participants in this study were students in a Massive Open Online Course on Human Physiology, recently offered by faculty at a leading university in the United States. The participants responded to online surveys of their course experiences within the course platform, both before and after the six-week course.

Of the 11,774 individuals who enrolled in the course, 3834 agreed to participate in the study and took the pre-course survey. There, participants selected responses to the question "Why did you enroll in this course?" To answer the question of how the presence of social intentions relates to course outcomes, we compared the engagement, learning, and satisfaction measures of students who reported at the start of the course that they enrolled in order to take the course with colleagues or friends (the "socially motivated" group), with those students who did not.

Results

The socially motivated students participated in the first module quiz and in the post-course survey at rates similar to their classmates who reported other motivations for taking the course. They participated at higher rates in the sixth (last) module quiz, a statistically significant difference (see Table 1).

Table 1: Participation rates of socially motivated students and their classmates

Pre-course survey (N = 3834)	Social (n=594)	Other (n=3240)	χ^2	*p*
Quiz 1 (n=2829)	450 (75.8%)	2379 (73.4%)	1.41	.24
Quiz 6 (n=1547)	261 (43.9%)	1286 (39.7%)	3.76	.05
Post-course survey (n = 1214)	200 (33.7%)	1014 (31.3%)	1.31	.25

To examine learning, we focus our learning analyses on the final course module, which addressed the physiology of variable pressure. On the end-of-section quiz on variable pressure, socially motivated participants scored no differently on average (M = 7.68, SD = 3.69) than their classmates (M = 7.52, SD = 3.83), $t(1545) = -.63$, $p = .53$, despite reporting more familiarity with how their body responds to variable pressure on the pre-course survey (χ^2 (3, N = 3703) = 9.61, p = .02). However, other outcomes relating to the participants' satisfaction with the course show significant differences (see Table 2). When compared to their classmates who had other motivations for taking the course, socially motivated students reported on the post-course survey that

- they were more satisfied with their learning, relative to their expectations;
- they were more satisfied with their communications with other students, both in the forum and when using other communication tools; and
- they had made more useful new contacts and met more new people who shared their interests.

Table 2: Comparisons of socially motivated students and their classmates on overall course outcomes

	Social %	Other %	χ^2	*df*	*N*	*p*
How much did you learn in the course relative to your expectations?* "Much more"	51.7	37.2	6.44	2	327	.04
How helpful were … Student interactions on the forum? "A little helpful" or better	82.5	72.7	8.43	1	1214	<.01
How helpful were … Student interactions using other communication tools (e.g. Skype, Facebook)? "A little helpful" or better	55.0	44.6	7.30	1	1214	<.01
I made new useful contacts as a result of taking this course* "Applies to me"	17.0	4.5	10.88	1	337	<.01
How much did this course introduce you to people who share your interests? "Quite a bit" or "Very Much"	27.5	16.9	20.49	3	996	<.001

*These questions were randomly assigned to a subset of the respondents on the post-course survey.

Discussion and conclusion

Taken together, these findings suggest that students who took the course with the intention to learn together with friends and colleagues experienced it quite differently than their classmates who did not. There are many possible explanations for these differences. For instance, it is possible that socially motivated learners may have been less motivated by a learning goal than a social goal, and therefore put more effort into interacting with others. Or, because they started out with greater prior knowledge, they had a lower expectation for learning in the course, so that the gap between their expectations and their perceived learning was larger.

The reasons students have for engaging in a course matter to how we measure success. Further exploration of different measures, of changes in what learners can say or do, will provide deeper insights into relationships between the reasons learners choose to enroll in an online course and their subsequent learning outcomes. We hope that these findings will prompt more research to understand the different ways in which online courses can be designed to meet the needs of learners with a range of motivations for learning.

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It Is Not (Only) Personal: Technology Enhanced Collaborative Reflection Processes

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Abstract: Previous research pointed at the challenge of developing high levels of reflectivity among students in higher education. In this paper, we present an empirical study that was conducted in a technology-enhanced collaborative learning community where Wiki-based reflective journals were extensively used to encourage students' reflection on content, personal and interpersonal issues. The study goal was to assess students' reflectivity as manifested in their journals. We found high levels of reflectivity for most students.

Keywords: CSCL, learning community, reflection, reflective journals

Introduction

Reflectivity has been widely recognized as highly valuable for learners (Dewey, 1960) and practitioners (Schön, 1987). Previous researches in CSCL communities points to the potential of reflective interactions to promote learning (Baker & Lund, 1997) and to the potential of CSCL environments to contribute to reflective interactions (Salmon, 2002). However, not much research has been directed to explore how engagement in CSCL communities in higher education may promote students' level of reflectivity and the potential role of reflective journals in such environments. Studies conducted in other fields present in many cases disappointing results regarding the level of reflectivity as manifested in reflective journals (Dyment & O'Connell, 2011). The study presented here was conducted in a CSCL community that supports the emergence of Collaborative Reflection Processes (CRP). We focused on assessing students' levels of reflectivity by evaluating their written reflections in a Wiki-based reflective journals (WIREJs). In this context, the following research question was formulated: What level of reflectivity characterized students' reflections?

Methodology

Setting

The research presented here was conducted in "Challenges and Approaches to Technology-Enhanced Teaching and Learning" (CATELT) – a semester-long course in an educational technologies graduate program, at the University of Haifa's Educational Technologies Program. In this course, students participate in a CSCL community while studying about the learning sciences. In conjunction with the course emphasis on "learning how to learn" (Bielaczyc & Collins, 1999), students were asked to reflect about their learning experiences as an integral part of their learning and throughout the course. Further emphasis was given to a collaborative reflection processes (CRP) in which students jointly explore their reflections significance, through sharing and conversing. Two arenas designated to enable and support the CRP were designed: In-class weekly Community Reflective Conversation (CRC) and the WIREJs. Building on the original Wiki's User-Pages, the WIREJs were designed as a personal "journal-like" space for each participant. As such, while personal, they were also accessible to all community members. The "conversation page", attached to each user page was adapted to contain students' direct comments to each other's journal reflections, enabling students to mutually deepen observation and to refine understandings.

Participants

A heterogeneous group of 13 students participated in this course. All participants were teachers and facilitators in a variety of levels and subjects and joined the MA program to become leaders in educational technology.

Data analysis

38 reflections of the 13 students, written after the 6^{th}, 9^{th} and 10^{th} meetings (three entries for each student, except one student that was absent during the 6^{th} and 7^{th} lessons) were analyzed. We used Williams et al.'s (2000) coding scheme to evaluate students' reflectivity level (see Table 1). We reviewed other conceptual frameworks

(e.g., Hatton & Smith, 1995) and chose this scheme since it was concurrent with our understanding of reflection and tested for reliability.

Table 1: Coding scheme for assessing level of reflectivity in journal writing (adapted from Williams, 2000)

Reflection level	Explanation
Non-reflective	Reporting on what is happening rather than analyzing the learning event, issue, or situation.
Describes	Describes the learning event, issue, or situation (what happened?). Describes prior knowledge, feelings, or attitudes with new knowledge, feelings, or attitudes.
Analyses	Analyses the learning event, issue, or situation in relation to prior knowledge, feelings, or attitudes (what is your reaction? why did it happen?).
Verifies	Verifies the learning event, issue or situation in relation to prior knowledge, feelings, or attitudes (what is the value of the occurrence? is it correct?).
Gains a new understanding	Gains a new understanding of the learning event, issue, or situation.
Indicates future behavior	Indicates how the new learning event, issue, or situation will affect future behavior.

Findings

Ten out of the 13 students (77%) presented a high level of reflectivity, reaching the highest stage of the coding scheme. In their reflections they were analyzing their learning experiences in relation to prior knowledge, feelings, and attitudes, verifying their new understandings and indicating new understandings and implications for future behavior. The other three (23%) reached only the descriptive level.

In their reflections, the students related mainly to interpersonal conflicts and socio-emotional challenges connected with their collaborative learning and expressed in the CRC. They also discussed the theoretical learning material in relation with their personal lives, teaching experiences and socio-cultural issues. Substantial part of their reflections were about the significance and contribution of CRP processes for their own reflective observations, as well as to their understanding of the nature and value of collaborative learning.

Conclusions and implications

We suggest that the significance of this research originates in the identification of high levels of reflectivity among students who participated in CRP within a CSCL community. This research points to the potential value of learning environments that enable and promote CRP. The integration of two correlating, in-class and on-line, reflective arenas, and the on-line and 'personal-but-public' nature of the students' reflective journals, is suggested as a significant element in such an environment. Several implications for further research are suggested: 1) to examine more closely and from different aspects the potential affinity between the learning environment design and students' level of reflectivity; 2) to closely examine the nature and characteristics of the CRP and their influence on students' learning and attitudes.

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It's My Turn: Using Rotating Leadership to Visualize Collective Cognitive Responsibility in a Knowledge Building Community

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Abstract: This study aims to explore the concept of collective cognitive responsibility in a grade 4 Knowledge Building class. Individual and group level leadership patterns were explored through temporal visualizations of betweenness centrality. Results indicate that the student network was relatively decentralized, with almost all students leading the group at different points in time. Our results are framed within Collaborative Innovation Network theory, which suggests that rotating leadership is conducive to group productivity and creativity.

Keywords: Knowledge building, collaborative innovation networks, social network analysis, collective cognitive responsibility, rotating leadership

Introduction

Growing international education initiatives aim to foster creativity, communication, collaboration, and leadership (Soland, Stecher, & Hamilton, 2013). Knowledge Building (KB; Scardamalia, 2002), which emphasizes sustained, creative work with ideas, offers a potential avenue for educators to meet such demands. Within a KB community, students assume collective cognitive responsibility for the advancement of their community knowledge. Thus, the success of the community lies in the distribution of group effort across all members, rather than a concentration of effort amongst a few individuals. For example, a case study analysis of a KB class revealed that the decentralization of the student network led to increased advances in collective knowledge (Zhang, Scardamalia, Reeve, & Messina, 2009). This observation is in line with research on innovative groups in open network communities, as research in Collaborative Innovation Network theory (COINs; Gloor, Laubacher, Dynes, & Zhao, 2003) shows that the decentralization of leadership across group members through patterns of oscillation is a good indicator of group productivity and creativity. The current exploratory study aims to use COINs theory as an analytical framework to investigate leadership dynamics in a KB community. We used social network analysis (SNA; Wassermann & Faust, 1994) in order to visualize patterns of collective cognitive responsibility over time. We expect that rotating leadership, as indicated by oscillating betweenness centrality similar to those of productive innovative groups (Kidane & Gloor, 2007), would emerge as the collective knowledge advances.

Methods and analysis

Our sample is a grade 4 class, comprising 22 students, who engaged in the inquiry of light over a three-month period (Sun, Zhang, & Scardamalia, 2010). Student discourse in an online KB environment (i.e., Knowledge Forum®) was exported into Knowledge Building Discourse Explorer (KBDeX; Oshima, Oshima, & Matsuzawa, 2012) in order to perform SNA based on a list of content-related words (101 words) compiled from the Ontario Curriculum of Science and Technology. KBDeX is an analytic tool which was designed to facilitate content-based SNA for KB discourse. It produces visualization models of word, note, and student networks based on the co-occurrence of words in a note. Edges in the student network show the strength of connections among students whose notes share the same word. KBDeX also supports temporal network analysis by showing animations of how the network metrics (e.g., betweenness centrality) change over time. The betweenness centrality measures the extent to which a member influences other members of the group (Gloor et. al., 2003). At the individual level, a betweenness centrality value of 1 means that a member is highly influential, whereas a value of 0 means that a member is equally influential as other members. At the group level, the centralization of betweenness centrality is used to indicate the extent to which the network is centralized (i.e., influence is not evenly distributed in the network, high influence is occupied by a few members of the network). A centralization of betweenness centrality value of 1 means that the network is completely centralized, whereas a value of 0 means that the network is completely decentralized.

Findings and future directions

First, we examined the centralization of the betweenness centrality of the student network in order to examine the extent to which the student network was centralized around specific members. We found that the average centralization of betweenness centrality is relatively low, m = 0.089, sd = 0.064 (range = 0 to 0.26), which suggests that the student network was relatively decentralized, and students shared more or less the same level of influence in their network. Students maintained a relatively high cohesive network over time.

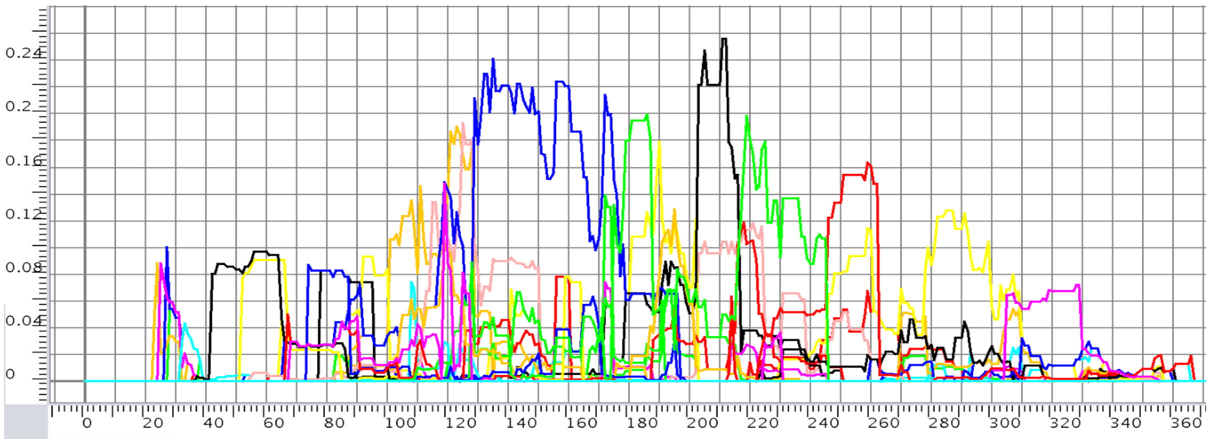

Figure 1. KBDeX visualization of individual betweenness centralities across time

Next, we examined the betweenness centrality at the individual level as shown in Figure 1. The Y axis of the chart shows the betweenness centrality value, and the X axis shows the time. Each student is represented by a coloured line, resulting in a total of 22 lines displayed in the chart. Of the 22 students, 20 students took a leading position, suggesting that different students were leading across different times. As a higher betweenness centrality means that the student holds a more important position in the social network, the overlapping phenomena of the lines indicate that the leading student (i.e., the student with the highest centrality at the time) is frequently changing. Our results confirm our hypothesis that rotating leadership is manifested within a KB community that assumes collective cognitive responsibility. Future research should further examine the conditions in CSCL classrooms that give rise to the phenomenon of rotating leadership, as well as its effects on group productivity and creativity. For example, it would be interesting to supplement our findings with qualitative analyses in order to detangle whether or not certain types of contributions to KB dialogue facilitate rotating leadership amongst group members.

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Retrospective Tagging in Online Discussions as a Method for Collaborative Reflection and Learning

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Abstract: This study addresses the increasing need for dealing with large student groups with limited resources, as well as the call for student-centred educational activities. A course module in which a group of 463 students engaged in online collaborative discussions as part of their teacher training is described and analyzed. After participating in an online discussion, the students tagged their own forum posts using categories informed by dialogistic theory, an activity referred to as retrospective tagging. They were also asked to write reflections on the forum activity and tagging. The analysis of the reflections shows that retrospective tagging creates possibilities for learning about participation, subjectively and collaboratively, as well as enriching engagement with content of forum discussions.

Keywords: asynchronous discussion groups, computer supported collaborative learning, higher education, learning management systems, tagging, content analysis

Introduction

In parallel with decreased financial and human resources, educational institutions have to uphold quality teaching with an increasingly diverse student population. Early attempts to include thousands of students in educational activities have however often been costly and demanding, and have also exhibited poor educational results (Jordan, 2014). In the light of this, several researchers suggest methods for analysing online discussion forums to better support collaborative learning in cost effective ways, involving automated coding (e.g. Erkens & Janssen, 2008). Manual coding of discussions, on the other hand, are generally described as arduous and time consuming.

The general idea of adding categories or tags to support interaction in online text-based communities have however received a significant amount of attention within the broader field of human-computer interaction outside of CSCL (e.g. Yew, Gibson & Teasley, 2006). These studies typically view the purpose of tagging as a way to structure information for future use and often emphasize how the tagging process itself can provide value to the users. In this study we explore a method we call retrospective tagging as an educational activity. The research question investigated is formulated as follows: In what ways does retrospective tagging create resources for reflection on participation in collaborative online discussion forums?

A dialogistic approach to tagging

Studies of students' use of epistemic categories in CSCL systems indicate that the specific character of the categories used, as well as the design of the tasks, seem to be of central importance for the meaning the students ascribe to the activities and how they unfold (e.g. Arnseth & Säljö, 2007). The idea informing the design of the study presented here is to alter the premises for categorizing by introducing a dialogistic approach (Bakhtin, 1981). Tags specifically adapted to the learning goals and educational framing were provided to the students.

The design of the tags was based on a qualitative analysis of posts from previous iterations of the course module and inspired by Dysthe's (2001) dialogistic analysis of asynchronous discussions. The tags use were #exp (reference to own experience), #que (question directed to other participant(s)), #lit (reference to course literature), #opi (position or opinion), #conf (confirmation or agreement with other participant), #count (counter argument or questioning of other participants posting), #grp (coordination of groups collaborative work), #off (off-topic) and #oth (other).

The activity followed a sequence in five steps. First students (i) participated in online discussions on a given topic. They were then (ii) introduced to the tagging scheme, and (iii) tagged the posts they had made in the discussion. After tagging they wrote a reflective text (iv), discussing their own participation and (v) received quantitative feedback based on the tagging as a further resource for reflection.

The tagging was performed by each student. They went through and edited their own posts in the previous discussions, inserting the appropriate tag(s) at the end of each message. Each student then wrote a reflection post in which the experience of the seminar was discussed in relation to the tagging process and course literature on dialogic processes in discussion forums. Five teachers were involved in step (ii-v) of the activity, instructing, facilitating and assessing students. After the students had completed their tagging, the tags were counted on base group level by the teachers, using a function supporting this in the LMS used.

The activity sequence was developed through several iterations of the module in the teacher training course. For each iteration the module was re-designed with the intention of minimizing resource use in the teachers' work (for example, by reducing overlap and unnecessary repetition in the writing of feedback), while simultaneously expanding the resources available for students' learning.

Analysis and results

The posts from step (iv), in which the students reflect on their participation in the online discussion and subsequent tagging, were analyzed using a grounded approach. By searching for recurring themes in a qualitative analysis, three types of content in the reflections could be distinguished. 251 extracted posts were then quantitatively analysed and assigned one or more of these types (the types are not mutually exclusive):

- Reflection type 1, On the tagging process: 47%
- Reflection type 2, On subjective participation; 67%
- Reflection type 3, On group collaboration: 18%

Further content analysis of the students´ reflections shows that during the process of retrospectively tagging their own discussion posts, the students were led to analyse and reflect on the communicative context, the communicative functions of the posts as well as the subject content discussed. A short excerpt from Cam's reflection contains all three aspects and provides a good illustration:

> Cam: the hashtags made it easy to survey how validatable my arguments were, and mirrors how I interacted with my fellow students. I could go back and re-read my posts and I realized that what seemed obvious to me could have been interpreted in a completely different way by someone else!

A potential explanation of this triple effect is that the students approached the content in the posts in two different ways during the writing of the posts and the retrospective tagging - in the first instance as producers and participants, and in the second as analysts dissociated from the production setting, demonstrating the Bakhtinian view that meaning is not fixed but created as a bridge between the writer and the reader (Bakhtin, 1981), in this case two roles taken on by the same person.

Conclusion

In contrast with previous research, describing tagging as a resource demanding task, retrospective tagging turns the analysis of forum discussions into a pedagogical resource. The tags and the tagging process used here were influenced by dialogic theory rather than the progressive inquiry tags often used in other CSCL systems. In the students' process of re-reading and tagging discussion posts, the previously transparent subjective participation became observable and possible to reflect on, and the tags provided a vocabulary for discussing the participation. We suggest that this is what led the students to analyse the communicative context, reflect on individual and collaborative participation and re-evaluate subject content. Retrospective tagging offers concrete tools for allowing students insight into participation in online discussions.

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Exploring Constructive Learning Activity in Online Programming Discussion Forums

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Abstract: In this paper, we explored constructive learning activities in an online programming discussion forum. We built a logistic regression model based on the underlined cognitive processes in constructive learning activities. The results confirmed that the crowd perceived Accepted Answers were likely to contain more constructive words. More importantly, users had as many interactions with Answers as with Accepted Answers, disregarding the quantity of constructive words. They especially bookmarked more and up voted more in difficult Answers when the content had more constructive words. The findings supported that *passive-proactive* behavior exists and suggested that detecting constructive content can be a helpful classifier in discerning relevant information to the users, and in turn optimizing learning opportunities.

Keywords: learning activity, engagement activity, discourse analysis, constructive learning, forum

Introduction

The juncture of Intelligent Tutoring Systems/Artificial Intelligence in Education (ITS/AIED) & Learning Science/Computer Supported Collaborative Learning (LS/CSCL) literature has successfully demonstrated that students can learn from a wide range of dialogue-based instructional settings, such as dialogic-based tutor, asynchronous discussion forums, etc. (Aleven, McLaren, Roll, & Koedinger, 2006; Chi, Roy, & Hausmann, 2008; Muldner, Lam, & Chi, 2014; VanLehn et al., 2007). Recently, studies show an alternative instructional context by *learning from observing others learn* (Chi et al., 2008) and is considered as a promising learning paradigm (Muldner et al., 2014). It suggests lurkers can still learn by reading the postings-and-replies exchanges from others due to the constructive responses in the content and if the lurkers also engage in some sort of activities (Chi & Wylie, 2014). Such paradigm addresses a major limitation on development time in ITSs & liberated the domains from procedural skills to less structured fields. However, to what extend can we capitalize *passive-proactive* learning activity (i.e. reading others' constructive dialogues voluntarily and later engage in some sort of learning activity)? In the context of programming learning, can we successfully model users' learning activities in such large-scaled open corpus environment? In this paper, we focus on researching the *passive-proactive* behavior and exploring the associated constructive learning activities in an online programming discussion forum. We aim to use quantitative approach to evaluate and harness students' learning activities in massive online discussion forums. To do so, we first apply ICAP (Interactive, Constructive, Active, Passive) learning activity framework, which defines "learning activities" as a broader and larger collection of instructional or learning tasks. It allows educational researchers to explain subtle engagement activities (invisible learning behaviors) (Chi, 2009; Chi & Wylie, 2014; Muldner et al., 2014). The framework examines comparable learning involvement, where *Interactive* modes of engagement achieve the greatest level of learning, then the *Constructive* mode, then the *Active* mode, and finally, at the lowest level of learning, the *Passive* mode. It will allow us to engineering algorithms to capture learning activity features in predicting learning outcome and estimating knowledge transformation. At current stage, we focus on constructive learning activities and neglect other activities. We consider constructive activities that include the following possible underlying cognitive processes, *inferring, creating, integrating new with prior knowledge, elaborating, comparing, contrasting, analogizing, generalizing, including, reflecting on conditions, explaining why something works*. Based on these cognitive processes, we build a constructive lexicon library. For instance, comparing & contrasting words, explanation, justification & elaboration words, etc.)

Preliminary findings

We sampled one year (year 2013) of forum posts in topic Java from StackOverflow site through StackExchange API (http://stackexchange.com, a question and answer website network for various fields). The data pool was selected from the top 10 frequent tagged questions due to most the posts in this section contained at least one accepted answer. It will allow us to build a baseline on the answer quality according to crowdsourced votes. There are total 16,739 posts, including 3,725 questions, 13,014 answers, with 3,718 accepted answers.

We consider two dimensions of features of constructive engagement activities 1) Social aspects features, including posting votes, poster reputation, poster status & 2) Content related features, including code snippets, content syntactic (length, average sentence per thread), and most importantly the constructive lexicons. We performed logistic regression analysis. The full model was able to successfully predict user engagement at 0.05 level, *adjusted-*R^2= 0.256. We tested the goodness of the models reserving 20% of the observations for testing with 10-fold cross validation (MAE_{10FOLD}=7.08) and selected a final model.

We found that there are significant more constructive words within Accepted Answer (*M*=0.827, *SE*=1.334) than Answers (*M*=0.583, *SE*=1.005), p<0.01 (Table 1). The result confirmed that the answers accepted by the crowd not only agreed as correct among the best available answers, but also contain higher constructive information. Accepted Answers also showed a positive correlation between user favorites and the amount of constructive words (r=0.0781, p<0.01), but we did not see such correlation between Questions/Answers and the amount of constrictive words. This result is not surprising. It indicates the community tends to bookmark *useful* Accepted Answers, but not Questions nor Answers. However, we found the community provided as many votes to Answers and Accepted Answers, no matter how constructive the content was. This observation was very interesting and revealed that the community may not bookmark the Answers as frequent as they do to Accepted Answers, but it did show the effort to screen the Answers and provide votes to them.

We further divided the content into two categories, Easy & Difficult (based on the topics covered in CS1 or CS2 courses). Easy topics include *Classes, Objects, Loops, ArrayLists* etc.; difficult topics contain *Inheritance, Recursion, Multithreading, User Interfaces* etc. We found that easier content had slightly higher constructive words than difficult content, but it was not significant. It was understandable that simpler problems may be easier to provide examples and tougher problems may require more efforts to justify the answers. However, we found that among Answers, users bookmarked more and up voted more in difficult content when the content had also more constructive words. But we saw no such pattern in Accepted Answers or in Questions. This again showed important evidence that the users in the community spending efforts in locating relevant information to themselves, even the answers are not the accepted ones. These results support the *passive-proactive* learning behavior, which users did not just read the Accepted Answers, but also Answers, and further provided some sort of actions. The findings also suggest that detecting constructive content can be a helpful classifier in discerning relevant information to the users, and in turn providing learning opportunities.

Table 1: Constructive word counts by content types and difficulties

Topic/Type	Question	Accepted Answer	Answer
Easy	0.956±1.253	0.959±1.385	0.646±1.035
Difficult	0.984±1.355	0.827±1.294	0.583±0.981
Average	**0.971**±1.309	**0.827**±1.334	**0.583**±1.005

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Youth Posting Behavior and Metacognitive Acts: Using Social Network Forums to Enhance Metacognition in a Design Based Science-Learning Environment

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Abstract: The present study examined youth learners' metacognition through youth posting behavior on a social network forum (SNF), *Edmodo*, as well as the facilitators' influence on learners' posts. Results indicated that learners posted the following contents in a descending order of proportions: thoughts and emotions, knowledge, social contents, learning, doing, evaluation, questions, and planning, with small proportion of metacognitive acts. The facilitators' prompting questions solicited significantly more posting units from the youth than postings of recognition and encouragement did. Implications for research and practice are discussed to improve the usage of SNFs to elicit metacognition among youth in similar science-learning environments.

Keywords: design-based science learning, metacognition, posting behavior, rural youth, social network forums

Introduction and theories

Informal afterschool learning environments offer many advantages over formal classrooms for engaging youth in STEM materials. The non-evaluative environment allows youth to experiment and tinker with STEM ideas at individual pace without the pressure of grades (Bevan et al., 2010). The collaborative nature broadens participation by allowing youth to share ideas and prior knowledge (Bell, Lewenstein, Shouse, & Feder, 2009) with adults and peers to make decisions and solve problems. Nevertheless, metacognitive ability plays a key role in any kind of learning environment (Flavell, 1979) and has shown benefits for communication, complex problem solving, and development of expertise in training (Wilsthire, Rosch, Fiorella, & Fiore, 2014) and learning outcomes and transfer (Ford, Smith, Weissbein, Gully, & Salas, 1998). Metacognition is defined as awareness and cognitive control of one's thinking (Flavell) and has several dimensions, including planning and monitoring. Metacognitive prompts reliably induced responses from middle school youth, and different types of prompts resulted in different types of responses (Wilson, Perry, Anderson, & Grosshandler, 2012). Writing reflective journals is one way to improve metacognition through monitoring thinking and learning strategies (Hawkins, Coney, & Bystrom, 1996), especially when learners received support for reflection (Songer & Linn, 1991). Social network forums (SNFs) have great potential for facilitating learners' reflection and metacognition. SNFs are platforms where users can build a self-profile, write about topics of interest at a relatively long format, and communicate with friends or peers with similar interests. Analysis of reflection journals on a SNF, *Tumblr,* revealed that college students in a robotics education course engaged in metacognitive acts in terms of evaluation and planning along the progress of their project (Huang, Varnado, & Gillan, 2014). With few empirical studies conducted to explore whether and how middle school students conducted metacognitive acts in a design-based science-learning setting where youth work in teams to design a solution to solve problems, the present study tries to answer the question through youth posting behavior on a SNF, *Edmodo*. More specifically: 1) What did the learners post on *Edmodo* and how much? 2) What were the change patterns of learners' posts? 3) How did facilitators' posts influence learners' posting behavior?

Methods

The present study included 30 middle school youth (5th to 7th grade; 14 male; 10 to 12 years old) and 3 adult facilitators in the US. Youth spend 70-80 minutes each lesson once a week in teams to complete the tasks in an afterschool design-based learning program, *Save the Black Footed Ferrets,* from February 3 to March 18, 2014. They were encouraged to use the SNF, *Edmodo,* to communicate with each other, and share ideas, photos, and other related resources. The codebook included eight coding dimensions with definitions and examples. The analysis used verbal data analysis (Geisler, 2004) and SPSS. The inter-rater reliability reached a simple agreement of 81% and Kapa value of 0.74.

Results

Youth did the majority of posting (247 posts broken down to 452 minimal meaning units) compared to the facilitators (17 posts 52 minimal meaning units). The posts were broken into the minimal meaning units to avoid redundant coding for posts that contains multiple meanings. The results (see Figure 1a) showed that the top two posting contents were thoughts and emotions (117 units, 25.88%) and background knowledge (116 units, 25.66%). In addition, learners also posted social (75 units), learning (57 units), doing (36 units), evaluation (34 units), questions (10 units), and planning (7 units). In the thoughts and emotions, learners reported a lot of positive emotions (52 units, 44%), indicating having fun, things are cool, feeling awesome, showing love toward the STEM program or particular object in the program. The amount of thoughts and emotion spanned throughout the whole program with peaks at the beginning and the end (see Figure 1, right). There was a small increasing trend for evaluation and doing, but the planning part was minimal through out the program.

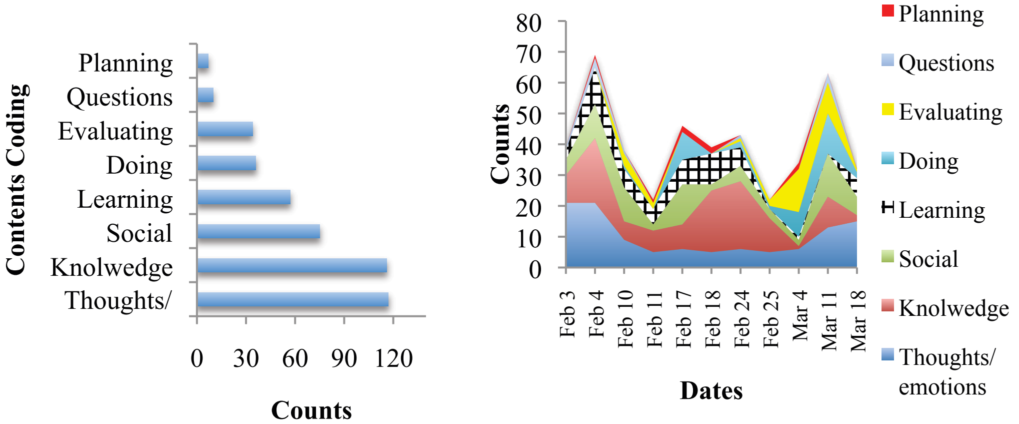

Figure 1. SNF posting contents and counts (left) and contents changing pattern (right)

Five out of 18 facilitators' posts were questions and the rest were recognition of achievement and encouragement. One-way ANOVA showed that youth posted significantly more units when a facilitator asked questions than not, F (1, 13) = 4.93, p <0.05. Bivariate correlation indicated that youth's counts of units had a significant positive relationship with facilitator's prompting questions, r = .52, p <0.05.

Conclusions and implications

This research provided empirical data to explore the possibility of using SNFs to elicit metacognition in a design-based science-learning environment. The youth postings on *Edmodo* showed a variety of things, but the proportion of metacognitive acts (i.e., evaluation and planning) was small. The amount and contents of youth postings may be influenced by facilitators' promptings. Facilitators' questions elicited more responses than recognition and comments did. The facilitators' prompting strategies (mixed random questions for each session vs. four standard questions for all sessions), participants' age difference (middle school students vs. college students), and format (conversations vs. blog) were different from the *Tumblr* study (Huang et al., 2014) and need to be further tested for learning effectiveness. Knowing the proportion of different types of contents, facilitators can use corresponding prompting strategies to enhance specific skills. For example, in order to increase planning skills in metacognition, facilitators can add planning related prompting questions.

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Young Adults' Use of Semiotics in Science News Infographics

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Abstract: This study examines how secondary school students use semiotics in creating science news infographics. A total of 156 students participated over two years in formal school and out-of-school contexts and created 170 infographics through a collaborative process, using computer-based tools. Analysis of the infographics shows both the promise of students producing complex, data-driven representations that allow multiple comparisons and the challenges of overuse by learners of non-value adding icons and still images in the process.

Keywords: semiotics, infographics, multimodal representations, science literacy, data journalism

Introduction

Visual inscriptions are essential elements of STEM education (Gilbert, 2008; Yore & Hand, 2010). They are often used in science textbooks and scientific journals to organize and communicate data and ideas. Researchers examined the nature and purpose of such inscriptions in relation to the role they play in students' learning (e.g., Lee, 2010), the challenges of learning from visual inscriptions (e.g., Bowen & Roth, 2002), and ways of developing students' representational competence (e.g., diSessa & Sherin, 2000). In-depth understanding of students' learning with visual representations and developing their representational competence necessitates examining the kinds of semiotic tools students use when they produce representations by themselves. When students produce visual inscriptions based on topics of their choice (as is the case in our project), they are both authors of the content and designers of the representation at the same time. Traditionally, authors of texts focus on the style, perspective, grammar, and spelling of their writing. Designers, on the other hand, used to focus mainly on visual presentation of the message (O'Grady & O'Grady, 2008). What kinds of representational repertoires do secondary school students use? How do their choice of semiotic tools contribute to the overall quality of the infographics? Answers to such questions can help to understand how students approach learning with and from representations as well as to design instruction for fostering their competence at multimodal representation. In this poster, we focus on students' use of learned and inventive representational forms in creating science news infographics.

Methods

This proposal is based on NSF funded research on STEM literacy in which students conduct data journalism by authoring infographics. We focus on one aspect of the project data, student generated artifacts (infographics). The project is situated in the Midwestern United States, and involves young adults aged 14 to 17 in a secondary school and an out of school internship program. The project started in fall 2012 and continued through spring 2014 with different groups of students each academic year. A total of 138 students participated at the secondary school, and another 18 interns participated in the out-of-school internship. Students had choice of working in pairs or alone. Overall, students produced a total of 170 final versions of infographics, of which we analyzed 123 (72%) using an inductive approach, constantly comparing the types of representational tools students used and the dimensionality (number of insights) of the visual inscriptions. The inductive categories are described in the findings section below.

Findings

Students used different types of representations in creating their infographics ranging from a minimum of one and a maximum of seven types of representations with an average of 2.86. These include pictures, icons, schematic charts, pictographs, quantitative graphs, text and others. We grouped the types of representations into four: iconic, text, schematic, and charts and graphs. Iconic representations depict structural associations with the referent object and may include icons and pictures. Text representations are descriptions using words and sentences (not including labels and titles). Schematic representations depict components of invisible phenomena and the relationships between the components. Examples include organizational charts and semantic maps. Charts and graphs represent quantitative data to provide concrete insight about the nature and relationship of datasets. Figure 1 presents the frequency of these types of representations in student-generated infographics.

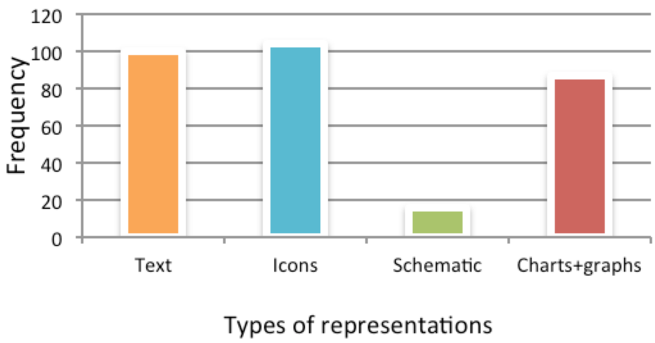

Figure 1. Types of representations students used

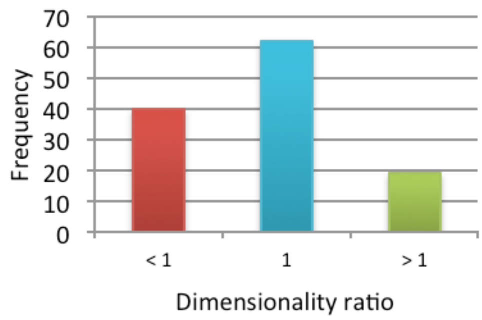

Figure 2. Dimensionality of Infographics

As an indicator of semiotic richness and representational efficiency, we also analyzed the number of dimensions each infographic provided for readers without the text component. That is, how many aspects of the represented phenomenon are addressed by the non-text representations? We then calculated a dimensionality ratio where we divided the number of dimensions an infographic has by the number of non-text representations. The dimensionality ratio tells the extent to which students created parsimonious representations by organizing their data and communicating more ideas with denser visual elements; the extent to which students used or avoided using unnecessary or less useful diagrams in their infographics. Ratio values of less than 1 imply use of representations without adding meaningful dimension to the message. A common case is the use of icons to represent a physical object without embedding any data, such as, a picture of a cigarette next to a bar graph that shows the number of smokers by gender, or a diagram of a brain next to data about brain injuries. If the dimensionality ratio is 1, it means one type of representation communicates one dimension of the issue under consideration. A ratio of greater than 1 implies one type of representation provides more than one dimension where it allows multiple layers of comparison. Further elaboration of these analyses and examples of the categories are included in the conference poster.

Conclusions and implications

Multimodal representations are increasingly used in science communications both in formal school and out of school contexts. Students who can decipher these representations and determine good, data-driven infographics from less useful ones with merely decorative images will be at an advantage over students with less sophisticated semiotic repertoires. Our findings show both the promises and challenges of working with young adults to develop their representational competence. On the positive side, 72% of all infographics are data-driven representations using charts and graphs, and 16% of all infographics have more dimensions than types of representations. Students do not seem to have trouble making use of iconic representations, as 86% include iconic depictions. But iconic depictions are less useful when utilized extensively, as happened in the 33% of infographics with a dimensionality ratio of less than 1.These infographics with low dimensionality ratios make use of non-value adding or decorative representations. The study has implications for understanding young adults learning with representations and in designing learning environments that foster greater student competence at multimodal representation.

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Orchestrating Visualization Tools for Supporting Collaborative Problem Solving in the Classroom: A Case Study

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Abstract: This paper presents the preliminary instruction design and enactment of a collaborative concept-mapping project on Food and Nutrition in the Web-based Inquiry Science Environment (WISE) platform with grade 7 students (n=25) in an urban high school in Canada. In this study, we present the design of the collaborative inquiry curriculum and examine student performance and perception on tasks. It informs us some information of how to orchestrate visualization tools for supporting deep learning from instructional design and supporting structuring learning process perspective.

Keywords: collaborative concept mapping, visualization tool, science education, case study

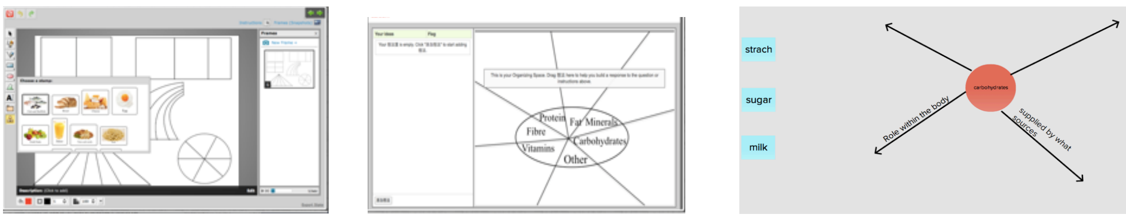
Introduction

Many research-based pedagogical and technological scaffold often bear little resemblance to authentic inquiry practice; on the other side, most science teachers do not have adequate classroom time or resources to involve their students into collaborative inquiry activities (Dillenbourg, 2013). Therefore, the CSCL field requires further study of how to orchestrate appropriate interventions to scaffold collaborative inquiry in the classroom.

Considering visual tool have the advantages of making thinking visible, providing resources for conversation and functioning as a "convergence artifact" that expresses the group's emerging consensus (Suthers, et al., 2007), it may sever as a pedagogical scaffolding for teacher to structure learning activities across different levels, while act as technological scaffolding for student to conduct dynamic collaboration and knowledge building. Thus, this preliminary study intends to investigate how to integrate appropriate visual tools in the classroom for both design and enactment the collaborative inquiry project.

Instructional design

According to Ontario curriculum expectation on Food and Nutrition, we designed a learning project addressing an open-end problem: "How to make a healthy food plan?" using WISE platform (Slotta & Linn, 2009). Consider that learners lack the knowledge experts for inquiry activities, and ideal inquiry involves adding new ideas and helping students distinguish among ideas in their repertoire, we design first three knowledge-orientation learning activities which are respectively supported in WISE by two built-in visual tools, namely Drawing and Explain builder and one embedded collaborative mapping tool, namely Mural.ly, and one inquiry-orientation learning activity supported by Mural.ly.



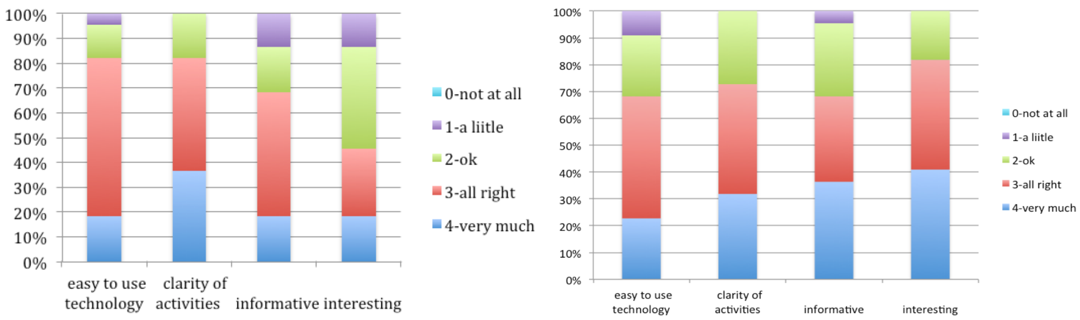
(a) (b) (c)

Figure 1. Chose "framework" and sorted foods in Drawing (a); Explain builder page of Nutrition category (b); and Mural.ly starter page: Carbohydrate group (c)

Specifically, in the first activity of understanding food groups, after sorting the 20 foods preloaded in Drawing tool into similar groups and writing a WISE reflection note to describe grouping rationales, students in pairs chose one of five pre-designed classification "frameworks" and sort the 20 foods again by "stamp" tool in Drawing tool (see Figure 1a). In the second activity of knowing six kinds of nutrition by exploring the Nutrition Fact Table (NFT), the NFT introductory page is designed and then a video of how to interpret the NFT is offered, which is followed by two small exercises to test pair students' NFT understanding. Finally, an Explanation Builder page is visualized for students to add and organize group ideas of six nutritional categories on the radial framework (see Figure 1b). In the third activity of understand each nutrition's function, 6 groups are assigned and each group is responsible for one of the nutritional categories. Based on readings of relevant learning material, each member in a group can log in Mural.ly to edit the same concept map simultaneously, seeing another's edits, and communicating through a chat window. In order to scaffold students focusing on the salient aspects of their food category, we designed a "starter map" that included some of the basic nutritional elements, and some starter links, such as "role within the body" (see Figure 1c). The goal of the fourth activity is to make a healthy food plan for a fictional student named Jennifer, who had been introduced earlier during the first three activities. In this activity, new Mural.ly groups are created with 6 students, one from each of the six nutritional category groups based on the idea of the jigsaw. Once again, a "starter map" is created, this time in the form of a time line, from 6 AM until midnight, with a clear prompt in the area above the time line, "Foods we think Jennifer should eat" and below "our ideas about nutrition and energy". Students are asked to draw as many lines of connection between different foods, and ideas, as possible.

Methods
This study involved 7th grade 25 female students in an urban high school in Canada. The science teacher administered a 30-minute pre-and post-test, as well as the entire curriculum design over four 70-minute class periods. Data collected in this round of trials include: students' pre-test and post-test performance on an assessment of conceptual understanding; students' perception of the main technologies and their Mural.ly maps.

Results
Findings revealed that: (1) students' learning gains around the targeted learning topic are improved ($t=7.97$, $P=0.000<0.05$), while they did not completely understand the relationships between food categories ($t=-1.49$, $P=0.150>0.05$) by a paired-sample t-test of the students' pre-test and post-test scores. (2) Students show high positive acceptances of the technologies used in this study, see Figure 2. (3) By analyzing map-data from Mura.ly, student not only can collaboratively add picture, text and arrows in Mural.ly map to represent group's understanding of learning topic, but also can group well to make some change to alter and extend group artifact.



(a) (b)

Figure 2. Students' perception of WISE (a) and of Mural.ly (b).

This study is the first design sequence to investigate how to orchestrate collaborative concept mapping in the classroom context of a meaningful inquiry activity. In this study, WISE was successful in orchestrating different visualization tools in different sub-activities. From the macro-perspective, WISE worked quite well to structure the overall inquiry activity. From a micro-perspective, the various visualization tools can practically served their purpose well in the classroom. However, we do not research the relationship between the orchestration design and the learning effect in the classroom. Therefore, for the future, the second-round study will emphasize more in the role of collaborative concept maps in supporting knowledge development.

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Collaborative Learning in Online and Offline Makerspaces

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Abstract: Recently, there has been a surge in making and DIY practices as a result of the maker movement. The online communities that have emerged from these practices and the shared physical locations, *makerspaces,* are broadly viewed as places for collaboration and peer production. This study examines learning and collaboration that happen among makers within these communities. Interviews with 39 makers provide empirical insight on current collaborative practices of making in online and offline maker communities.

Keywords: makerspace; DIY; collaborative learning; remix; peer-to-peer learning, peer-production

Introduction

The *maker movement,* characterized by the do-it-yourself (DIY) creation of physical objects has grown tremendously in the past decade (Dougherty, 2013). Consequently, there has been an increase in research and educational programs in the United States seeking to leverage the maker movement (Fagin & Merkle, 2002; Kuznetsov & Paulos, 2010). For example, Buechley et al. focus on how the maker movement can contribute to the learning experience in informal settings and in K-12 classrooms (Buechley, Peppler, Eisenberg, & Kafai, 2013). Other researchers have started to examine the collaboration and learning that happens in *makerspaces*— the physical spaces where makers work, share tools, and organize events (Sheridan et al., n.d.). While others have focused on learning in *physical* places, our contribution is a descriptive exploration of both *offline* and *online* maker communities and how they serve as learning platforms.

Background and motivation

The increasing popularity of the maker movement has given rise to institutions such as the Fab labs (Mandavilli, 2006), events such as the Maker Faires (Rosenbaum, 2012), publications such as *MAKE Magazine*(1), and platforms such as the Arduino boards (Sarik & Kymissis, 2010). The multiple disciplines and motivations for makers suggest that we need to explore a wide variety of makers to understand their learning practices. To situate our findings, we looked at collaborative learning that seemed to hold potential for the maker movement, as well as the previous research that has examined collaboration and learning in making and makerspaces. Proponents of learning-by-making argue that hands-on experience facilitates learning and makes it a collaborative experience (Dougherty, 2013; Katterfeld, 2014). However, while there is a great deal of rhetoric that makerspaces promote collaboration, we found little empirical evidence in literature that collaborative making or learning was happening in makerspaces or in online maker communities. A recent study (Sheridan et al., n.d.) reported some collaboration on formal learning projects with adults helping children, but most projects centered on makers developing individual projects and approaching other members of the community when they needed help or feedback, or wanted to share their project. Lindtner et al. looked at more professional spaces that encompass the DIY maker activities (Lindtner, Hertz, & Dourish, 2014). Although these spaces placed a strong value on collaboration across makers, researchers only reported observing collaboration between individuals and outside organizations, such as manufacturers, government groups, or large corporations.

Methods

This study is based on interviews conducted with 39 individuals who self-identified as makers, hackers, or crafters, followed by a short survey about demographic data. The questions sought to understand the interviewees' making and crafting practices, including their online and offline learning experiences, and their participation in communities. The participants were recruited via email (to maker groups and student organizations), physically going to makerspaces, and asking makers/crafters for referrals to others. Researchers used pattern coding (Saldaña, 2012) to identify emergent themes in the data and describe the higher level patterns that emerged from the interviews.

Discussion

Makerspaces and the online communities of makers can provide open platforms for various audiences to collaborate on personally meaningful projects. The potential of these spaces has been identified but calls for a closer look at collaboration and learning practices that are happening, both online and offline.

What do common collaboration practices look like in online maker communities? Online maker communities provide a platform for collaboration through support of remixing and iteratively building on each other's work. Peer production, similar to open software productions where a group collaborates on a shared project, was rare among online makers. The appeal to remixing may be due to the physical aspect of making, which makes collaboration on shared projects difficult in a distributed setting.

How do these collaborative practices compare to collaboration in physical makerspaces? Findings suggest little collaboration is happening in makerspaces in terms of working on shared projects. There is a contradiction between the little collaboration our interviews revealed and the continual presentation of these spaces as supporting collaborative work. There could be a number of explanations as to why this conflict in understandings may be happening. For example, it may be that the rhetoric simply is not in line with the reality, or collaboration is occurring in ways that the interviewed participants did not recognize as collaboration.

What do common learning practices look like in online maker communities? Makers often engage in information seeking to solve particular problems on their personal projects, engage in question and answers with their peers, and browse different projects for inspiration. Often these inspirations result in further exploration of new fields and contexts that lead to additional learning. Makers also engage in remixing practices and the learning outcomes that stems from remixing. Iterative building and tagging online is promising for collaborative knowledge building and calls for further investigations.

Contrary to the common assumption that makerspaces inherently promote collaboration and collaborative learning, these practices are not as common as envisioned. While future research should investigate the reasons behind this lack of collaboration, we observe another type of peer-production among makers online, in the shape of remixing. Barnes (2012) describes remixing as a new form of social learning. While our findings provide evidence for learning in makerspaces in the shapes of peer-to-peer question and answer, igniting interest in tinkering, and exploring new diverse sets of disciplines; they also suggest there is further potential for learning in these spaces by supporting remixing practices.

Endnotes

(1) MAKE Magazines estimates a readership well above 300,000. http://cdn.makezine.com/make/sales/Make-Magazine-Overview-and-Rates.pdf

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Thinking Within and Between Levels: Exploring Reasoning with Multi-Level Linked Models

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Abstract: This poster presents a pilot study with a prototype technology that allows learners to link agent-based models written in NetLogo models and run them simultaneously as a coupled system. We describe ongoing design work using this prototype to investigate how learners conceptualize multi-level modeling of complex systems in ecology.

Keywords: agent-based modeling, NetLogo, complex systems thinking, ecological complexity

Introduction

Agent-based models (ABMs) have been used for decades as educational tools, helping students conduct the analytical inquiry of modeling and reason about complex systems (Wilensky, 2001). Learners investigate the behavior of a complex system by "growing it" from the simpler behaviors of its constituent *agents* (Epstein & Axtell, 1996). This process involves identifying agents (e.g., wolves, sheep, and grass), and defining computational rules for their interactions (e.g., "wolf-hunts-sheep" or "sheep-seeks-grass"). An ABM may include thousands of computational agents, whose combined activity can give rise to emergent system-level behavior (e.g., the stability and fluctuation of a wolf-sheep-grass ecosystem). Importantly, the process of modeling involves delimiting and simplifying reality: creating representations whose *utility for a purpose* compensates for their loss of verisimilitude (Box, 1976). However, once an ABM has been built, learners often have ideas and questions about how the phenomena it highlights may interact with features or systems in the world "outside" of it. We see this drive to explore connections of an ABM as a powerful gateway to new kinds of model-based inquiry and as an important synthesizing counterpoint to the analytical work involved in creating a single model. Placing a model in an *ecosystem of related models* could offer a powerful bootstrap to reasoning about multi-tiered and nested complex systems. Here we describe a design study addressing the question, How do learners reason across *and between* models when programming connections between them?

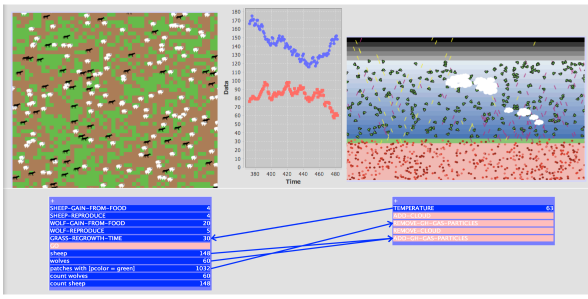

Figure 1. The ModelConnector GUI. Arrows indicate learner-created relationships between models.

Methods

To explore learners' ways of thinking about linked models, we built a prototype environment (ModelConnector, see Figure 1), which executes a pair of NetLogo (Wilensky, 1999) ABMs simultaneously (here, the wolf-sheep-grass ecosystem and a Climate Change model of greenhouse effects). Through a point-and-click interface, learners construct new computational relationships between the two models, which are enacted during the execution of the model-pair. ModelConstructor provided us an environment to investigate learners' reasoning about these models and their conceptions of links between them. Because little research has been done on learners' conceptions of Multi-Level Linked models, we took a broad, open-ended approach in our study. We recruited two high school science teachers, Tom and Taylor (pseudonyms) who had previously used ABMs in their classrooms. We had them collaborate using ModelConnector to explore and discuss relationships between Wolf Sheep Predation and Climate Change, as follows. First, they worked with each of the models individually, spending 20 minutes on Wolf Sheep Predation and 10 minutes on Climate Change. In this phase, they identified and explored the rules and behavior of each. When we felt they had sufficiently understood the individual models, we opened ModelConnector for them to investigate links between them. They engaged in this work for 25 additional minutes, discussing and programing links that caused the two models to affect each other. During this entire process, we conducted an unstructured interview about how the two systems might be related. The session was video recorded, and the participants' software interactions were captured with Camtasia.

Analysis

We first did content logging of the resulting video, identifying episodes in Tom's and Taylor's reasoning about the models and reducing our video data from around 68 minutes to around 9 minutes. These episodes were selected on the basis of whether either participant talked about *what* in the two models might be connected, *how* they might be connected, or *why* they might be connected. We then coded the selected video in greater detail, taking an open-ended approach informed by prior research on using ABMs for studying complex systems reasoning. In this poster we present two particularly interesting codes from this process: "within-model questioning", and "unpacking relationships". We provide an example of each, below.

Findings

When asked how the models might affect each other, Tom immediately suggested that climate change would affect vegetation, while Taylor believed the most important relationship was how the ratio of wolves and sheep to the amount of grass would contribute to greenhouse gases. When asked to elaborate on the former, they said,

Taylor: So if you say that it's less water because it's hotter out, then [grass growth] would go down. But with some plants [...] they can grow even faster because they have more light and more energy

Tom: And it may affect plants at different levels of temperature change. Again, initially it may be promoting more growth, but once you reach a certain point, it may have a detrimental effect.

Thus, when asked to reason about the relationships *between* the two models, basic assumptions *within* the models became salient to the participants. When they had earlier discussed the Wolf Sheep Predation model, they did not mention or critique the model's assumption that all grass grows equally. This suggests a potentially powerful use of inter-model reasoning: creating these links may enable learners to develop new perspectives about the individual models. We then asked the participants to examine Taylor's idea that the 'ratio between wolves and sheep to grass' would impact greenhouse gasses as specific relationships. She and Tom began unpacking that idea into the individual relationships it comprised: (1) wolves and (2) sheep individually *increase* greenhouse gasses through flatulence; and (3) grass *reduces* greenhouse gasses through photosynthesis. In this way, Taylor and Tom moved from thinking about the relationship at the aggregate level (ratios between populations) to a more agent-level kind of reasoning in which each individual affects the system. This kind of reasoning has been shown to be particularly productive for reasoning about complex systems. This suggests that linking models may help learners to concretize their intuitions so they can be expressed in specific behaviors. It helps them unpack relationships and reason about agent-level mechanisms.

Conclusions and implications

While very preliminary, our data suggest that inter-model reasoning is a fruitful subject for further study: Our participants were able to reason productively about the relationships between models, and this further helped them critically assess each of the models individually. Our future research goals include designing and testing curricular units that draw on these cognitive affordances of Multi-Level Linked modeling, and on increasing the power and expressivity of software environments that support learners in creating Multi-Level Linked models.

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Young Children Reading iPad App Books Together: Reading Approaches, Meaning Making, and Changes Over Time

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Abstract: Emergent coding and constant comparative analysis were used to analyze 14 pairs of kindergarteners' approach, social interactions, and comprehension depth when reading iPad app books, and their changes across time. Children used three approaches--hotspot-centric, text-centric, and integrated, which were differentially related to comprehension depth. Social interactions were related to changes over time. Findings inform instructional planning for multimodal reading in early childhood.

Keywords: multimodal text, buddy reading, early childhood, reading approaches

Introduction

Young children are increasingly engaging with digital media (Schuler, 2012), which requires use and interpretation of multiple modes of information (e.g., images, sounds, movement, spoken language) that occur across diverse pathways (Kress, 2010). Little is known about how children use these modes to make meaning and comprehend. Situated by a sociocultural view of learning (Vygotsky, 1978) and evidence that children co-construct and scaffold one another's meaning-making process with traditional text when they work collaboratively (Flint, 2010), we examine (1) multimodal reading processes, (2) social interaction styles, (3) comprehension depth, and (4) how these change over time, for pairs of kindergarteners reading multimodal iPad app books together. Findings suggest implications for multimodal reading instruction.

Methods

The study took place in two Midwestern U.S. classrooms, from which 29 socioeconomically, racially, and linguistically diverse 5-6 years-olds participated. 15 pairs of children read together multimodal iPad app books that included hotspots (that moved, made sounds, or talked to provide additional information) and text that the app read aloud. Each read 12 books, twice for 15-minutes each, across 6 months.

Figure 1. Children buddy reading multimodal text on iPads

For each pair of children one video per month for Oct, Nov., Jan, Mar., and Apr. were selected for preliminary analysis (70 events and 17.5 hours of video). Emergent coding and constant comparative analysis were used to identify (1) reading approaches, (2) social interaction styles, and (3) comprehension depth. (4) Codes across the three videos for each group were analyzed to identify changes over time.

Table1: Codes used for data analysis

Approaches	Social Interaction Styles	Comprehension Depth
Hotspot-centric - mostly attended to information by pressing hotspots, not by listening to the app read text aloud	**Collaborative** - children helped each other interact with text and discussed meaning together	**Level 0** – No discussion about meaning
Text-centric – mostly listened to text read aloud by the app; pressed few or no hotspots	**Non-Collaborative** - children interacted with book, but not one another	**Level 1**- Labeling what is presented in the app book, or creating personal story (not related to text) based on

Approaches	Social Interaction Styles	Comprehension Depth
		hotspots
Integrated – mostly listened to the app read the text read aloud, then pressed hotspots		**Level 2** – Responses related to the text-based storyline
		Level 3 – Higher order responses about the story (inference, critical thinking, connections)

Findings

Approaches were related to comprehension depth—text-centric was related to Level 0 comprehension, hotspot-centric with Level 1, and integrated with Levels 2 -3. Children often initially used the hotspot-centric approach (12 pairs did in Oct.). Integrated reading developed over time, via collaborative social interactions (see Table 2). Non-collaborative was not related to integrated reading (Table 3).

Table 2: Collaborative reading over time—Anna and Burt

	Oct.	Nov.	Jan.	Mar.	Apr.
Approach	Hotspot-centric	Hotspot-centric	Integrated	Integrated	Integrated
Social Int.	Collaborative	Collaborative	Collaborative	Collaborative	Collaborative
Comp.	Level 1-labeling	Level 1-creating story	Level 2 – respond to text-based story	Level 3-connections	Level 3- critical thinking

Table 3: Non-collaborative reading over time—Destiny and Dennis

	Oct.	Nov.	Jan.	Mar.	Apr.
Approach	Hotspot-centric	Hotspot-centric	Text-Centric	Hotspot-centric	Text-Centric
Social Int.	Non-Collaborative	Non-Collaborative	Non-Collaborative	Non-Collaborative	Non-Collaborative
Comprehension	Level 1-labeling	Level 1- creating story	Level 0 – No discussion of meaning	Level 1-labeling	Level 0 – No discussion of meaning

Conclusions

The study identifies children's' approaches to reading iPad app books and how these are related to comprehension, as well as how social interactions are related to changes in reading approaches over time. Our findings about social interactions align with previous research on children's collaborative reading of traditional text (Christ & Wang, in press). Our findings suggest teachers should provide opportunities for social reading and facilitate collaboration to support an integrated approach to multimodal reading.

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Exploring the Effect of Technology-Supported Collaborative Writing on Individual Learning of the Italian Language

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Abstract: This study investigated the contribution of a collaborative writing activity to 14 university students' individual learning of Italian. Students engaged in three writing activities using Google Docs. The analysis of pre-post learning gains, and students' participation in the collaborative writing task, yielded statistically significant results for students' communicative competency. Findings suggest that such wikis can be productive technologies for the learning of a foreign language at the individual and collaborative levels but under conditions.

Keywords: google docs; collaborative writing; foreign language learning; communicative competence; Italian language

Introduction

Collaborative activities in foreign language learning are commonly used and viewed as beneficial to learning (Kessler, 2013; Mutwarasibo, 2013). Learners are reported to be more motivated when working with technology-supported collaborative activities than in individual learning situations (e.g. Ray, 2007). Nonetheless, despite the widespread use of collaborative technologies, such as wikis, in foreign language learning it is not yet clear how such technologies contribute to individual learning (Bennett, Bishop, Dalgarno, Waycott, & Kennedy, 2012; Elola & Oskoz, 2010). This paper examines the contribution of technologically-mediated collaborative writing on university students' individual learning of the Italian language. In particular, this study explored whether three key aspects of foreign language learning (namely, communicative competence, grammatical correctness and conceptual completeness, and writing skills) are enhanced through collaborative activities with the use of the wiki software Google Docs.

Methods

Participants and learning activity

The study was completed in three consecutive Italian language sessions at the level of A1 (introductory stage). Individual learning was operationalized according to the guidelines for Italian language learning and focused on three aspects of foreign language learning: communication skills, grammatical correctness and conceptual completeness; and writing skills. The sample consisted of 14 undergraduate students, between the ages of 17-24, with demonstrated limited prior knowledge of the Italian language. For the purposes of the collaborative activity four equivalent groups were created. Each student was involved in a) an initial individual activity, b) a group activity, and c) a final individual activity. Together, the initial and final individual activities were designed to provide a way to assess individual learning gains. The activities involved authentic communication scenarios likely to occur if a student travels to Italy for the purpose of study or pleasure, and took place in Google Docs. The activities required students to write a dialogue in Italian.

Data collection and analysis

The students' individual and collaborative tasks were conducted using Google Docs. Students' written work was coded using existing coding schemes for a) communicative competence, b) grammatical correctness and conceptual completeness, and c) writing skills. Students' group work participation was also coded based on the history provided by Google Docs.

Communicative competence**:** We used a coding scheme first developed by Hymes (1974) to code students' communicative competence. This was accomplished by tracking individual students' appropriate use of the language for communication, examining contributions in the developing online document such as situation-based exchanges, logical sequence of exchanges, and the use of social norms in the discourse. Students' contributions were categorized in Levels 1-3, with Level 3 being the highest.

Grammatical correctness and conceptual completeness: This coding scheme was based on the Certification of Italian as a Foreign Language exam (CILS) and captured students' spelling, syntax, and cohesion of sentence building. Students' contributions were scored and categorized in Levels 1-3, with Level 3 being the highest.

Writing skills: This coding scheme referred to students' ability to organize the passage they were writing, select appropriate communicative words and use accurate and appropriate vocabulary. It was based on the Common European Framework of Reference for Languages. Students' writings were categorized in Levels 1-3, with Level 3 being the highest level possible.

Students' group participation: Each student's participation in the group activity was also coded in three levels (with Level 3 being the highest), according to the following three aspects: a) appropriateness and frequency of participation, b) quality of participation, and c) peer review and feedback.

Findings

Research Question 1 examined whether students' participation in the collaborative activity led to pre-post learning gains, while Research Question 2 examined if there was any correlation between students' contribution to the group activity and their learning gains.

To answer the first research question we run a Wilcoxon signed-rank test comparing students' initial and final writing performance using students' scores on a) communicative competence, b) grammatical correctness and conceptual completeness and c) writing skills. The pre-post differences were significant for communicative competence, $Z= -2.14$, $p<0.05$ but not significant for grammatical correctness and conceptual completeness, $w=5$, $p>0.05$, or for writing skills, $w=8$, $p>0.05$. Thus, results indicate that students improved their communicative competence but that the writing activities centered on communicative acts, did not help them improve on the other two key issues of learning a foreign language used in this study.

The second research question asked whether the nature of students' participation in the wiki-based collaborative activity was related to the pre-post learning gains for each of the three scoring dimensions. For this reason, we conducted a Spearman's rho correlation test between students' pre-post gains and their level of participation in the group activity. Only one statistically significant correlation was observed, between students' communicative competence and their contribution to the group work (r_s [14] = .036, $p<0.05$).

Conclusions and implications

This study examined university students' Italian language learning, as a result of their participation in individual and group activities using a Google Docs wiki. Findings indicated that the use of the wiki contributed to students' statistically significant pre-post learning gains on communicative competence and that these gains were correlated to students' participation in the wiki-based group activity. The lack of measurable improvement in the other two areas of foreign language learning (grammatical correctness and conceptual completeness, and writing skills) may be contributed to the nature of the writing task, which was focused on developing a dialogue around a communicative act.

The results provide empirical evidence in support of the use of collaborative technologies in foreign language learning and add to the scarce literature on the technology-mediated learning of the Italian language in particular. We acknowledge the sample size and the lack of a control group as the main limitations of the study. Our findings have implications for the use of wikis for the learning of a foreign language. Wikis represent an example of social software that can support synchronous or asynchronous collaborative writing co-located or distributed in space. Our study indicates that depending on the fit between the design of the task and the nature of the task itself the use of wikis can be productive for foreign language learning. Future research should explore these issues with larger sample sizes, discuss the process of learning in more depth and in different learning contexts.

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Measuring Group Progress through a Complex Computer-Supported Design Task: Identifying the Effects of Scaffolds on Learners' Activity

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Abstract: This paper investigates three groups of three postgraduate students who completed the same collaborative design task. Each group was given a different scaffold focused on the design process, assigned roles, or tool use. An analysis of the coded discourse using First Order Markov models showed differences between the groups' decisions related to the scaffolds. Implications for assessment of group progress, and recommendations for the use of scaffolds for collaborative computer-supported design tasks are discussed.

Keywords: collaborative decision making, learning by design, processes of learning

Introduction and background

When we ask learners to participate in complex collaborative tasks, we hope that in addition to the content, they will learn skills such as the ability to collaborate, to use and adapt technology, or to undertake creative problem solving. The focus of this paper is the application of a new coding scheme, the Design Process Coding Scheme (DPCS). It is a discourse-centric measure of the design process as well as tools, task and social interactions. As part of a larger study (Thompson et al., submitted), we applied Carvalho & Goodyear's (2014) analytic framework to the design of three scaffolds for a computer-supported collaborative design task. The *tools scaffold* was focused on use of the tools in the dedicated design space, the *design process scaffold* helped participants to engage in a structured design process, and the *social roles scaffold* gave students roles to adopt.

Methods and findings

As part of a larger project, the role of scaffolding was investigated on three groups of three postgraduate students (the Design Group, the Tools Group and the Social Group) undertaking a complex computer-supported design task (Thompson et al., submitted). The aim of the task was for participants to design a blog about a river system in Australia. Participants were expected to produce a design concept and preliminary sketch based on an exploration of websites and the resources provided. After one hour participants were expected to produce a short statement containing the main ideas for their design concept, and after a further 30 minutes, they were expected to produce a sketch or brief outline of their design solution. The data was collected in the Design Studio, a dedicated space for researching the processes of design at the University of Sydney. Multiple video streams, images, audio recordings, screen captures, and tracking of the websites accessed, and digital and physical artifacts created were collected during this study. Transcripts of the discussion between participants were coded for the decisions that were made.

The DPCS was based on the *design process scaffold* (Carvalho, 2010), and the topics and questions raised during the study. Due to the emergent nature of the coding scheme, coding occurred in several rounds, with three researchers: (1) additions were made based on the application to the Design Group (1311 utterances); (2) further additions were made based on the application to the Tools Group (1408 utterances) and (3) then based on the application to the Social Group (1411 utterances); (4) reapplication of the DPCS to the Design Group and (5) the Tools Group. Participants were expected to progress through the stages of discussing phatics or social interactions, tools, planning (overall), the topic, and the task (Kennedy-Clark & Thompson, 2014). Within the design task, progress through understanding the problem, planning the design, producing the design concept, producing the design sketch was expected (Carvalho, 2010). The DPCS consists of categories and sub-categories: *Social* (managing the information given in the scaffold; roles that were assigned to the participants; *Tools* (using a tool; understanding the tools available); *Overall* (research, task, coordination and technology troubleshooting); *content* (understanding the content); *design process* (understanding the design problem, coming up with a plan, developing the design concept, and producing the design sketch); the *debrief* (debrief). Each sub-category or category was considered to be a state. First-order Markov transitions were calculated (Thompson & Kelly, 2012) and of interest were the identification of transitions *between* phases, which happened rarely. Therefore, a threshold of transitions that occurred more than twice was used.

First order Markov transition diagrams were created based on the transition matrix for each group. In the Design Group, this analysis showed clear, iterative steps through the phases of the design process, mediated by discussion of the task. The regular cycling between design problem to design plan, design plan to design concept, and design concept to design sketch, showed that this group followed the *design process scaffold* closely. In the Social Group, the *content* was particularly important when the group was discussing the *design problem*, and also related to discussion of the *tools*. Managing the *social* interactions was important in the context of the *design plan*. The production of their *design sketch* was only related to the *design concept*. The Social Group followed the *social roles scaffold*, which required participants to take on one of three roles. Two of these (the designer and the content matter expert) played an important part in their discourse. In the Tools Group, a discussion of *tools* was a mediating state for the design process. There is no evidence of the adoption of an iterative design process although progress was made through the phases of design. Far more than the Social Group or Design Group, once the members of the Tools Group began discussing a particular topic, they remained discussing that topic without interruption. While this is interesting in terms of focus, design needs to be an iterative process in which decisions are re-examined on the basis of the new information that is included as the design process progresses.

Discussion and conclusion

The aim of the research was to determine the differences that can be observed in the processes of learning that could be related to the scaffolds. There were observable differences in the processes of learning that appear to be related to the scaffolds that the groups were given. The Design Group undertook an iterative design process, regularly referring back to the materials, or relating what they were doing to the task itself. The Social Group similarly undertook an iterative design process, referring to information about managing the task, and also included reference to the content about the environmental system when understanding the design problem, and discussion of the social, with respect the roles adopted by members of the group when developing the design plan. The Tools Group did not undertake an iterative design process and a discussion of tools was the mediating state. In both the Design Group and the Social Group, students were able to adopt an iterative design process. The *social scaffold* provided the Social Group with the roles needed to participate in complex interactions of tools, task and social. The *tools scaffold* was the least effective. This study was different to others that have used First Order Markov models, it was those links that occurred only rarely, indicating transition between states or phases of design, that were of most interest. The findings here, particularly with reference to the role of mediating states, and the effects of scaffolds on the processes of learning, will contribute to a greater understanding of the interplay of tools, task and social interactions that occurred.

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Implementing a Digital Learning Environment in the Middle School: Lessons Learned from the Pilot Study

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Abstract: This paper sheds light on the challenges and the lessons learned when an innovative digital learning platform was implemented in the Finnish middle school. The topic was physics. More specifically it aims to analyze and present the challenges which arose when applying a digital learning environment in a different culture. Cultural awareness and engaging both teachers and students in designing prototypes should be recognized.

Keywords: digital learning, student collaboration, student learning, culture

Introduction

The educational research is actively trying to catch up with the latest technological evolutions (Kammerer & Gerjets, 2012) which occurred in the previous five years and was a result of the radical development in communications and the spreading of the internet in every corner of the western and not only world. Soon after this revolution a new set of devices such as smartphones, tables and smart boards were created leading the way to a highly digitalized environment which is present in every aspect of our lives including education and learning (Harteis, Gruber, & Hertramph, 2010; Kammerer & Gerjets, 2012). The challenge for the researchers in education is to make use of them in an efficient way (Kammerer & Gerjets, 2012).

The development of digital graphic representation along with the fact that now we are able to, relatively easily, record every step of the user while working in a digital environment, via log files, provides numerous possibilities to not only extend the existing knowledge of specific topics, but also generate new discussions on classic issues within this new status quo. Conceptual thinking and concept maps can now be seen from a different scope given the high visual representation we can offer to the user, re-opening the discussion about the nature of scaffolding and traditional vs. e-textbooks as well (Puntambekar & Hubscher, 2005).

The focus of this paper is to present the attempt to adapt and implement an already used digital learning platform in the framework of an international co-operation. The aim was to reveal potential problems when applying such digital learning material authentic classroom context in different cultural context. In the last phase of the research design there was also an observation and recording of the interaction and collaboration between the students when organized in small groups. The authors found the implementation of this digital material rather challenging facing numerous issues which have been proven to be a useful lesson for the future of the project.

Method

The data was collected as part of a pilot study with the long-term goal of developing a novel design and architecture for dynamic digital textbooks for STEM (science, technology, engineering and mathematics). The researchers have used CoMPASS (Concept Mapped Project-Based Activity Scaffolding System) (Puntambekar, Stylianou, & Hubscher, 2003); an already existing online java platform which is using concepts of physics (force) and it was ideal for the purposes of the research since it combines the implementation of a digital learning platform in a school environment dealing with a scientific field (physics) and its evaluation from the students themselves. After various modifications on the original material in order to adapt to the Finnish context, and fit the purposes of the current project such as alteration of examples used in order to be better comprehended, on May 2013 the researchers proceeded to the data collection. The participants (n=63) were 8th and 9th grade students (male=30 and female=33) from the International Middle School in Turku, Finland. The students were assigned in three groups according to their class and within each group they were randomly assigned into one of the following interfaces: graphical representations vs. textual representations on physics (force). During the modification, distribution and completion of the tasks an expert in the domain of physics was present as an advisor.

During the first day, the students took their time to get acquainted with the tasks and CoMPASS without recording their moves in any log file, filling a pre and post-test at the beginning and the end of the session respectively. At the second day, they had to actively try to complete the set of tasks using CoMPASS while their activity was recorded in log files. In the end of the session they also filled in a post-test which was followed by a recorded group discussion in an attempt to reveal the dynamics between the students and a questionnaire regarding the digital material as a whole.

Findings

The findings show a slight improvement in the performance of students in these tests during the first day which cannot be considered as significant though. However, in the end of the second day when they completed the post-test, their performance showed an important decrease of the wrong answers compared to the pre and post-tests of the first day.

Moving to the second part of the results, the researchers analyzed the responses from the questionnaires which were distributed after the completion of the implementation addressing students' attitudes towards CoMPASS. The findings clearly showed that the platform was not perceived positively from almost half of the students since they felt it was not appealing to them for various reasons (e.g. it was boring, too long, and pointless). The attitudes towards the digital material can be demonstrated in a very clear way when looking at the overall evaluation on the usefulness of CoMPASS.

The overall stance of the students towards CoMPASS was estimated by the sum score of their answers in the relevant questionnaire. It is pretty clear that more than half of the participants evaluated CoMPASS as rather not useful demonstrating the balanced attitudes which are present also in every item.

Conclusions and implications

Implementing digital environment in a different cultural learning context proved to be rather challenging in many levels. To begin with, there were issues with both the hardware and the software as well as with the process itself reminding to the researchers that the use of technology can offer many possibilities but can also cause new problems e.g. compatibility issues. Moreover the researchers had to deal with the obvious lack of motivation from the students e.g. not completing the questionnaires which can be explained in many ways such as bad distribution timing of the material when students were tired. Additionally, the language was proven to be an unexpected barrier; even though the study occurred in an International School were the vast majority of the students are bilingual, the use of scientific terminology seemed as rather demanding for them asking for clarifications quite often even to basic concepts such us Newton's Laws. Furthermore, useful knowledge was gained during the group discussion too: students were uneasy and unwilling to generate meaningful discussion on physics and collaborate with each other e.g. talking about random everyday issues and ignoring the instructions. Last but not least there were also problems with the teachers who were not familiar with the procedure and could not contribute as they would wish to and the school when it came to administrative arrangements e.g. scheduling and communication.

Some of the aforementioned obstacles were rather easy to overcome whereas some others demanded a lot of effort and creativity. The problems with the hardware, software and procedure were analyzed afterwards and taken into consideration when designing the next phase of the project. A better design and detailed instructions have also helped solve the issues with the students, teachers and school.

Despite the challenges, the implementation of CoMPASS in this pilot study had very useful outcomes as it increased the understanding of teacher's and students' perspective on the procedure which functioned as a base for planning and designing the next phases of the project. In few words, this pilot study revealed the challenges and patterns in real life adaptations of digital environments in the school. Additionally, the discussion about the lessons learned is considered useful not only for the researchers but also for the e-learning community enriching the already wide experiences, challenges and solution pool for those interested in the field.

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The Emergence of Norms in a Technology-Enhanced Learning Community

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Abstract: Meaningful collaborative learning can be fostered by successfully dealing with personal and interpersonal challenges faced by members in technology-enhanced learning communities (TELCs). To better understand these challenges, this research takes a micro-genetic approach to investigate the processes of norm emergence in a TELC where graduate students successfully resolved an intra-group conflict. Our preliminary findings focus on the process whereby implicit norms became explicit.

Keywords: CSCL, norms, technology-enhanced learning community

Introduction and background

The purpose of this exploratory research is to examine how norms emerge within a newly formed technology-enhanced learning community (TELC). Norms are a central source of social order and predictability and form part of the culture of every society. While there have been many definitions of norms ,the understanding of norms taken in this research is that norms are not explicit rules, but rather a collective notion of expectations and obligations of behaviour as well as the regulations of relations between people and attitudes that are formed in a TELC. Norms regulate the type of collaborative learning that happens in a TELC.

One key aspect of successful group collaboration for meaningful learning is the ability to work fruitfully together by forming and following group norms (Bielaczyc, 2009). The processes of norm emergence can reveal significant interpersonal challenges such as those stemming from incompatible members' working styles (Näykki, Järvelä, Kirschner, & Järvenoja, 2014), or tensions between previous learning habits and a new learning culture encountered by newcomers to a TELC (Hod & Ben-Zvi, 2014). Therefore, the aim of this research is to investigate the characteristics of socio-emotional norms that emerge in a TELC as well as how do these norms emerge?

Methods

Participants and setting

The participants in this research were 20 students from a graduate level course called "Challenges and Approaches to Technology-Enhanced Teaching and Learning" (CATELT) which is a mandatory, introductory course lasting a semester for students at the University of Haifa's Educational Technologies Program. MA students enrolled in CATELT met face-to-face once a week at the University for four hours. In between these meetings, during the week, the students maintained a reflective diary on an online Wiki platform that was open to all members of the TELC. In addition, students interacted with each other on the Wiki in interactions that consisted of responding to each other's writing, collaboratively editing content pages as part of course tasks as well as communicating about social, emotional and content issues

Data collection and analysis

Data for this research were obtained from all face-to-face meetings, which were video and audio recorded and then transcribed verbatim, from students' reflective diary writing on the Wiki as well as writing on the community page of the Wiki. The data were micro-analyzed and triangulated by a team of novice and experts peers (Hod & Ben-Zvi, 2014).

Specific research questions

The aim of our research was to create a case study whereby the characteristics and process of norm emergence could be illustrated (Yin, 1994). To do this the following operational questions were asked:

1. What interpersonal conflicts emerged between students within CATELT?
2. What norms developed following these interpersonal conflicts?

Preliminary findings

During the fourth week of the course, different members of the TELC were beginning to experience discomfort and unease due to interpersonal issues that arose from their collaborative learning assignments. Members of the TELC were faced with conflicting work styles and different perceptions of their role in the TELC. For example, students felt differently about how much authority any single member should take in collaborative learning tasks. In the context of the rising tension, a crisis event occurred that was centred on an e-mail that was written by a dominant member of the TELC. The e-mail was sent to certain members of the group who appeared not to be involved in a collaborative task assigned to the group that week. The content of the e-mail was an invitation to these members to put their names in a table that consisted of a list of smaller tasks derived from the main collaborative task assigned to the students for the week. The e-mail was copied to the moderators as well. The inclusion of the moderators in the email led the members to feel that they were being 'policed' or 'scolded'. The incident was discussed in the next reflective meeting where tensions ran high to the point that the student who sent the e-mail left the room in tears.

During the week that followed, several students related to this incident in their personal reflective diaries. For instance, one student, an artist by profession expressed her understanding of the incident through a watercolour drawing in which she reflects about how words could be misunderstood and yet there existed a deep desire in the community to reach common understanding. Her drawing represented the emergent community's understanding that conflict should be used as a learning experience to better integrate and appreciate different opinions and work styles. Other students, reached out to the student that wrote the email reassuring her of the community's appreciation and support for her ideas even if they did not agree to them. A few students wrote about pre-supposing that each member of the community would contribute to the best of his /her ability: "*An important principle of our work is that each one of us does the best that he/she can without looking at the amount (of work) another person does*" (Ursula, entry from reflective diary). In general the approach taken by the majority of the community was a desire for acceptance of and tolerance for differences (an emergent norm).

This conflict initiated a process where the group started articulating and negotiating their norms more explicitly. Specifically, the beginnings of a norm of tolerance was observed through the understanding that conflict could be used as a learning experience. The idea of pre-supposing that each member of the community will contribute to the best of his/her ability was articulated explicitly.

Discussion and conclusion

Our research questions asked about the interpersonal relationships that developed within a learning community and aimed to define the norms that emerged from these interpersonal conflicts. Different working styles and role perceptions led to a conflict that revealed implicit understandings within the community. The conflict allowed the members of the community to define a norm of tolerance. The unique design of the course utilizing the Wiki, allowed for transparency and a window to the thoughts of members in the community. The writing and discussions within the reflective diaries allowed the members of the community to negotiate their expectations and beliefs about learning in a community. Given the limited time frame of the course, the public venue of the Wiki acted as a catalyst for a consensus to emerge in defining a norm of tolerance.

Examining norms through a CSCL learning community lens sheds light on the socio-emotional-cultural and cognitive processes by which norms arise and attain a normative status. Such an examination can also help elucidate a key component in the development of technology-enhanced learning communities.

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Interactive Visible Light Communications: Using Human-Light Interaction in Learning Contexts

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Abstract: This paper describes a conceptual framework about the exploitation of light in a novel and integrated manner, using a solid-state lighting infrastructure to provide wireless connectivity, illumination as well as advanced ambient intelligence. These capabilities are achieved by using lighting sources made of light emitting diodes (LEDs). The fact that LEDs can be easily controlled brings another dimension to the proposed concept, as the light sources are used to provide visual signaling in the space-time-color and intensity domains. This will allow embedding intuitive visual information to users to enhance social interaction, orchestrate activities and manage learning situations.

Keywords: light emitting diodes, visual light communication, human-light interaction, learning cube

Introduction

Our paper is a future-looking initiative focused on the use and exploitation of solid-state light in novel ways. (Nakamura, 1997; Pimputkar, Speck, DenBaars & Nakamura, 2009). We aim to use of visible light as a way to provide wireless communications. As such it is a promising and novel approach complementing radio technologies in a variety of uses and scenarios. This aspect is known as Visible Light Communications (VLC) and it has not been studied extensively yet as it is a rather novel concept introduced approximately in year 2000 (O'Brien & Katz, 2005). However, we believe that this approach can be enhanced and extended by adding new dimensions to the concepts of VLC. We propose the concept of interactive visible light communications (iVLC) as an integrated solution providing (optical) wireless connectivity together with energy-efficient illumination, as well as intuitive ambient intelligence and social interaction.

Smartbeams: Multiple dimensions of light

The iVLC concept uses beams of light generated by solid-state sources. Light beams capable to generate light that can be exploited in multiple dimensions are called *smartbeams* in this project. However the lighting elements need not to be necessarily arranged as a two-dimensional regular array but they can be in fact in any position of a three-dimensional space. In practice lighting elements could also be on the floor, walls and integrated into furniture, appliances and objects, for instance. As human being are the ultimate beneficiaries of the light, we define this interaction as Human-Light Interaction (HLI).

In short, human-light interaction defines how certain target actions are mapped into light outputs. A target action is a desired activity or situation an actor wants to achieve. For example, an act could be an elaborated succession of activities defining for instance certain orchestration. An actor is a person, a group of persons or a machine, local or remote, managing or controlling a space with people. A target action could be for instance broadcast certain information to people, provide visual guiding, orchestrate a situation, create a particular mood, illuminate the room, display a graphic symbol or icon (still or moving), send data to a particular device or group of devices, etc. It is important to note that several target actions can be realized at the same time, for instance, while illuminating a given scenario, the system can also provide data coverage as well as produce visual signaling in the time-space-color-intensity domains.

Lightcube as a conceptual tool for human-light interaction

LightCube (figure 1) is a conceptual tool for learning contexts. It is a cube where each of its faces can be used for sending and receiving data information through light while at the same time each face can change color and intensity as a way of signaling visual information. LightCubes can be made small and portable, to be used as personal information hubs, and also they can be larger in size to serve as a hub for several people in a given space. For instance, in a classroom each student could have a LightCube serving as a hub for interacting with other actors around him or her. The upper face of the cube could serve as a visual student-teacher interface whereas the left and right faces could visually connect the student with his or her immediate classmate.

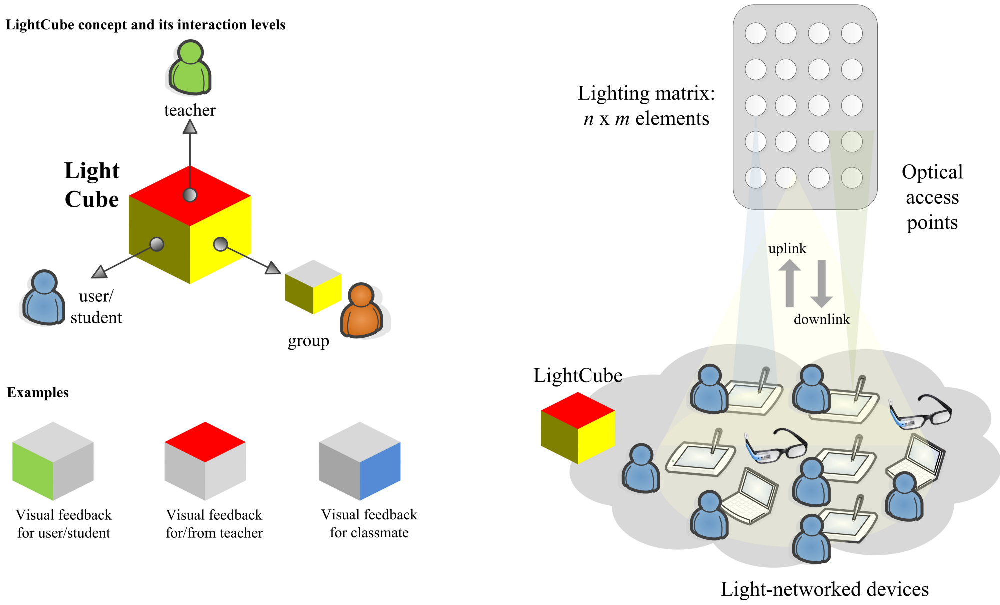

Figure 1. The concept of LigthCube

Human-light interaction scenario in a learning context

This scenario is based on three design principles for supporting socially shared regulation (Järvelä & Hadwin, 2012): awareness, externalization and prompting regulation (Järvelä, et. al, 2014). The classroom is illuminated by inexpensive and very low-power consumption solid-state lamps, a prevailing green attitude of the time. Students in the classroom use portable devices (e.g., tablets) including lightcubes (described above) as learning tools. Teacher uses ceilings lamps, cubes and VLC equipped furniture for orchestrating (Dillenbourg, 2013) teaching and learning activities. She/he will start by having whole class session in which learning materials are broadcasted on the devices' screens as the teacher goes through the agenda of the following groupwork and introduces the topic. During the class students can externalize their emotional, motivational or cognitive states by using the LightCube. As light wavelength (i.e., color) of ceiling lightning and lightcubes can be dynamically tuned, appropriate ambient atmospheres will be created in response to students' cognitive, emotional or motivational states. Light is used in the classroom for carrying all required information, namely data to/from the wireless VLC devices and visual intuitive information to the students' eyes. Because VLC connectivity is based on light, classroom is equipped with activity specific VLC tools: e.g. homework syncronization hotspot and groupwork table with special data areas. In sum, light is used in this classroom to guide and support, in a natural and simple fashion, all classroom activities, orchestrating intuitively actions such a class workflow control, guided collaboration and teamwork, timing and order management, group formation and others.

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Visualising Socio-Material Practices in Knowledge Creation

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Abstract: This poster presents a technique for analysis and representation of socio-material knowledge creation processes for a case-based study of tertiary student groups. Plotting objects, actions and focus on a timeline creates a visualisation of emerging epistemic agency. This visualisation complements ethnographic description and multimodal analysis. The research for which pilot data is presented below aims to inform learning design by investigating the interplay of student actions, constructed objects and learning environment.

Keywords: knowledge creation, epistemic objects, socio-materialism, student learning, analysis

Theory

The theoretical basis for the research lies in the knowledge creation metaphor (Paavola & Hakkarainen, 2005) and its concepts of shared epistemic agency and the social construction of objects. Shared epistemic agency refers to how people create knowledge socially: how they create shared epistemic objects, but also how they organise and construct the conditions for effective collaborative work on those objects (Damşa, Kirschner, Andriessen, Erkens, & Sins, 2010; Muukkonen, Lakkala, Kaistinen, & Nyman, 2010). Agency is 'situated': it takes place with a particular problem, in a particular environment, using specific tools, practices and shared objects. It is the shared objects that form the locus of interaction. Objects can have varying roles in interaction: as the focus of knowledge work—an 'epistemic object'—or as a supporting 'technical object'. An epistemic object is an artefact, inscribed or not, that expresses contested, emerging or negotiated knowledge (Ewenstein & Whyte, 2009; Knorr Cetina, 2001) and is acted upon and changed. It may be a document under collaborative construction or a concept under dispute. By contrast, a technical object (Ewenstein & Whyte, 2009) is static and tool-like, for example a textbook diagram of the epidermis—and generally taken at face value.

The objects, actions and tools used by the group make up their specific environment or infrastructure for collaboration. This happens in the context of a constructed, relational and situated learning environment (Ellis & Goodyear, 2013) that is a 'laminate' (Goodwin, 2013) of available options, both formal and informal.

Method

Video, audio and object (eg notes, resources, photographs) data were collected as a pilot from groups in a 90-minute session in an undergraduate Science Education course. Discussions were transcribed and videos observed for the use and creation of objects. Actions, categorised using Damşa et al.'s (2010, p. 175) schema, and objects as well as the focus of the groups were plotted on a timeline and analysed for focus or higher-level actions (Norris, 2004). I looked for the things that became visible in interaction, dealing with the 'issue at hand' (Barab, Hay, & Yamagata-Lynch, 2001). The actions were coded using using 'E' for epistemic actions, 'R' for regulative or group management actions, numbers for categories within those divisions and the final letter to specify codes (the key is available on the poster).

To complement the graphical representation, I applied elements of multimodal interactional analysis (Norris, 2004) in a textual description of the observed collaborative session, using her concepts of 'fluid' actions that take place in real time and 'frozen' actions that are represented in objects (Norris, 2004). Modes of communication—eg 'visible,' 'audible,' 'fleeting' or 'persistent'—were also applied. This analysis also describes actions such as 'creating space for others' contributions' (R3c, ie a regulative action in the category 'relational') that are evident in physical and verbal cues.

Representation

The objects and actions of a group in a sample 15 minute period are represented in Figure 1. In the process of mapping objects and actions, I referenced Norris' (2004) concept of 'higher-level' actions made up of a series of 'lower-level' or elemental actions, as well as the idea of an 'overarching' action. In my analysis, I have thought of the overarching action in terms of an epistemic object, an emerging construct under negotiation. In Figure 1, the observed overarching epistemic objects included: making the experiment appropriate for students (the series 'Experiment' and 'Handouts and activities'); and creating a schedule that allows for student engagement within time, data and equipment constraints ('Lesson planning/timing'). In this episode, scientific and pedagogical concepts were used by students. Another diagram might use other categories, trace individuals or contract time intervals to gain a view of interaction over a longer period.

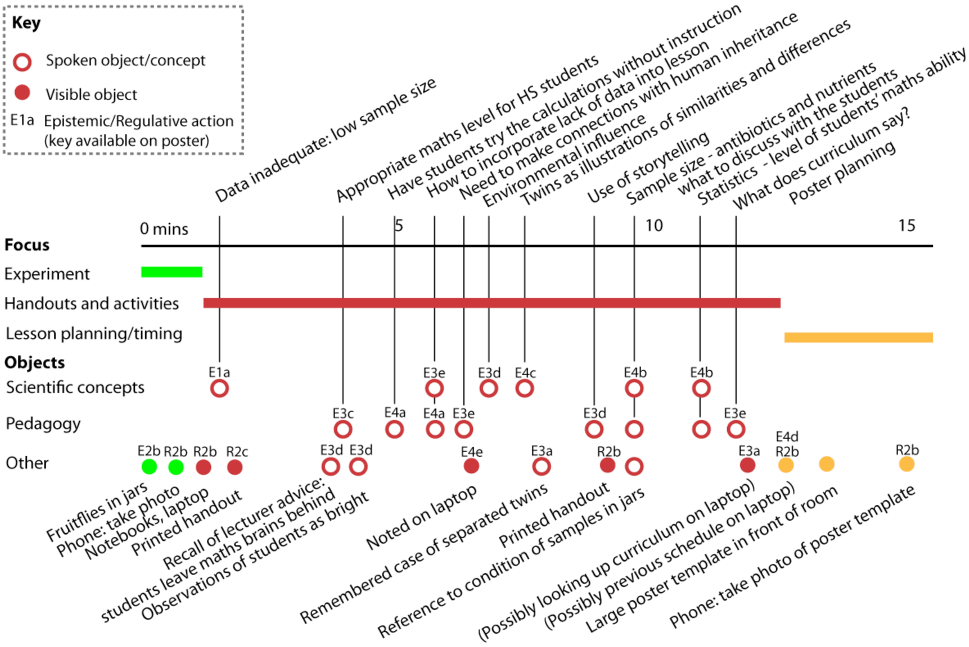

Figure 1. Excerpt from representation of Group 2 interaction, showing actions, focus and objects. The letters and numbers represent categories of actions indicating shared epistemic agency from Damşa et al. (2010).

Discussion and implications

The developed visualisation technique offers a way to represent the organisation of actions and objects within a group collaborative project. This allows us to see the group's focal points and ongoing development of their project, aiding recognition of overarching epistemic objects and changing patterns. It is an interpretive *representation* that aids in pattern and theme recognition, helping trace and compare how groups exercise epistemic agency. It helps to contextualise detailed multimodal or ethnographic exploration of shorter sequences of interaction, enabling a rich understanding of what is happening within a group project.

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Trust, Technology Affordances and Feedback in Peer Assessment Frameworks in MOOCs

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Abstract: The preliminary findings in the automated peer assessments in the assessment framework in a MOOC are discussed here. We discuss whether the assessment framework underpins pedagogical approaches including feedback and collaboration between the participants. The empirical foundation is research on data from a recent MOOC from Melbourne University titled "Teaching and assessing 21st century skills".

Keywords: CSCL, Feedback, Trust, Peer Assessment, MOOC, Collaborative Problem Solving

Introduction

Massive Open Online Courses, MOOCs, are significant newcomers in learning and education on the internet. MOOC development is still in its infancy, but there is an ongoing development in the way MOOCs deliver content and build knowledge for learners.

Computer-supported Collaborative Learning, CSCL, is embedded in several ways in the pedagogical construction of most MOOCs. It can be seen in forum participation and in diverse self-directed collaborations between peers on assignments. These peer assignments and peer reviews are the focus of this study.

CSCL emerged in the 1990s as the internet and computer technology provided new ways of connecting people and thus created new learning opportunities. (Stahl, Koschmann, and Suthers, 2006). The concept of affordance is central to the CSCL tradition, because of the idea of affordance as embedded in technology - "Technologies possess different affordances, and these affordances constrain the ways that they can possibly be "written" or "read"(Jones et al., Suthers 2006). The concept of "perceived affordance" builds upon the concept of "affordance". The concept of perceived affordance includes an object`s "suggestion" for interaction (Normann 1999). This means that a person brings previous experiences and expectances with similar objects and situations to the affordance of the object – all this together frames the perceived affordance. The perceived affordance of quizzes, assignments and evaluations is given by their construction and map onto the participants` previous experiences and expectances with similar assignments.

A condition for collaborative learning and problem solving is *trust* in that peers act according to the rules for the peer assessment process. If trust is betrayed, by cheating or otherwise, it erodes the foundation for the entire collaborative review process and creates frustration.

Research evidences that feedback has a significant influence on the learning outcome. Hattie and Timperley`s feedback model summarized three stages of feedback measurements points: feed up, feedback and feed forward. (Hattie 2009). Feedback is conceptualized "as information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one`s performance or understanding….. Feedback thus is a "consequence" of performance". There are several types of feedback with various outcomes, for example, self-assessment is described as a powerful self-regulatory proficiency which requires metacognitive skills and enables the learner to know how and when to seek and receive feedback (Hattie and Timperley, 2007).

Several learning theorists have described stages in developmental learning e.g. Piaget, Vygotsky (1978), and Dewey, who emphasized that prior knowledge and experiences are important in developing new knowledge (Dewey, 1964). Vygotsky argued that teaching would be most effective if it targeted the individual learners emerging skills as the teaching should stretch and extend the evolving knowledge and skills.

Methods

The empirical foundation for this exploratory study is the MOOC "Assessment and Teaching of 21st Century Skills" from University of Melbourne (hereafter ATC21S MOOC). The ATC21S MOOC followed a developmental progression as materials, video-lectures and quizzes were "locked" until the participant had watched and assessed the syllabus in the predefined order. The assessment framework in the ATC21S MOOC was not purely designed for grading purpose, but for learning stimulation too. The assessments consisted of three Multiple Choice quizzes and two bigger assignments –writing tasks, both to be peer reviewed and self-evaluated, one worth 40% and the other worth 50%. In addition to this there was multiple choice quiz-questions in some of the video lectures – these questions linked to discussion fora where the subject of the questions and related topics were discussed by the participants - These discussions were not part of the formal assessment structure, but contributed to the collaborative elements in the assessment framework. Data used in the present study were obtained from log files capturing information on the participants' behavior in the assessment framework.

Findings and conclusions

Findings showed that ATC21S MOOC participants as a group were vocal, well educated, experienced as MOOC`ers, and professionally interested in assessment issues too. They responded strongly to the peer evaluation features of the course mainly in two ways: a) on the one hand, participants valued the opportunity to evaluate other's work (great ideas, useful insights) and to get feedback from others. b) on the other hand, participant response indicated unhappiness (ranging from irritated to enraged) about the inconsistency in peer response: they pointed to incompetent, rude, unfair, careless evaluations, and were uncharitable about free-loaders who did not pull their weight.

Up to 9% submitted but did not evaluate others; and up to 5% gave everyone full marks regardless of quality of the submission. An as-yet unknown number did not submit qualitative remarks as requested, and a number also put identical marks and remarks for every submission. There were sometimes wild discrepancies in evaluation by different peers of the same submission; and there appears to be a tendency for people skilled in domain to be better than novices at evaluating, this is also found in other research e.g. Suen (2014). Our analyses suggest that each of these issues was of low incidence, but they were common enough to set the tenor about the peer evaluation, and appeared to disincentive participation.

Formative feedback was present in the discussion on course subjects in the fora. Feedback was also embedded in the multiple choice quizzes. These quizzes helped the participants to acknowledge their understanding of the course subject and decide on how to proceed or redo previous lectures. Although we argue that the feedback information is limited in multiple choice quizzes we acknowledge it is there. We also found a correlation as a tendency between peer grading and self-grading such that the students who assigned a high grade to their own assignment in self-grading were also awarded a high grade by their peers in the peer reviews.

Looking into the participants behaviors in the peer assessment it showed that most of the participants, which were primarily teachers of various kinds, had a collaborative attitude and behavior in the peer assessments; they did work out well considered and valid comments to their peers. The opposite behavior however, was seen in the peer reviews as well: There were participants who responded with a very general review and reused this review in all their peer reviews. Attitudes and feelings of frustration and a feeling of unfairness were detected in connection with the peer reviews. We argue that not properly considering the peers assignment and giving constructive feedback undermines the concept of meaningful peer assessment.

Based on the analyses above we argue that the perceived affordance of an assessment framework should include a sense of the necessary collaborative behavior including fairness, trust, transparency and respect for peers. And it should include the ability to avoid cheating in the peer assessments, ability to support the trust not to be broken and the fairness of the rubric. Peer assessments are probably a viable way to generate feedback and assessment for learning and innovative development should be undertaken to develop assessment frameworks including peer assessment and peer evaluations that underpins collaborative problem solving skills, trust between peers and feedback loops.

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A MOOC for Teachers: Network Connections that Facilitate Collaboration and Dialogue for Learning?

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Abstract: In this article a Massive Open Online Course (MOOC) created by and for teachers is in focus. The interaction taking place in digital forums, such as blogs and Twitter, is analysed in order to detect if, and what kinds of, dialogues that take place. Dialogues are crucial for learning to occur and therefore exploring what kinds of dialogues that take place in the MOOC becomes important in order to discuss the learning potential of the MOOC.

Keywords: MOOC, dialogue, connectivism.

Introduction

The MOOC, *Digitala skollyftet,* took place during the autumn of 2013 and 1.500 persons enrolled in the course. *Digitala Skollyftet* can be regarded as a competence development for teachers as it attempted to contribute to raising the digital competence amongst teachers in Swedish schools. The MOOC aimed at addressing three cornerstones; digital competence, sharing-is-caring and school development. Unlike most MOOCs, *Digitala Skollyftet* was not connected to any educational institution. It was designed as a cMOOC based on connectivist and networking notions and with a focus on community building and interaction (Jobe, Östlund & Svensson, 2014). To emphasize the network aspects the organisers of *Digitala skollyftet* tended to refer to the MOOC as a Massive Open Online Community, rather than Course.

Ravenscroft (2011) argues that the important role of dialogue in meaning making and learning has not been sufficiently accounted for in the connectivist perspective. He stresses the need for dialogues to facilitate critical inquiry, reflection and negotiation. To connect digitally with others is one thing, but in order to investigate how these connections may evolve and become spaces for learning, attention needs to be paid to the dialogues that the connections facilitate (ibid.). Wegerif (2007) argue that three types of dialogues are embodied in thinking skills; creative, critical and caring dialogues. According to both Ravenscroft (2011) and Presteridge (2010), critical dialogues are a prerequisite for learning.

Prestridge (2010), who studied the interaction in an online professional network, argues that the teachers' engagement establish a context, community, that enables critical discussions. The focus on community building in cMOOCs is contradictory to the notion of massive, as communities consists of groups who have a strong sense of shared norms and practices. In order to analyze the learning potential in the MOOC, we are focusing on the dialogues that occur rather than development of communities within the course, even if those two intertwine.

Findings

The empirical data consist of collected data from blogs, Twitter and Facebook groups from 66 persons. Open online resources, have been scraped for data which concerns *Digitala skollyftet*. From the blogs a total number of 154 blog posts were collected as well as 85 comments and 48 replies from the author of the blog post. 162 postings were collected from Twitter as well as 182 mentions from and 282 mentions to the participants involved. Data from two open Facebook groups were collected, these two groups were chosen since the groups were created in connection to *#Digiskol*.

Findings from the blog posts show that, the participants in *#Digiskol* do not to any great extent utilize the ability to comment in blogs in order to engage in more extensive dialogues with other participants. Questions about the actual content of the blog posts are not common and comments that contain questions often remain unanswered. Most comments consist of short positive feedback on the blog-post and many also include aspects aimed at building, strengthening and developing the participants' digital network. Instead, dialogues where the participants reason with each other and exchange experiences and practical advice are common. What could be termed critical dialogues, including challenging comments, do not occur.

In Twitter, positive feedback is frequently given to other participants in *#Digiskol* as well as mentions to and from participants. Regularly, the feedback regards something that has been done in connection to *#Digiskol*. It is also relatively common for the participants to send tweets where they mainly seek to get in touch with someone who is interested in the same questions as they are or who teaches the same subject or work with the same age group of students.

In one of the analyzed Facebook groups, aimed at teachers in biology, the content of the posts mainly related to pieces of advice. There were no longer, or critical, dialogues in this group. In the other Facebook group, with interest in developing scripts in Google Docs, a complex pattern of interaction across different forums was found. One example is a sequence that started with a question in the Facebook group, a person (Anna) asked about help and received some answers. After that were no activity seen from her for almost two months, until she on Twitter posted that she learned how to use scripts. The same day Anna wrote a post in the Facebook group with a link to a blog post she had published that day. The blog post described how she had utilised, the tools she had learned to use, in her teaching. She received positive feedback in the Facebook group. The next day, Anna posted a question on Twitter and in the Facebook group, the question was answered during the night. The interaction the following day concerned how to solve the problem that had occurred, and during that day Anna came up with a solution. After that were Anna an active member of the group, she posted on her blog, answered questions and gave positive feedback on Twitter and in the Facebook group.

From this data it's possible to discern that some of the participants in *#Digiskol* engage in a reasoning dialogue where they pose questions, give answers, cooperate. The participants, in the Facebook group, were all very active in *#Digiskol* and through their activities they engaged in dialogue. They had found a common interest and had similar goals with their engagement. However, not even in this group, which was the only group in the data that could be defined as a community, was it possible to detect any critical dialogues.

Conclusions

In summary, dialogues taking place in the MOOC are short and mainly consist of encouraging comments on what other participants have done, which could be described as caring dialogue (Wegerif, 2007). Comments regularly aim at establishing contact in order to collaborate. This was also a central task in the MOOC. To some extent this explain the courteous and positive nature of the comments. The MOOC became a platform from which it was possible to start to engage in the different forums. Despite focusing on community building, only one group resembling a community has been found in the data. This implies that positive feedback is not sufficient to build a community. As stated by Prestridge (2010), there is no point in membership in a community built on camaraderie if there are no 'opportunity for learning to occur through critique' (ibid, p. 257).

Critical dialogues, including challenging comments, which Ravenscroft (2011) claims to be a prerequisite for learning to occur, were rare in the MOOC. When questions were asked in the comments on blog posts, the interaction relatively often met a "dead end" since the question was never answered, neither by the blogger or by others. Questions received answers to a greater extent in Facebook groups and on Twitter than on blogs, but rarely lead to longer dialogues. This is different from the findings in Prestridge's study, where she concludes that 'questions initiate critical discussion' (2010, p. 254).

To participate in engaging dialogue may have involved learning for those who were not very experienced in online interaction. Besides caring dialogue, the interaction appears to be of a reasoning nature where participants give each other advice on different issues. If these exchanges lead to learning is difficult to assess since further interaction with local colleagues may have taken place or interactions in other contexts where it was possible to try out the given advice in classrooms. However, the participants state that engaging in *#Digiskol* has been of great value to them.

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Monoplant: Developing an Innovative CSCL Application for Teaching Photosynthesis Using Multiple Representations

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Abstract: We present Monoplant, a plant growth monitoring system, and its application for teaching and learning in biology at the high school level. In a 3-week design experiment, students used Monoplant to compare the growth of two plants and solve a photosynthesis assignment. We studied a small group of students' verbal and non-verbal interactions during the inquiry and focused on the role of multiple representations and interactions with the plant.

Keywords: collaborative inquiry, empirical analysis, Monoplant, photosynthesis, physical context

Introduction

Monoplant is a self-assembled, innovative CSCL software and hardware prototype that monitors plants' growth in real time and displays quantitative data of its ontogenetic development (external morphology). Components of this system (Figure 1) include digital sensors collecting environmental data, using an Arduino sensor-wiring platform with USB connection, which is connected to a Rapberry Pi programmable computer, running a Debian Linux operating system. The Monoplant API has three resources: Plants, sensor-values, and generated time-lapse videos. Data from the API is displayed in a graphical user interface (Figure 2) in a web application (http://www.monoplant.me).

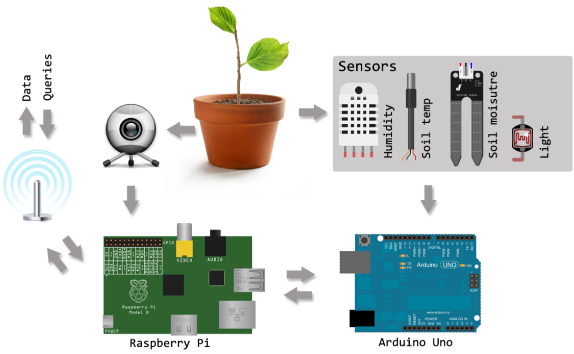

Figure 1. Hardware components of Monoplant

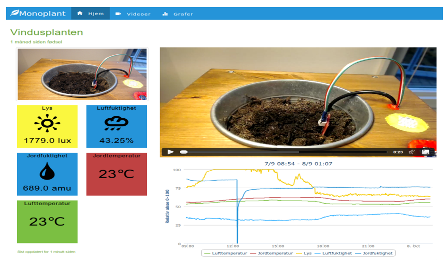

Figure 2. GUI: Time-lapse video and graphs

Our research investigates the students' talk in small groups using Monoplant to answer an assignment given by the teacher, and how the talk is interspersed with actions toward the plant and its context (biological and digital), and toward Monoplant's multiple representations of up-to-the-minute time-lapse video snapshots of the plants' growth attributes: stem length, color of leaves, soil moisture, temperature, and humidity levels. The dynamic linking between the different representations assisted students' meaning making process (Figure 2). Our approach challenged and supplemented the conceptual modeling approach presented in the biology textbook. We argue by empirical examples Monoplant stimulates collaborative learning and supports grounding the scientific concept of photosynthesis (light-dependent and light-independent reactions taken into account).

We address the following research questions:

1. What characterizes the students' collaborative inquiry in interaction with Monoplant?
2. How does Monoplant, by presenting photosynthesis differently from the textbook, support inquiry?

Methods and perspectives

Our interventionist approach combines participatory design (Simonsen & Roberson, 2013) and design-based research (Hoadley, 2002), in which a teacher and two researchers collaborated to design and deploy an innovative CSCL application for 3 weeks while conducting an experimental study of the innovation. We propose a collaborative inquiry perspective, combining CSCL and scientific inquiry. This gave us a set of analytic categories for data classification and analysis. Related work on multiple representations informed the design of Monoplant's user interface. Interaction analysis was used as our main method for data analysis.

Data collection

Our design design experiment took place at a high school in Oslo in which Monoplant was deployed for 20 days. Monitoring the growth of two plants: Plant A (exposed to sunlight) and plant B (inside a closet). The first experiment lasted for 7 days and the second 13 days. The class consisted of eleven girls and three boys (17-18 years), following a Norwegian high school biology curriculum during fall 2013. Each group consisted of four students. We video recorded one group's activities and observing the other groups (3 x 45 minutes). Supplementary data included students' answers to the teacher's assignment and researchers' observation notes.

Data and analysis

Students were given the assignment on a sheet of paper to answer questions on photosynthesis, involving explaining the discrepancy of the growth of the two plants (A & B), which based on first observation is contrary to common sense. By encouraging the students to question their previous understanding of a scientific concept, they could develop new knowledge by integrating their skills into a real-life context. Table 1 shows the number of utterances and the number of hypotheses generated by the video-recorded group (Table 1).

Table 1: Number of utterances and hypotheses generated by the students

Verbal count/student	Linda	Nora	Siri	Fredrik	All
Utterances	14	118	182	67	381
Hypotheses	0	3	8	4	15

The students' collaborative inquiry followed an iterative process involving the following activities: Asking questions, proposing hypotheses, and arguing for and against the different hypothesis. We identified fifteen hypotheses proposed by the four students. Four of them were: "green light", "stem color of plant", "energy source in the seed", and "growth without exposure to light.

During hypothesis generation and argumentation, students made frequent references to external representations obtained from Monoplant, the physical plants, and the textbook. These actions and interactions became the focus for our analysis. The analysis is omitted for space reasons.

Discussion

Monoplant assisted the students by digitally scaffolding the understanding of the relations between the physical plant and its context (biological and digital) as observed and interacted with and the scientific concepts described in the biology textbook. However, the context of the experiment is new for the students, making it difficult for them to apply their prior knowledge to understand the phenomenon. This can be because textbooks often simplify complex phenomena in order to make topics comprehensible. Hence, real-world evidence can be difficult to interpret when factors outside the curriculum become important descriptive factors.

There is a benefit to using multiple representations to deepening one's understanding of the domain, but it comes at the cost of an increased cognitive load on students, leaving fewer resources for actual learning. The task of linking can, therefore, be simplified, either by grouping or integrating representations or by dynamic linking (Ainsworth, 1999).

Conclusions

The Monoplant system consists of the biological plant with five sensors, a cloud storage solution for storing data, and a user interface on a web page. We studied spoken utterances and nonverbal interactions, mediated by Monoplant. We found evidence of students generating multiple hypotheses, but also a problem with this as one student maintained her current hypothesis, despite conflicting evidence. We also found that the textbook's and the teacher's presentation of photosynthesis provided students comprehension of the scientific concepts, whereas Monoplant provided them real life (physical) experiences linked to the concepts. This, in turn, led some of the students to gain greater conceptual comprehension, or a better physical grounding of their concepts.

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Using Students' Speech to Characterize Group Collaboration Quality

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Abstract: Collaboration is a core teaching and learning process, as well as an important 21st-century skill that students must be able to master as they progress through school and into their careers. This project is investigating the feasibility and challenges of using the speech of small groups of students to determine the quality of each group's collaboration. Preliminary data analysis of this early-stage project will be presented.

Keywords: collaboration skills, learning analytics, discourse analysis

Introduction

Collaboration is a core teaching and learning process, as well as an important 21st-century skill that students must be able to master as they progress through school and into their careers (National Research Council [NRC], 2011). Collaboration is also an integral part of STEM learning.

Management and assessment of collaborative learning tasks is difficult in typical classrooms when teachers attempt to monitor 10-15 groups with 2-3 students in each group (Cohen, 1994). Ideally, teachers would listen to peer interactions in each group for long enough to understand how discourse is proceeding—and very few teachers can do this well for so many groups. This new project is working on building speech-based learning analytics for collaboration that could help teachers by identifying what is going on in groups and enabling teachers to target their interventions. For example, teachers could rearrange membership of a group when one student is too dominant, adjust roles if all students are not participating, explore further if the groups' rate of progress has slowed, or visit the group to debug frustration among the members. Thus, we see speech-based analytics not as replacing, but rather as informing the teacher's exploration of group dynamics, diagnosis of issues, and development of an intervention plan.

Therefore, this project is investigating the feasibility and challenges of using the speech of small groups of students to determine the quality of each group's collaboration. We are engaging human observers to code small-group collaboration while simultaneously collecting high quality speech data. We are developing feature detectors that can code the speech data automatically and are using machine-learning techniques to find ways to aggregate the signal from these detectors to agree with the judgments of human observers.

Methods

In fall 2013 we conducted a small pilot data collection in the classrooms of two middle school mathematics teachers. The teachers allowed us to visit their classroom for one class period (about 45 minutes) and have their students work collaboratively on some mathematics tasks delivered. We videotaped and audio recorded two groups from each class, for a total of 14 students.

The mathematics tasks had been developed in the context of another project, as discussed in more detail below. The tasks were a collaborative variation of the cloze task. In a cloze, students fill in blanks in a sentence in order to show their comprehension of material they have recently studied. In a *collaborative* cloze, three students each fill in one blank in a sentence (or short explanation) to express their mutual understanding. The tasks were embedded in an online delivery system and students worked in groups of three on a laptop together. Each student wore an individual microphone to pick up his or her contribution to the discussion.

Field notes were collected at the time of data collection to note times of particular collaboration indicators of interest, and video data was collected to aid the human coding of collaboration indicators.

A speech activity detection system was run on each student's audio channel and provided data on who was speaking when. Pairing this speech data with timing information from the software (e.g., which question the students are working on) enables us to analyze how much each student was speaking during each problem.

Findings

One of the collaboration indicators of interest was that of equality of participation. Researchers noted in field notes and video annotations that Group 3 members seemed to work well together during the beginning of the class period but that the collaboration quality decreased by the end, when the group had come to be dominated mostly by Student 3-1. We looked for quantifiable evidence of this trend that could be extracted using automatic speech technology.

Figure 1 below shows, using the speech activity detection system, the amount of time that each student was speaking during the session, with each student represented by a different line. Each tick along the *x*-axis represents one task in the computer-based collaborative software. We can see that three students had relatively similar shares of speaking time for the beginning problems in the set. However, Student 3-1 (green) began to speak more and more in the later sessions, eventually dominating the floor. Speaker 3-3 (purple) dominated an early session (problem 6.5) but later was the least active participant.

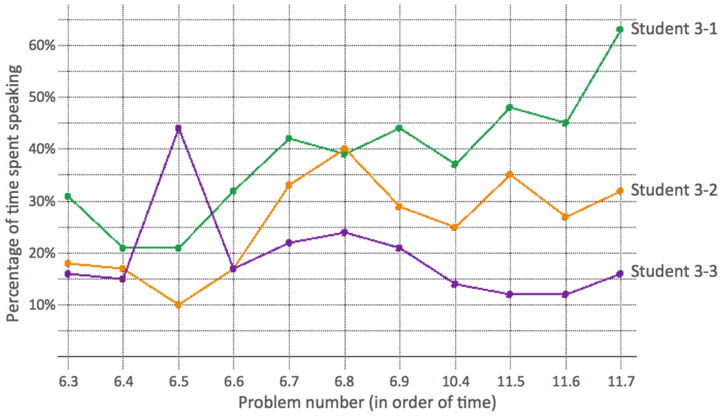

Figure 1. Speaking trends per problem over time for Group 3

The pilot data revealed over collaboration indicators of interest, including turn sharing and frustration. For turn sharing, we found a number of examples of both anticipatory completion (finishing another's sentence) and coproduction of turns (Lerner, 2002) (saying the same words at essentially the same time), indicating what Edelsky (1993) refers to as the "collaborative floor." This type of speech feature has been related to successful collaborative learning (Roschelle & Teasley, 1995) and automatically detecting it could thus be valuable.

Other collaboration indicators (such as suppressing off-task behavior, asking questions, and inviting others to talk/contribute to problem solving) will be included in the next phase of data analysis and will be discussed at the CSCL conference.

Conclusions and implications

Although this study is in early phases, it is a new approach to solving challenges with the management, assessment, and scaffolding of collaborative learning in classrooms. This approach has the potential to rapidly measure the quality of student collaborations, provide teachers with insights about their students' collaborative learning, and enable teachers to intervene based on the data.

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Finding Productive Talk Around Errors in Intelligent Tutoring Systems

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Abstract: To learn from an error, students must correct the error by engaging in sense-making activities around the error. Past work has looked at how supporting collaboration around errors affects learning. This paper attempts to shed further light on the role that collaboration can play in the process of overcoming an error. We found that good collaboration is more likely to happen after an error occurs *and* after a student has requested and discussed a hint with their partner than at either of these points separately. These finding suggest that cognitive support can enhance collaborative sense-making of errors.

Keywords: educational technology, cialogue analysis, and computer-supported collaborative learning

Introduction

Research in both individual and collaborative learning indicates that errors can be good moments of learning (Koedinger & Aleven, 2007; Ohlsson, 1996). Rummel, Mullins, and Spada (2012) suggest that performing collaborative sense-making activities around errors can be beneficial for learning and may lead to students making fewer errors on future problem-solving steps. In addition, hints have been shown to be effective in supporting individual learning with an intelligent tutoring system (ITS), provided students use them appropriately (Koedinger & Aleven, 2007). However, students often engage in poor help-seeking behaviors, for example by not requesting a hint when one would be useful or engaging in hint abuse (Roll et al., 2014). Although Rummel, Mullins, and Spada (2012) explored how collaboration scripts can support students to take advantage of the system feedback around errors, their study does not address specifically how collaboration can be most beneficial in learning from errors and what role hints play in the process. In the current paper, we investigate the degree to which and the conditions under which interactive dialogue, as defined by Chi's (2009) ICAP framework, happens around errors. We also study whether/how dialogue and system-provided hints can work together to support learning. Chi proposes that interactive activities are more conducive to learning than constructive, active, or passive activities. Interactive activities include collaboration where there is giving and receiving of explanations along with co-construction of knowledge (Hausmann, Chi, & Roy, 2004; Chi, 2009). In order to better understand the role that collaboration can play in overcoming and learning from errors, we first looked at the types of collaborative talk that were associated with subgoals in ITS problems on which errors were made. Based on our findings, we then did an in depth analysis of four dyads selected randomly, looking at subgoals with errors to see how the talk was influenced by the ITS feedback.

Methods

Our data is a set of collaborative data in which 26 4^{th} and 5^{th} grade dyads, paired within a grade (i.e. 13 4^{th} and 13 5^{th} grade dyads), engaged in a problem-solving activity in a collaborative ITS for fractions learning. Problem sets were developed using standard ITS support with step-level support for problem solving (immediate feedback and hints). Each student had their own view of the collaborative ITS while they were synchronously working on a problem and communicated through Skype. The collaboration was supported through three different features: assigned roles, individual information, and cognitive group awareness. Each dyad worked with the tutor for 45 minutes in a lab setting at their school. All activities on the ITS were recorded in a tutor log including hint requests and errors. Students' conversations during the collaborative problem solving were recorded and later rated.

The rating scheme consisted of four major code categories: interactive dialogue, constructive dialogue, constructive monologue, and "other". For our analysis, we focused on the interactive dialogue category, in which students engage in actions such as co-construction and sequential construction. Interactive dialogue aligns with ICAP's joint dialogue pattern (Chi, 2009). Our rating scheme was developed to look at groups of utterances associated with subgoals (i.e., a group of steps that all are for the same goal within a problem) to account for the interactions between the students. An inter-rater reliability analysis was performed to determine consistency among raters (Kappa= 0.72).

Findings

The average number of subgoals completed per dyad was 59.2 (*SD* = 24.6) and 78.59% had talk. Of subgoals that had talk (1196 subgoals), 26.6% had at least one error. To investigate the association between errors and interactive dialogue, a hierarchical linear model with two nested levels was used to analyze how the talk during subgoals related to the number of errors made. At level 1, we modeled errors for each of the talk types and each of the collaboration features for the subgoals. At level 2, we accounted for random dyad differences. Since there was no effect for collaboration features, it was removed from the model. We found a significant difference in the number of errors associated with the different talk types, $F(3, 1189)= 10.91$, $p < .001$. Post hoc analyses indicated that the average number of errors was significantly higher where *interactive dialogue* took place compared to the "other" talk category ($p < .001$).

To better understand the patterns of talk that occur around errors, we performed a qualitative analysis on the errors. Four dyads were chosen at random, of which three had above-average learning gains whereas the fourth dyad had below-average learning gains. The four dyads had 61 subgoals in which errors occurred (M = 15.25, SD = 4.99). Of these subgoals, 59% had only one error (M = 2.31, SD = 2.55). Students having interactive talk on a subgoal did not guarantee that they had interactive talk after an error occurred. Of the subgoals that had interactive talk, only 33.3% also had interactive talk occur after the error as well. When interactive talk occurred during a subgoal but was not present after an error, the students would try to answers without any discussion. Knowing that an error was made did not provide enough support for the students to engage in a productive conversation. When *interactive talk* happened *after* an error occurred, in 88% of these cases, it was prompted by the students asking the tutoring system for a hint. 90.1% of the subgoals with errors did not elicit any interactive dialogue after the error and in these cases the students did not discuss any hints. Thus, it appears that the hint provided a starting point for the discussion and a way to engage in the interactive talk. For the subgoals on which there was no interactive talk before or after the error, often the students would try to guess the correct answer without discussing their reasoning behind the proposed answers. Even when the tutor logs showed that a hint was requested, which both students could see, the students did not discuss the hint.

Conclusions

Under what conditions does interactive talk happen after an error occurs? Previous work has looked at how supporting collaboration around errors affects learning. We build upon this by showing that errors are an opportunity for collaborative sense making after students are aware of the misconception *and* request a tutor hint, which provides some measure of support for interactive talk. The hints provided a starting point for a conversation by providing domain related talk that the students could use in their conversation. When students did not discuss a hint, they often did not have a productive conversation and instead guessed and checked. These findings imply that to support collaborative learning effectively, it may not be enough to just encourage students to collaborate when students are struggling as was done in Rummel, Mullins, & Spada (2012). Especially for younger students, who are still developing the vocabulary needed for effective discussions in STEM domains, it may be important to provide hints, which can serve as starting points for the domain discussion when students make errors. A next step for this research would be to see if interactive talk that happens after errors are made is correlated with learning.

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Collaborative Media-Making as Agent for Identity and Learning

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Abstract: This poster presents results from qualitative research exploring and testing conjectures on how the process of media-making collaborations between secondary school students and teachers can precipitate a cascade of highly desirable and pro-social phenomena. These phenomena include important shifts in identity, agency and autonomy that bear deeply on the evolution of mathematical and scientific conceptual systems. The US National Science Foundation supports this work.

Keywords: maker movement; mathematical cognition; metacognition; identity

Introduction

This poster furnishes preliminary analyses of a body of interview transcripts from exploratory research involving workshops in which secondary school mathematics and science teachers and students collaborate to produce short videos and other media for the purpose of teaching students mathematical and scientific concepts. The workshops have taken place in the USA, Kenya, Ghana, Namibia, and Uganda. This particular exploratory work is supported by research grants from US National Science Foundation (NSF) (Hamilton, 2010, 2011); it seeks to create conditions that test conjectures related to creativity, intergenerational collaboration, mathematical and scientific cognition, and high engagement or flow-like experiences. The workshop activities track closely with the ascendant maker movement, and connect that movement to formal classroom settings (Hamilton, Chaves, Chaves, & Harding, 2011).

As described below, these interviews confirm well-established findings about the value of phenomena such as peer-tutoring and self-explanation. They also take place in the context of what is now a commonplace practice of making instructional videos for repositories such as YouTube. The research repeatedly suggests the viability of media-making in school settings as a means to routinely attain deeply engrossing flow states by both teachers and students, a worthy and humane goal for design of educational environments.

Methods

This research now involves approximately 22 separate workshops in the US, Africa, and Australia, in addition to several dozen follow-up sessions. In these workshops, the research team introduces participants to the process of creating video media to represent rich mathematics. Among workshop features are opportunities for teachers and students to collaborate in design and editing of video media and subsequent use of technologically-adapted Japanese-style lesson studies (Isoda, 2007; Lewis, 2002) for reflecting on and improving those videos.

Structured interviews served as one of several methods for identifying and observing these processes. The 22 workshops have produced approximately 250 interviews, of which approximately 80 have been exposed to coding book and inter-rater reliability scoring and are in aggregation and relational analyses.

Initial findings related to flow, conceptual growth and identify shifts

Several prominent patterns have emerged that are independent of how the participants structured their media-making activities. It turns out that each teacher and each student reported experiencing the sensation of loss of a sense of time consistent with deeply engaging activities, in a manner consistent (though not always as viscerally expressed) with the earlier interview excerpt. Additionally, their reports are consistent with other phenomena that track closely with classical features of flow experience (Csikszentmihalyi, 1996; Weber, Tamborini, Westcott-Baker, & Kantor, 2009). Deep engagement and flow were in repeated evidence across international boundaries. One USA student commented, "when making the video…you slow down, and you re-evaluate everything that you have worked out, so then you have to process it more and more and more, and the more you look at it the more you are understanding … it." Another, also from USA, commented "… as I did more videos, more I guess ways of doing math got stuck in my head, so my scores went up to advanced proficient, like to the highest in the class." This particular student is instructive in describing relational changes. Immediately preceding the comment above, he explained, “my relationship with my teacher has changed…. (making videos together) brings us closer now to talking about a subject that I enjoy and she enjoys and we could work together because we could both give each other advice…And, it’s really great, just working with a teacher, to know that wow, like I am working with my teacher to improve this class and this subject.” Student 1, from a workshop in Uganda, illustrates assimilation of new aspects of identity empowering shifts in perspective about learning. Student 2, from rural Kenya, voiced similar observations.

Student 1: This workshop has made me feel like a teacher. A teacher to my first student, so, I’ve gained a lot from it...I thought of leaving this school ... but, due to the introduction of this workshop, I feel more… interested to come back to my school and teach…

Student 2: I think it is good, if you have ever been in a place (where) there are students, where there are adults, where they are the same, where they are at par, we are doing things together, they are showing us what …(they) are doing, (we are) …(showing them what we) are doing, I think the interaction is very good, and I think I'd love more of this.

This sentiment of these students has arisen repeatedly in preliminary analyses of participating students reporting in interviews that they see themselves as agents of learning and teachers to others. During video-making workshops, students and teacher collaborations disrupt conventional classroom hierarchies, restructuring familiar paradigms. Environmental feedback provides continual reinforcement of this empowered role in learning as students learn from each other, and perhaps, most significantly, as they see teachers learning from students. This appears to have catalyzed a self-reinforcing cycle: teachers begin to view students as knowledge sources, interacting with students differently, which in turn affects students’ self-perception, triggering agency in their learning, leading to increased skill and proficiency. These complementary socio-perceptual shifts in students’ view of teachers and teachers’ view of students interact to create a dynamic system that reinforces the developing student identity as a knowledge agent triggered by the collaborative task of media-making.

Conclusions

Interviews from these workshops suggest that structuring a space for creative media-making in service of a school curriculum can precipitate positive, pro-social and pro-learning mechanisms. These begin with processes of known intrinsic power, such as self-explanation and peer tutoring. In this particular context of intergenerational collaboration, preliminary evidence suggests assimilation of new aspects or dimensions of self-awareness or identity in ways that materially benefit mathematical learning. One important direction the data appears to suggest is that the deeply immersive experience of creating and editing videos may function as a scaffolding or staging for growth in self-regulated engagement in learning. What is unique to this learning context is how the additional factors of autonomy, mental focus, and a tangible sense of personal control over the creation process in addition to the prompt, intensify an individual's level of engagement, precipitating a state of flow. While the acquisition of a new skill inherently expands self-concept, the state of flow produced in the video making process endows an individual with an intrinsic sense of accomplishment that uniquely employs seamless and continuous metacognitive reinforcement.

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Active Learning Spaces: Blending Technology and Orchestration

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Abstract: In the last decade there has been increasing interest in building technology-rich active learning classrooms that support the enactment of social constructivist theories. We report on a six-year design-based research involving the evolution of such spaces at a college in Quebec, Canada. In particular, we discuss design principles of the technologies, including student-dedicated interactive whiteboards and cone-shaped tables, and the role they play in supporting the learning, student engagement and opportunities for teacher orchestration.

Introduction

Technology-rich collaborative learning environments, or active learning classrooms (ALCs), are drawing attention in post-secondary education. The architecture and furnishings of ALCs intentionally shift the object of instruction toward student-centered activity and reshape traditional authority structures. Instead of rows of front-facing desks, these new spaces feature pod-like clusters that promote peer collaboration. Commonly featured technologies in ALCs are large writable surfaces (e.g., whiteboards or writable walls), networked computing device (desk-top or personal) and projection systems (single or multiple) that allow for various display modalities – shared only with the pod of students, shared with the whole room, and so on. Research on how the design of such rooms impact collaboration and learning is beginning to draw interest among those in the CSCL community (e.g., Mercier, Higgins & Joyce-Gibbons, 2014; Slotta, 2010). The current study adds to this literature and reports on a six-year design-based research project that has lead to the construction of three ALCs at a large urban college in the province of Quebec, Canada. We describe how student engagement and group interaction patterns have guided the iterations of these designs, and when design alone is not enough.

Background

ALCs were designed to accommodate *active learning*. Active learning pedagogies bring into play tenents of social constructivist theories, many of which characterize learning as participation. Active learning often means creating joint-problem spaces and opportunities for students to engage in collaborative learning – i.e., the mutually coordinated engagement of individuals working together on specific tasks (Roschelle & Teasley, 1995).

Technology has played an important role in providing learning opportunities and facilitating requisite conditions for learning. Recent studies with shared digital interactive spaces include both the physical (Mercier, et al, 2014) as well as the virtual (Cakir, Zemel, & Stahl, 2009). Key feature of these spaces is how students' collaboration produces results that are co-constructions and can represent the collective knowledge. This current research uses these conceptual frameworks as a point of departure for evaluating the design of our first ALC.

Methods

This study is an example of a design-based research (DBR) project, with aspects of participatory action research. Data were collected from: (1) five years of classroom observations (~8 teachers, ~300 students); (2) student interviews (~60); (3) teacher interviews (~12); and (4) student surveys adapted from the National Survey of Student Engagement (~ 600 students, over 5 semesters).

ALC design iterations

The first generation ALC (ALC-V1) was designed on models from existing rooms (Priscilla Laws' Dickenson College in Pennsylvania being a primary influence). This version contained nine four-person pods each with two desktop computers arranged around the perimeter of the room so as to form a wide U-shape that flanked the teacher's space with a small movable table instead of traditional desk. Behind this table were two interactive whiteboards, dedicated for teacher use. These were connected to a projection system with two screens that anchored the far corners of the room allowing students to view the teacher's work even when their backs were turned away. Using an ethnographic approach the classroom observations revealed that students collaboration was hampered by the bottle-necking phenomenon that occurs with small screens and keyboards, as a single input device. Additionally, the four-person tables sometimes proved to be difficult to coordinate when students were absent and/or unprepared, creating groups that were less functional. An unanticipated use of the room came when several students ventured to use one of the writeable surfaces, and were later encouraged to use the

IWB, which until then had been reserved exclusively for teacher use. This marked an important change in practice among students.

Figure1. Arrangement of technologies within ALC-V3.

The second and third generation ALCs (ALC-V2 & V3) was based on the idea of putting IWBs into the hands of students. This process led to the reconceptualization of the student pods. Common table shapes for ALCs have been round tables but to put the emphasis on the student-dedicated IWBs tables were sculpted into cone-shaped tables (CST). The IWB located at the wide end of these tables and draw the pod's attention to the multi-user writable, interactive and public space.
Differences between second and third iteration of the ALC lies in the arrangement of the pods from a clustering to a horseshoe arrangement (see Figure 1). While the intention is to create a space that facilitates larger class-as-a-whole activities the student-dedicated IWBs and cone-shaped tables continue to be the most important technologies in the room design. What did change was how the teacher began to orchestrate the students' engagement. Creating activities that required students to stand up while using the IWBs.

What have we learned?

Unlike multi-touch tables, multi-touch IWBs, as designed into ALC-V2 and V3, provide opportunities for students to work together in truly public spaces. The large interactive surfaces not only afford student engagement in a physical joint problem-solving space but it is visible to other groups and the teacher. This design further facilitates teacher orchestration of activities and management of the groups. Specifically, teachers can scan the room to see the progress of each group and can interact with groups and the artifacts produced.

Learner agency also changes both as a result of design but more so as a result of the teacher orchestrational moves. The early design (ALC-V1) saw limited student agency with roles being more traditional collaboration between the dyads. Later designs (ALC-V2 & V3) showed new patterns of engagement, we identified three modalities: (1) tutor/tutee; (2) conference executive; and, (3) group learning. We discuss the third. The group learning mode illustrates the greatest amount of group agency. All students stand at the IWBs and use its capacity to create multiple sandboxes – editable workspaces. In this mode students were observed creating new resources such as temporary inscriptions and drawings (knowledge artifacts) to mediate their efforts to communicate and construct their thoughts. The temporary personal artifacts would allow a student to explain their understanding, and elaborate on a communication breakdown.

Design of the space and the location of the IWB technology has produced differences in the discourse and interactional patterns and resulted in different modes of student engagement. Interestingly, the most significant change in engagement observed was a result of the teacher orchestration. Further study is in progress.

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Broken Windows in Online Public Spaces: A Challenge to Literacy Educators

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Abstract: Public spaces for online discussion (e.g., comments on YouTube) are often plagued by aggressive or irrelevant contributors. At the same time, these spaces do provide opportunities for exploring and practicing *dialogic literacy*, which is a key competence for active participation to the knowledge society. This study suggests an approach to dialogic literacy based on active participation in public debate, negotiated within a knowledge building classroom, where formal learning acts as a bridge towards fair participation in online spaces.

Keywords: dialogic literacy, online environments, agonistic/antagonistic discourse, secondary school

Introduction and background assumptions

According to the so-called "broken glass theory", inspired by an experiment carried out by psychologist Philip Zimbardo about the signaling effect of urban disorder on anti-social behavior, "vandalism can occur anywhere once communal barriers – the sense of mutual regard and the obligations of civility – are lowered by actions that seem to signal that 'no one cares'." (Wilson & Kelling, 1982).

Highly frequented online public spaces in Italy – e.g., readers' comments on the websites of national newspapers or on YouTube videos – indeed resemble a vandalized landscape, marred by hate speech, aggression, self-expression and lack of dialogue. This scenario is not unique to Italy: also in countries with a tradition of democratic debate 'antagonistic discourse' (Mouffe, 1999) – that is, discourse portraying the other as an *enemy* to be destroyed – can prevail on controversial issue (e.g., Zoonen, Vis, & Mihelj, 2011).

In this scenario, educators are in a difficult position, since they recognize the potential of the internet as a resource for developing competences in language and communication, but feel uncomfortable with the *tone* of public online debate. They thus have to succeed in a double challenge: helping young people prevent these antagonistic behaviors and offering them cultural, linguistic and social tools to participate in meaningful dialogues. Online public spaces offer therefore a huge, chaotic repository of attempts to communicate values, fears, expectations that do play a role in the word outside the classroom. Indeed, dialogue, debate, and participation can be fostered within the classroom, but breaking the virtual wall to engage in participatory practices in the world outside could be a more comprehensive approach towards the development of online communicative competences or – with a more ambitious term – 'dialogic literacy'.

Our approach is inspired by studies on *participatory culture* and the challenge it poses both to young people and literacy educators (Jenkins et al., 2009; boyd, 2014), and builds on the notion of 'dialogic literacy' developed by Bereiter and Scardamalia (2005). The authors suggest that dialogue underlies all the knowledge-creating disciplines and professions, while "modern information technology [...] affords means by which dialogue can become more dynamic, democratic, and creative." (p. 750)

This poster presents the design principles of one area of intervention within a study on fostering dialogic competences through observation and participation in the public space.

Goals, context, design principles

The authors' current research about fostering dialogic literacy is organized in three interconnected areas of intervention, whose goals are:

- defining prerequisites for dialogic literacy, with primary focus on how discourse constructs identities and relationships (Gee, 1996), but also with attention to competences that go beyond communication, such as understanding how value systems can differ (Haidt, 2012), how collaborative decision-making requires and builds social capital (Innes & Booher, 2010), and how certain types of digital interaction may actually erode it (Antoci, Sabatini & Sodini, 2012);
- defining criteria for vetting examples of more or less dialogic communication, with focus on identifying conditions and strategies that make dialogue possible, as well as behavioral patterns that preclude dialogue and discourage participation; in the process, producing worked examples for use in educational setting;

- identifying places and designing learning activities for engaging students in practices of participation and reflection.

The first two areas are currently the subjects of a parallel thread of interdisciplinary investigation. This poster focuses instead on the third one, whose concern is the design of reflective collaborative practices in a classroom-based learning setting, in which computer-supported collaboration is deeply integrated with in-presence activities.

The first iteration of educational intervention is currently being designed for a classroom of Italian lower secondary school pupils (grades 6^{th} to 8^{th}), in which practices of in-presence and computer-supported collaborative learning are routinely integrated in learning activities across disciplines. All the pupils have access to individual Google accounts through the Google Apps for Schools service and use a Wiki as a both collective and individual log-book and forum, as well as shared repository for learning material (Delfino, 2013).

Dialogue in classroom and gradual transfer of responsibility to the pupils for a range of activities is well-established practice in the experimental school in which this study takes place. The new focus on dialogic literacy builds therefore on existing practices with the goal of fostering awareness about attitudes, knowledge, beliefs, competences and tools that make it possible for a group to share cognitive and organizational responsibility for achieving a common goal. At this stage, the pupils learn the vocabulary and conceptual tools for reflecting on their own collaboration practices in the classroom.

When the pupils start using the online space on their own initiative for informal collaboration and discussion – a process that usually takes 3-4 months for 6^{th} graders – they are ready for teacher-initiated online activities, based on tasks or problems that require the student to negotiate solutions, rather than expressing opinions or demonstrating the acquisition of given information. These online negotiations and discussions will in turn become an object for analysis in the classroom, with the goal of highlighting effective and less effective communicative strategies, unconscious bias, power conflicts, and especially moments of advancement in understanding problems and designing solutions.

At this stage, towards the end of 6^{th} grade, the class moves towards observation of dialogue in the public space through assignments that require a group to analyze examples of online interactions and give a principled answer whether and how it is advisable to add a contribution. The analysis will be carried out by annotating discussion threads or specific comments (e.g., on *YouTube* videos) through a web-annotation service (e.g., *Diigo*) or simply by copying portions of discussion threads into shared *GoogleDrive* documents open to annotations; in the case of video-contributions to discussion, the same analysis will be performed through collective annotation of video (e.g., with *VideoAnt*). Prospective contributions to discussion by the students will be discussed and reviewed in the classroom before posting.

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Through the Looking Glass: Using a Classroom Discourse Visualizer to Support Teacher Reflection on Practice

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Abstract: In this presentation, we report on the initial field test of a CSCL tool for collaborative inquiry designed to support teacher reflection on instructional practice. The *Classroom Discourse Analyzer* (CDA) is an interactive tool that uses discourse analytics to visualize classroom discussions. We examine collaborative inquiry between elementary school reading teachers and teacher trainers using the CDA to refine discussion facilitation techniques. We discuss the implications of the use of personalized, data-centered learning technologies for supporting teacher learning and instructional practice.

Keywords: discourse analytics, teacher learning, visualization, professional development, classroom discourse

Introduction

Facilitating academically productive discussions means opening up discursive space for student reasoning and thinking, moving away from traditional recitation modes of classroom dialogue. Scaffolding the norms of collaborative reasoning has been shown to support students' learning (e.g., Webb, 2009). However, several studies have shown that it is challenging for many teachers to learn and effectively integrate these kinds of discursive practices into their instruction (e.g., Clarke et al., 2013). The growing field of discourse analytics offers new possibilities for leveraging fine grain data of dynamic processes as evidence for grounding teacher learning in evidence derived from their own practice.

In this paper we report on the initial field test of a discourse analytic tool called the Classroom Discourse Analyzer (CDA) for collaborative inquiry about practice between teachers and teacher trainers (hereafter referred to as coaches) (Chen, Clarke, & Resnick, in press). The CDA is designed to visualize multiple features of classroom discussion, to enable teachers and coaches to examine the micro-level processes of discussion using their own instruction as data. The CDA provides a lens though which to view practice that other forms of data would be insufficient to visualize and/or extremely time-intensive to analyze.

Classroom Discourse Analyzer

Reflection has been widely accepted as a useful means for learning in professional development programs, however reflection that is based on memory and fieldnotes can add a layer of analysis to the instructional event of interest and hinder noticing important details of interaction. On the other hand, video-based approaches may add extraneous detail. The CDA was designed to assist teachers and coaches in noticing important features of discourse processes, using teachers' own instruction as data and evidence. The CDA visualizes discussions that occur through face-to-face classroom interaction using transcripts as input data. The interface includes four frames that display four visualizations of the same data: *turn-taking distribution and length of utterances, distribution of speakers over time, transcripts,* and a *coding scheme*. A central feature of the interface is that all frames are synchronized, allowing teachers and coaches to examine four different representations of the same data in tandem. Each of the frames provides different information about the discussion data. Together they offer a way to revisit the discourse through a condensed, visual array, sums and tallies, patterns of turns, actual words, and the interpretive layers that coded data affords.

Methods

The CDA was field tested in a North Carolina school district with six reading teachers and three coaches. Coaches were given the CDA manual that described, in general terms, the tool's capabilities and provided a primer on how to interpret data visualizations. Coaches had full autonomy on how to use and integrate the CDA into their coaching with teachers. Coaches led teachers through two coaching cycles using the CDA, which consisted of a pre-lesson conference, an enactment of the target lesson, a post-lesson conference, and a CDA conference. The CDA conferences were used to reflect on the target lesson and goals using the CDA. All phases were video recorded and transcribed. All three coaches and two of the teachers were interviewed after the field test to probe their experiences using the CDA.

Qualitative content analysis was used to examine the ways in which participants appropriated the CDA to support learning about academically productive discussion. Content analyses examined, (1) the features of instructional practice that participants identified as a target of reflective discussions, (2) the rationale participants provided for focusing on these pedagogical features, and (3) the ways in which participants reported using these features to develop their understanding of instructional practice. These features were then used to examine target lesson enactments quantitatively. Quantitative analyses examined whether the features identified using the CDA were the features of practice that teachers became more expert at when they facilitated class discussions with their students from the first coaching cycle (Round 1) to the second (Round 2, one month later).

Findings and conclusions

Content analysis of interviews and conferences showed that coaches and teachers used the CDA primarily to focus on two features discussion: (a) Accountable Talk (AT) 'moves' and (b) participation patterns. AT moves are utterances that function to elicit cognitive processes in discussions (e.g., Clarke et al, 2013). Participation patterns refer to the distribution of turn-taking amongst student speakers in class discussions.

Target lessons in Round 1 (R1) and Round 2 (R2) were coded for AT moves. We examined the percentage of teachers' turns that were AT moves to total teacher turns. We found that only one of the six teachers showed growth in the number of AT moves used from R1 to R2. However, four of the six teachers showed growth in specific AT moves from R1 to R2, e.g. eliciting students to elaborate on a student's idea. This targeted growth corresponds to specific AT goals that teachers and coaches identified in coaching conferences. The largest differences, however, were observed in the level of student involvement between R1 and R2 lessons. Five out of the six teachers engaged more students in the discussion in R2 than in R1. This result shows that the teachers tended to be more aware of the number of students involved in R2 than in R1 classroom discussions.

The findings suggest that the CDA can help to make salient some features class discussions by visualizing the dynamics of discussions. Salient features can be used as an object of reflection on practice in collaborative sense-making coaching discussions. In addition, salient features, and sense-making discussions about these features can support changes in teachers' instructional enactments. In this field test, the CDA visualizations of student turn-taking helped teachers to become aware of inequitable student involvement in class discussions. In coaching conferences, teachers and coaches problematized these patterns, developing strategies for disrupting the pattern to encourage wider student participation. When teachers enacted the subsequent lessons (R2), they engaged more students in these discussions, potentially opening up opportunity spaces for silent students to benefit from these discussions.

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Using Real-time Trace Data to Predict Collaboration Quality and Creative Fluency in Design Teams

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Abstract: In this study, sixteen Engineering students were assigned to small groups (n=4) to work collaboratively on engineering design tasks. Using wearable sociometric devices, we collected real-time non-linguistic speech data on team interaction including turn-taking, successful interrupts and overlaps. Results from 2-stage regression models indicate that speech and conversational dynamics such as turn-taking and successful interrupts are significant in predicting the perceived collaboration quality and creative fluency of design teams.

Keywords: collaboration quality, creativity, sociometrics, design learning

The social processes in computer supported collaborative engineering design settings are influential to collaborative outcomes (Dillenbourg, 1996). In real-world settings, engineering design is predominantly collaborative and relies extensively on social interaction to generate creative design ideas and maintain collaboration quality (Bucciarelli, 1994). Therefore, it is important that we identify key social interaction dynamics to promote engineering design learning. In this study, we demonstrate a novel and unobtrusive method for capturing and analyzing social interaction dynamics among students working on collaborative engineering design task.

In recent research, data from sociometric sensors that collect real-time speech and behavioral data have been found to be successful indicators of collaboration in different settings (Pentland, 2012). We explore the possibility of using such data to predict creative and collaborative outcomes in learning teams, by quantifying their speech and behavioral dynamics.

Methods

We recruited 16 students (14 men and 2 women) aged 21-37 years), from a mechanical engineering graduate design course, and randomly assigned to four teams of four participants each. Each participant team was assigned to one of the four experimental conditions that varied in *context* (Standard or Commons room) and *sketch tool* (skWiki or paper). Each team was given one toy and instructed to first classify it based on the play pyramid (Kudrowitz & Wallace, 2010). Then the students changed the play value of the toy and sketched ideas for new toys. Each team spent roughly 60 minutes on the entire task.

Materials

Participants sketched on iPad tablets using capacitive-touch styli running skWiki (Zhao et al., 2014), a browser-based application for collaborative sketching. The sketches generated by each team member were synchronized across all other team devices, allowing sketches to be shared, elaborated, and collaboratively developed.

Measures

Collaboration dynamics

We used wearable sociometric sensors to capture real-time data on a series of non-linguistic social signals (Pentland, 2012). In this study we focused on measures of speech and conversational turn-taking, analyzing four measures: turn-taking *by* a speaker and *after* a speaker, successful interruptions, and speech overlaps. 10-second speaking segments were calculated from data captured every second.

Collaboration and creativity measures

Participants completed two surveys at the end of the session and a brief 1-minute probe in the middle of the session to assess collaboration quality, and creative fluency and flow. To assess the participants' perceived collaboration quality, we used a 9-item scale (α = .90) adapted from a scale for collaboration readiness of scientific teams (Mâsse et al., 2008). For flow, we used an 8-item scale (α = .91) derived from Arici (2008). Both used 5-point Likert scales. We measured fluency as the number of sketches created by each participant.

Findings

Regression model for creative fluency

We analyzed the data using a two-stage hierarchical regression model. We controlled for context, sketching tool, and students' sense of flow in the first stage of the model, followed by turns after, successful interrupts and overlap in the second stage of the model. Results showed that the model was significant in predicting fluency, $R^2 = .73$, F(6,9)=4.18, *p*=.03. While the sketch tools and context were not significant in the model, turns taken after a student has spoken, $\beta = -2.62$, *t*(16)=-3.32, *p*=.009, and successful interrupts, β =2.42, *t*(16)=3.22, *p*=.01, were significant predictors of creative fluency.

Regression model for collaboration quality

Similarly, in the two-stage hierarchical regression model for collaboration quality, we first controlled for sketching context, sketching tool, gender, and student classification (i.e. undergraduate/graduate). In the second stage of the model, we included turn-taking, turns taken after a student spoke, successful interrupts, and speech overlap as predictors. The model significantly predicted collaboration quality, $R^2 = .85$, F(8,7)=5.07, p=.023. While the sketching tool and context were not significant predictors of collaboration quality, turn-taking, $\beta = -1.14$, t(16)=-3.56, p=.009, turns taken after a student has spoken, $\beta = -2.91$,t(16)=-2.98, p=.02, and successful interrupts, $\beta = 4.22$, t(16)=4.003, p=.005 were significant predictors.

Conclusions and implications

This study contributes to the literature on computer supported collaborative learning by demonstrating that regardless of the context or materials for collaboration, social interaction dynamics are significant predictors of creative fluency and collaboration quality in engineering design learning. These findings are aligned with social construction theories that highlight the importance of inter-subjectivity and the joint construction of ideas (Stahl, Koschmann & Suthers, 2006).

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Designing PyTutor: A Social Tutor to Support Computer Science Education Through Collaborative Study

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Abstract: This paper reports on the design of PyTutor, a social tutor and study platform that offers computer supported collaborative learning of computer science, relying on peer instruction rather than artificial intelligence for just in time learning. The software provides a test-driven approach to authoring questions through a wiki-like interface allowing for the rapid, collaborative authoring of high quality questions, while replacing the expert domain modeling prevalent in cognitive tutors with a crowdsourced approach. A social networking model allows learners to reach out to their peers and mentors for help while studying.

Keywords: computer science education, social tutor, peer instruction, computational thinking

Introduction

PyTutor is a novel computer science education platform, which borrows familiar patterns from social media to support collaborative learning for novice computer programmers. This paper reports on the design experiment developing PyTutor with a series of usability tests with college level students in an introductory computer science class. PyTutor is responsive to the recent push to broaden the teaching of computer science (CS). The "computational thinking" emphasizes the relevance of CS problem solving techniques to many domains. Proponents argue that by studying computer science we can apply approaches such as algorithmic thinking, abstraction, decomposition, pattern recognition, and more to a variety of problems (Grover & Pea, 2013). Drawing on methods developed by the Free Open Source Software development community and social media we can provide a scalable computer science study platform that can be an important piece of a learning network for broadening our computational thinking competency.

Methods

PyTutor is in current development by a small team of one faculty and two students at Adelphi University. Source code is written in the Python programming language, released under a Free Software license (GNU AGPL) and hosted publicly on Github. The team follows an iterative development process with small, frequent releases informed by small-scale usability studies. Usability tests have been conducted with a small pilot group of introductory programming students, faculty and adjunct computer science instructors, and professional software developers. Usability testing methods included direct observations of users completing directed tasks, think-alouds during testing sessions, and individual and group interviews with users in the pilot groups.

Design

PyTutor shares many design principles with the CMU LISPTutor described by Anderson and Reiser in 1985, including the basic tenet that, "[a] student should be able to work on a problem in a 'friendly' environment, as if he were using a smart, structured editor. However, whenever he makes a planning or coding error or asks for help, the tutor should provide helpful information" (p. 160). We believe that novice computer programmers benefit from exposure to many, discrete problems before progressing to unstructured problem based learning that is required to further develop expertise (see Guzdial, 2015). PyTutor replaces the advanced artificial intelligence techniques and careful domain modeling that are hallmarks of cognitive and intelligent tutors, relying on peer tutoring for instructional remediation and collaborative domain-modeling and task authoring.

PyTutor's **study interface** presents learners a series of Python tasks, targeted at their current level of mastery. Learners enter solutions with a full featured, web-based, programmer's text editor. Keyboard shortcuts allow students to test their code against a suite of unit tests. Test results show the *assert* statements used to validate the student's code, the expected result, the actual result, and a Python *exception*, if one was raised.

PyTutor rallies the benefits of **peer instruction** (PI) to provide interventions when learners ask for explanations or struggle. Broadly, PI asks students to develop their own understanding of topics and then share their understanding with a peer. PI fosters deeper conceptual understanding, while increasing retention in high risk courses (Crouch & Mazur, 2001; Porter, Bailey Lee, Simon, & Zingaro, 2011). PI offers a low-risk alternative to faculty led instruction, and has been successful in large lecture courses and other formats that rely heavily on didactic pedagogies. PyTutor users initiate tutoring by creating a "help" request or hitting the "panic" button. Help requests notify the learner's "friends" that someone in their social network needs help. PyTutor friends follow familiar social networking site conventions. It's important to note that friends are not necessarily "peers" in the sense of peer instruction. Even in our small studies, friend networks consist of peer and expert tutors. Panic requests are not limited to friends, but broadcast to all active (online) users.

In addition to hosting a potentially large set of problems, PyTutor offers leaners the chance to study **solutions to problems**. When prompted with a problem, learners are offered the opportunity to "view other solutions." The "other solutions" offer a look at the passing solutions of other learners (listed anonymously) and the passed and failed solutions provided by editors, pulled from the question revision history. This opportunity to compare their code to others' code shows computer programming as a creative process that allows for multiple solutions and approaches to the same problem. By showing "expert" editor solutions that both pass and fail the unit tests, learners gain insight into the development process of the question authors.

Editors serve as curriculum designers and domain experts, writing task specifications (prompts); providing expert solutions and unit tests; and classifying questions into hierarchical levels and crosscutting tags. A test-driven approach combined with revision history builds on computer collaboration practices developed in Wikiepdia and (extreme) programming communities, encouraging editors to, "be bold" and "refactor mercilessly." Our unit tests have been simplified by testing only pure functions. Pure functions do not rely on program state (they only reference the arguments passed into the function) and do not have any side effects (their only action is to return a value). Users, even those without experience writing unit tests, easily contributed new questions to PyTutor, while other users, though, miss the power of fully programmed unit tests.

Like cognitive and intelligent tutors, PyTutor uses an **adaptive model** to determine which questions to serve to students. Based on previous correct and incorrect responses, PyTutor chooses questions that target the learner's current level of mastery or review recently mastered topics. PyTutor does not use a Bayesian model or carefully constructed task analysis to sequence questions, though. Rather, it relies on the question level indicated by the authors and refined by responding to question flag feedback. At the time of writing, the usability tests have been too limited in scope to determine if this approach is sufficient and further research is needed with a full set of question data and more extensive studying.

Conclusions and implications

PyTutor's novel approach to computer supported collaborative learning uses patterns from social media and agile software development to enable online peer tutoring. Traditional cognitive tutors posses certain advantages in efficiency over PyTutor's social model. AI tutors offer more immediate feedback to learners, at the line-by-line level of coding, whereas the social model relies on swift responses to help requests for just in time learning. Peer instruction has cognitive advantages by asking users to play the roles of tutor and tutee. Further, PyTutor facilitates true human-expert tutoring, which is still considered the gold standard of instruction. Like other social media, PyTutor is designed to take advantage of network effects. As more people use PyTutor to study and author questions, the quality of questions will increase, as well as the quality and availability of tutoring. Social tutoring is compatible, and works best, with the goal of teaching computational thinking on a large scale. This approach may be particularly compatible with the unstructured, self-directed learning evidenced by MOOCs and other "instructorless" models prevalent today, but can also play a supporting role in courses that employ problem or project based learning. PyTutor has been designed to explore an instructional design paradigm that can supplement intelligent tutoring systems, after further explorations of this method, a hybrid social-intelligent tutor may prove to be a powerful combination.

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Coordinating Tools and Talk in a Tangible Tabletop Game

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Abstract: This paper discusses how children use tools with language to support their interactions in a tangible tabletop game. Using Speech Act theory as a theoretical framework, videos of dyads using the land use planning game *Youtopia* were qualitatively analyzed to identify emergent themes. A key finding is that learner's use tools and talk together to present evidence to support their position. The implication is that tangible designers can target support for specific kinds of collaborative interactions by creating tools to provide evidence for anticipated points of decision making, negotiation and conflict.

Keywords: tabletops, TUIs, multi-touch, CSCL, discourse, children, sustainable games, design

Introduction and purpose

Youtopia (Antle et al., 2013) is a tangible tabletop sustainability simulation designed to support children in collaboratively learning about tradeoffs between environmental health and human needs. Drawing on theoretically-informed tangible design guidelines (Antle & Wise, 2013), game activity is based on interdependent land-use stamps which can be used to support the food, shelter and energy needs of a population and/or preserve aspects of the environment. Two other system tools are relevant to this study: an impact tool which pauses the system and provides game state information (levels of food, shelter, energy and pollution) with the goal of prompting learners to reflect on their decision-making and the world they create; and an eraser tool that allows learners to remove land-uses (thus encouraging experimentation and exploration of the underlying interdependences between meeting basic needs and creating pollution). The current study builds off prior work around embodied interaction (Antle, 2013) to explore the ways in which pairs of children use Youtopia's tangible tools in conjunction with language to interact with each other and negotiate decisions.

Methods and participants

This study was a secondary analysis of data collected by Wise et al., (in press) which consisted of video data from 20 pairs of 5th grade children using Youtopia to build a world "they would want to live in" over 25 minutes. The videos were reviewed for episodes meeting one of the following criteria: (1) conflict; (2) "same-page" thinking (e.g., dialogue that moves learners towards shared goals or trains of thought); (3) in-depth reasoning; or (4) other particularly interesting collaborative interactions. Two to nine episodes were transcribed from each of 18 videos totaling 100 episodes of dialogue. Two videos had no episodes identified as these pairs had little verbal interaction. Episode transcription included both utterances and descriptions of actions taken as part of the pairs' interactions. An iterative data analysis of the episodes was conducted following the approach of Ziegler et al., (2013) using Speech Act Theory (Searle & Vanderveken, 1985) as a conceptual framework to examine how learners spoke in relation to tool usage (see Table 1). Speech act theory is grounded in the notion that in addition to literal meaning, utterances have an intended effect on the listener. Categories of intended effect (illocutionary force) of speech used in this analysis included: assertives (providing information); directives (providing instructions); expressives (providing personal values); commissives (committing to actions); and declaratives (redefining the reality of actions).

Findings

One key way learners used tools and talk in their negotiation was by presenting evidence to support their position on a game choice. Prototypically this would be initiated by one child engaging the others' attention via an assertion paired with physical use of a tangible tool (often the impact tool). This would be followed by a directive and/or discussion of next steps involving expressives and often also additional presentations of evidence (assertives along with tool use). An episode would conclude with decisive action by one child (based on consensus or taken unilaterally), often accompanied by an assertive or expressive to assess their decisions, or a commissive or directive as they commented on actions while performing them or planed next steps.

This pattern is outlined in the following example (see Table 1). At 9:52, Sai uses the impact tool to pause the game and draw Ben's attention to the pollution level. In response, at 9:55, Ben builds on Sai's comment and suggests they reduce pollution. Sai agrees at 9:56, and emphasizes her concern about the pollution, reusing the impact tool to draw attention to the current level. Between 9:58 and 10:06 while discussing what to do next, Ben tries out erasing an energy source and directs Sai uses the impact tool to check what difference this made; she reports that now (only) some people have energy. At 10:11Sai recognizes and describes the core tradeoff between providing energy and creating (some) pollution. Ben considers her comment and at 10:19 suggests erasing the coal plant as an alternate strategy to reduce pollution. The analysis shows how Sai repeatedly uses the impact tool to generate evidence that helps stress her concerns about the pollution and how together Ben and Sai use the eraser plus impact tool to reason through the tradeoffs embedded in the game.

Table 1: Episode in which Sai and Ben negotiate tradeoffs between energy needs and pollution

Time	ID	Dialogue	Action	Speech acts to interpret events
9:52	Sai	There's some pollution	Uses impact tool	Sai *asserts* the pollution level
9:55	Ben	We need to cut down the pollution		Ben *directs* them to lower pollution
9:56	Sai	K don't let anything else that might [xxx pollution]	(Re) uses impact tool	Sai agrees with *direction*, *committing* to the plan to limit pollution
9:58	Ben	So do you think we should take out the hydro dam?	Removes impact tool	Ben asks Sai for *direction* to erase hydro dam
10:00	Sai	No, cuz, then people wl'(will not) have energy		Sai *expresses* concern against Ben's suggestion
10:02	Ben	Now wait (.) check that	Uses eraser tool to delete hydro dam	Ben erases dam to test a theory and *directs* Sai to check the impact tool
10:06	Sai	Some [people have energy]	Uses impact tool	Sai *asserts* the energy level
10:11	Sai	[So] if we add one of this (hydro dam) then many people have energy (.) but there'll be pollution	Points at energy ring on impact tool	Sai *asserts* that adding energy sources will contribute to pollution
10:19	Ben	I think we should take out (.) the coal stuff	Removes impact tool, erases coal plant	Ben *commits* to erasing the coal plant as he follows through

Conclusions and implications

This analysis showed one way in which children used Youtopia tools in combination with language to support their interactions: by providing evidence to support their position. The suggests that tools that provide game state information while pausing the action can create not only opportunities for reflection (Antle & Wise, 2013) but also support for collaboration through engaging a partner's attention, directing it to particularly game aspects, and creating a common referent point for negotiating shared interpretation (and evaluation) of game goals, strategies and progress. One specific approach to generating evidence involved making a single change and then showing the direct impact of this on the game state. The main implication emerging from this work is that tangible designers can target support for *specific* kinds of collaborative interactions by creating tools that can provide evidence for anticipated points of negotiation. This suggests value in pre-identifying key decisions or areas of potential conflict and the kinds of evidence relevant to exploring and resolving them. In addition, there seems to be value in pausing (game) interaction to allow such negotiation take place.

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Creative Collaboration and Flow: Validating the Use of Trace Data to Measure Dynamics of Creative Flow in Collaborative Design Teams

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Abstract: We use sociometric trace data to create an index of dynamic group flow in collaborative design teams. Sixteen students in four teams worked on a collaborative engineering design task, while wearing sociometric devices to collect real-time data on team interaction. Results indicate that group flow as measured by dynamic trace data is partially correlated with self-reported flow. This finding implies the potential to use trace data to provide reliable and dynamic measures of task engagement during collaborative learning.

Keywords: group flow, creative collaboration, sociometrics, engineering design

Introduction

In the field of engineering design, where high demands on creativity and collaboration are prevalent, *flow* is been regarded as critical element in enhancing the quality of creative and collaborative outcomes. Csikszentmihalyi (1990) defined the experience of flow as a peak experience, or state of heightened consciousness, during high-challenge, high-skill moments when performing autotelic or intrinsically-motivated tasks (Nakamura & Csikszentmihalyi, 2002). *Group flow* describes the situation when the collaborative group is performing at maximum effectiveness, and is closely associated with higher creativity (Sawyer, 2008). Several characteristics, such as close listening, characterized by listening and responding without preconceived notions, and equal participation, shown by each participant assuming equal roles in group activity, are considered to be crucial dynamic behaviors for the emergence of group flow. In extending the concept of flow from the individual to the group, Sawyer (2008) proposed a set of ten characteristics that constitute or contribute to the state of group flow, including conditions that set the stage for good flow, as well as dynamic behavior characteristics that contribute to group flow.

Despite efforts devoted to promoting flow and collaborative outcomes in engineering design, existing measures of flow suffer from two important drawbacks. First, they are typically administered infrequently (e.g., probing after a task, or a few times during a task), and are thereby likely to miss moments of maximum or high task engagement that occur at times other than the probe. Second, they rely upon self-reported data from students and participants, which are disruptive and time-consuming to administer, sometimes biased, and potentially unreliable measures of task engagement (especially in younger audiences).

Recent developments in wearable sociometric sensor technologies (Olguín et al., 2009) enable researchers to capture data about vocal, speech, and body activity using unobtrusive methods. Wearable sociometric technologies are useful in capturing data about interaction in groups, including syntactic, prosodic, and body movement cues that are produced by speakers. These data reveal important information about the speech and conversational dynamics of collaborative learning, including how speakers coordinate or tune their speaking with one another by using various cues during conversation.

In this study we test and validate the use of trace data from wearable technologies to measure group flow collected continuously and unobtrusively from wearable sociometric badges that roughly correlate with five of the ten characteristics modeled by Sawyer for group flow. We create an index of group flow, and then test the validity of this index by correlating the dynamically generated measures of task engagement with self-reported (individual) flow surveys. Then we map these measures over time to provide a visualization of flow dynamics over the course of a collaborative design learning session, to indicate the process of flow during collaborative learning tasks. In doing so, we demonstrate the use of novel wearable technologies to measure group flow as a dynamic process of engagement with a task and with collaborative peers in design processes.

Methods

Sixteen students ranging in age from 21-37 years (M=25.25, SD=3.92) were recruited from a graduate mechanical engineering course on global design and randomly assigned to four teams. Each team was given one toy and instructed to redesign the toy, using sketching to collaboratively design new ideas (Taborda et al., 2012). Teams sketched their ideas using either paper or digital sketching tablets. The *skWiki* sketching system includes 10-inch tablets interfaced with a web-based sketching application that allows users to sketch with a capacitive-touch styli and synchronize design sketches across devices (Zhao et al., 2014).

To collect information about *collaboration dynamics,* we used wearable sociometric sensors to capture real-time data on a series of non-linguistic social signals. We recorded seven measures: participants' speech activity (*speaking, listening, overlap*, *participation*) and conversational *turn-taking* (by and after each speaker) and *successful interrupts*. Data were captured in 1-second intervals, and analyzed in 10-second speaking intervals. The item for *listening* exhibited a negative average covariance among the items and was removed from the scale, yielding a 6-item index ($\alpha = 0.88$).

To assess *creative flow,* we created an 8-item scale with questions probing cognitive engagement (activity was exciting, challenging, and required concentration), skill (participants were skilled or successful at task), and affective engagement (participants enjoyed the task, found it important, and were satisfied with performance) (Arici, 2008). Items were measured on a 5-point Likert scale, and aggregated ($\alpha = 0.91$).

Findings

The partial correlation between the Group Flow Index and Individual flow index was not significant. We then assessed correlations between individual items of both indices, and found significant correlations between dynamically measured flow and self-reported indications of whether the activity was considered challenging.

Conclusions and implications

We use continuously and unobtrusively collected trace data to create an index of group flow based upon 5 of the 10 characteristics of Sawyer's (2008) model of group flow: communication, close listening, equal participation, blending egos, and moving it forward. The Group Flow Index allows us to dynamically measure two important indicators of the process of collaborative learning: a) the *communicative engagement* and participation of members (Sawyer's communication, close listening, and equal participation) and the characteristics of *collaborative elaboration* (represented by Sawyer as blending egos and moving it forward), in which the conversation of members becomes more synchronized, overlapping one another, and participants begin to successfully build upon and elaborate the ideas and knowledge that are contributed by others on the team. In future work, we will continue validating the Group Flow Index in a diverse set of design tasks, and correlate this index with specific events during collaboration, in order to analyze the relationship of group flow to collaborative events and outcomes. This work includes the development of predictive models relating speech, conversational, and body signals to a variety of collaborative learning processes and outcomes.

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Proposing an Alternative Framework for the Assessment of Collaborative Problem Solving

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Abstract: We propose a framework for the assessment of collaborative problem solving, by letting children solve knowledge-rich problems both individually and collaboratively, and assessing differences between two modes. Results show that they improved performances, indicating their potential. We also identified two obstacles for releasing the potential: self-consciousness of gaps in ability with the partners and the lower sense of goals. Assessment frameworks are discussed to examine children's differences at the edge of their capability.

Keywords: collaborative problem solving, assessment, 21st century skills, collaborative learning

Introduction

The knowledge society requires defining and assessing 21st century skills in ways integral to the processes of teaching of higher quality. Scardamalia *et al.* (2012) summarized that ways of integrating 21st century skills into curricula can range from superficial to fundamental levels: "*additive change* (addition of new skill objectives and new curriculum content)," "*assimilative change* (existing curricula and teaching methods are modified to place greater emphasis on critical thinking, problem solving, collaboration, etc.)," and "*systemic change* (schools are transformed into knowledge-creating organizations)." Although we should cause *systemic changes* in every school, the OECD's Collaborative Problem Solving (CPS) framework (OECD, 2013) adopted in PISA2015 can invite schools to resort to *additive changes*, because it aims at assessing "domain-general" capabilities (Looi & Dillenboug, 2013) and captures no emergent properties of collaboration such as creating new questions. Instead, we should at least make *assimilative changes* happen by proposing an alternative framework. Our proposal is simple: letting children solve domain-specific, knowledge-rich problems both individually and collaboratively, and assessing differences between two modes to examine their CPS by addressing questions below (Figure 1).

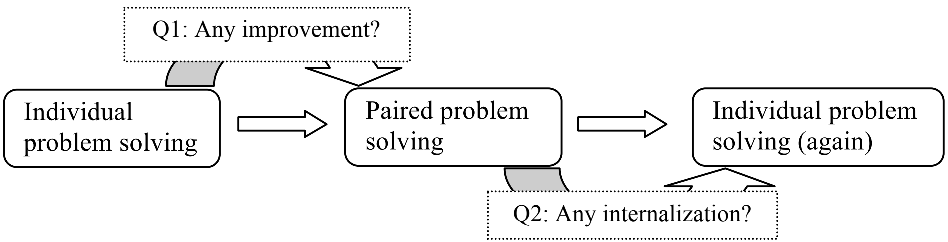

Figure 1. Assessment framework for CPS

Methods

We report results of 49 pupils (6th graders) from three public schools. We made 23 pairs and one trio on the principle of "pairing randomly" to reveal their potential regardless of their partners' performance, character etc.

We used problems from the National Assessment of Academic Ability which Japanese ministry of education has carried out in mathematics and language for 6th and 9th graders. There are two types of problems: Type A "knowledge" problem and Type B "use" one, roughly corresponding to TIMSS and PISA literacy problems respectively. The first main problem (i.e., part) concerns the parallelogram and has three sub-problems, the last of which asks its areas in an information-overloaded situation. The second main problem questions the decimal fraction and percent of basis: for example, the second sub-problem asks "Distance between outstretched thumb and forefinger is called 'Ata.' Chopsticks that fit one's hand are 'one Ata and a half' long. Ata is roughly equal to 10% of one's height. If your sister is 140cm tall, how long will her chopsticks be?" The third main problem concerns about the ratio, asking pupils if they can pick up numbers from a cross table to compare ratios.

We assigned one main problem from the three above to each pupil, asking her or him to solve it individually in eight minutes, then to solve it with a nearest partner in eight minutes, and finally to separate them again and explain how she or he had solved it to the experimenter (we did this only in difficult problems). We gave a set of worksheets to each pupil in the individual solving phase, withdrew it, and gave another set to each pair in the paired solving phase to let members of the pair discuss over the worksheets.

Results and discussion

Table 1 shows the ratios of individuals (in the individual solving and explaining phases) or pairs (in the paired solving phase) who answered correctly with justification. The table also includes average scores of the problems in the National Assessment. Their performances in the paired phase went up from those in the individual phase, especially up to 100% in three problems. Those performances mostly stayed in the individual explanation phase. We examined what kinds of pairing yielded what kinds of results by collapsing the data to find that 1) 100% of six pairs (one trio is included) both members of which solved the problems correctly in the individual phases solved them again correctly, 2) 90% of ten pairs one member of which solved the problems solved correctly, and 3) 50% of eight pairs neither member of which had solved them individually solved the problem correctly. The results up to here indicate children's potential of their collaborative problem solving.

There were however pairs who did not reach correct solutions and individuals who did not "internalize" solutions. The process analyses indicate that unsuccessful pairs did not take many turns nor discuss reasons and justifications, being satisfied when they got *any* answers. Especially when one member hesitated to ask questions to her or his partner, their conversations did not come alive and their solutions were not "taken away." In contrast, successful pairs tackled the problem on an equal basis without hesitation regardless of the correctness of their solutions, explored and discussed many possibilities, wrote detailed answers including expressions and their meanings, and gave newer questions.

Thus, we can identify two obstacles: 1) pupils' excessive self-consciousness of gaps in the math grade or ability with their partners, and 2) their lower sense of "goals" (for example, reaching solution means "getting things done"). They are typical features resulting from the instruction of "*backward approach*" (Scardamalia *et al.*, 2012), in which the goal is set by a teacher and specified as a collection of utterances and behaviors. Students compete with each other to reach the goal first, which yields unnatural ranks among them and prevents further explorations beyond the goal. But for these obstacles, pupils could engage in "healthy" collaborations.

We cannot tell if the differences between successful and unsuccessful were caused by certain factors (e.g. skills, experiences, climates of schools) or only by chance (e.g. relationship between partners). More studies are needed, but we see some prospects of our framework. First, it reveals children's basic understandings in the domain as well as how they deepen them through collaboration, because our assessment is knowledge-based. Second, if we can accumulate positive results, we will be able to show skills of collaboration not as *something to add* but as *something to pull out* from children. Third, if this assessment is coupled with education for idea improvement and proves its merits, it gives teachers hints for both assimilative and systemic changes.

Table 1. Results by phases on the target problems

	Parallelogram(3) (n=28)	Ata(1) (n=13)	Ata(2) (n=13)	Ratio (n=8)
National Average	18%	46%	33%	24%
Solo	36%	77%	77%	50%
Pair	75%	100%	100%	100%
Solo (Again)	—	—	85%	88%

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Interactive Events and Data Sessions

ClassroomImaging:
A Tool to Code and Visualize
Complex Classroom Learning Processes

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Abstract: Data from classrooms is typically complex as it includes the presence of multiple actors (e.g., 25 students and a teacher), possible activities (e.g., explaining, questioning, monitoring), social levels on which learning takes place (e.g., individual learners vs. small groups), and artifacts that are used by the participants. Further, all these aspects may change over time. Yet, few tools are available that are capable of both coding such data in an integrative manner and of creating intuitive, dynamic visualizations of the learning process. This paper describes ClassroomImaging, a tool to code and visualize complex classroom learning processes by resorting to (a) a spatial representation of the classroom, (b) a symbolic representation of the participants (teacher, students), artifacts, (c) teaching and learning activities, (d) the social level on which learning is realized and (e) the temporal dynamics of the above properties during the learning situation.

Keywords: classroom learning, coding, data analysis, data visualization, learning processes

Introduction

Over the past years, a lot of CSCL research has dealt with how to effectively orchestrate complex classroom learning (see Dillenbourg, 2013). In that research, emphasis is given to the constantly changing conditions and processes of classroom learning. For example, the teacher may switch between different teaching and learning activities, which may be situated at the plenary, the small-group or the individual level (Dillenbourg & Jermann, 2007). Further, learners may interact with artifacts (e.g., chairs, desks, laptop computers) and with other learners as they are learning.

Empirical research is interested in the effects of such orchestrations on the learning process of the class. E.g., research might focus on the effects different orchestrations have on the frequency or quality of explanations (van Boxtel, van der Linden & Kanselaar, 2000), questions (King, 2007) or arguments (Weinberger, Stegmann & Fischer, 2010) that are produced by the learners. The effects of one orchestration may then be compared to the effects of an alternative orchestration (see Kollar, Wecker, Langer & Fischer, 2013). To perform such analyses, researchers typically do two things: (a) *Coding data*: They develop a coding scheme that captures a certain process dimension (e.g., argumentation quality) of the data of each individual actor (which may exist in the form of videos, audio recordings, chat logs, etc.), and then code the data accordingly. (b) *Visualizing results*: To demonstrate the effect of a certain orchestration on a certain process variable, they compute and visualize the frequency of the occurrence of certain learning process variables (e.g., the frequency of warranted arguments), e.g., in bar or line diagrams.

Yet, researchers face several challenges during this process. With respect to *coding*, the data sources are often spread across several files with different formats (such as audio recordings of talk and logfile data). That way, it is complicated to quickly switch between the multiple data sources available, which makes coding of the learning processes of all possible actors inconvenient. With respect to *visualizing* the effects of different orchestrations, a reliance on bar or line diagrams that aggregate frequencies of particular process categories obscures what particular aspects of the learning environment actually evoked those learning processes and whether single individuals were differentially affected by those aspects (e.g., a certain teacher activity). This is even more problematic when acknowledging the dynamic nature of complex classroom scenarios (Mercer, 2008), in which a given learner may find herself in a face-to-face discussion within a small group during one phase of learning, and learning individually with a laptop in the next.

Interaction analysis has been a topic in CSCL research for several years, and has resulted in many helpful tools such as interaction awareness tools (Gassner et al., 2003) and video coding tools (Avouris et al., 2007). A lot of these approaches support analysis at an abstract and general level, such as the contingency graph analysis (Suthers, 2009) that associates users, messages and their semantic relations or trace analysis tools (Settouti et al., 2009, or the Tatiana toolsuite). In contrast, our approach stresses the physical aspect of learning within a classroom and its orchestrations, information that is not easily detectable automatically if not using wearable technology (Hernández-Leo et al., 2013). Thus, we see interesting synergies with the mentioned approaches in the future, yet have to create our own dedicated approach and tool that captures classroom interaction data before integrating it with other tools.

This paper therefore presents ClassroomImaging, a software tool that is supposed to afford (a) the coding of classroom data stored in different files and formats in a convenient and integrated way, and (b) the visualization of the flow of activities within complex scenarios in a dynamic, non-aggregated fashion, thereby providing an intuitive understanding of the learning processes that go on in complex classroom scenarios.

Introducing ClassroomImaging: Code and visualize complex classroom data

The basic goal that guided the development of ClassroomImaging was to create an integrated tool that helps researchers to (a) conveniently code learning processes that occur in complex classroom scenarios and to (b) create dynamic and intuitive visualizations of those processes. To do so, we argue that the representation used for coding as well as for the visualization ideally should mirror the actual classroom situation.

Preparing for coding within ClassroomImaging

In a first step, ClassroomImaging asks the user to re-build the classroom from which the data is coming (and for which appropriate recordings must exist) in a symbolic, albeit sufficiently realistic way. For that purpose, ClassroomImaging helps the user create a bird's-eye-view-representation of the classroom. This includes the possibility to choose from a set of objects that are commonly used in classrooms (such as desks, whiteboards, laptops) and to freely drag and drop them to the appropriate positions. Furthermore, users can represent every single actor (i.e., each student plus the teacher) and position them in the representation (using circles as representations for students, triangles for teachers) according to their position in the video recording (or photo/drawing, if no video exists). To make every actor identifiable, each actor can be given a code (e.g., a number) that is "sticked" to him or her (see fig. 1 for an example of the initial setup of a classroom situation).

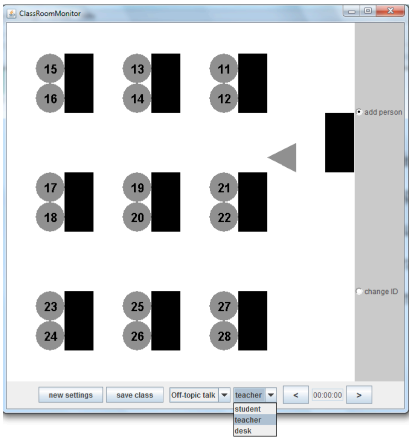

Figure 1. Editing the classroom layout and initial position of students and teacher.

For future versions of our tool we plan that after the initial set-up of the classroom is completed, available data sources for each actor are associated with the physical representation of that actor. I.e., if for one student video plus logfile data is available, a double-click on the symbol that represents that actor will bring up those files so that they can immediately be coded. If multiple files exist, the user can choose which one to use for coding. This extension will enhance the integrated and interactive coding we describe in the next paragraph.

Coding activities and social settings within ClassroomImaging

After the classroom representation is created, the actual coding of the activities the single actors engaged in can begin. Precondition of course is that the user has already developed a coding scheme that captures those process categories that are of interest. ClassroomImaging particularly supports two objectives of coding, (a) the coding of the kinds of activities an actor engages in (e.g., arguing, listening, explaining, etc.), and (b) the social setting that is realized (i.e., whether the actor is part of a group or not; groups can range from dyads to the whole classroom, to also differentiate between small group and plenary phases). The coding of the activities of an actor can be done by assigning a code that can be chosen from a choice-list (fig. 2 middle) based on a schema file the tool is started with and that can be changed easily without any programming knowledge. The information about the social setting is planned to be possible in different ways, such as multi-select to group actors or selecting via area selection/framing with a free curve like in a drawing tool.

If video or audio data exist, coding can be done as the recording is running, and the assigned codes are stored together with a time stamp that indicates when the respective activity was shown by the learner. If logfile data exists, and if these carry time stamps, these time stamps can be transferred to each code that is assigned as well. The ClassroomImaging prototype can be configured with the time interval the researcher finds appropriate, e.g. ten-second-segments for each of which one code for each coding dimension can be given. A similar approach has been used in other video-based coding software, such as Videograph® (Rimmele, 2004).

Resulting data visualization within ClassroomImaging

To visualize the flow of activities within the classroom, ClassroomImaging's visualization output is dynamic, i.e. a flipbook-like representation that can be "played in sequence" that basically includes four features.

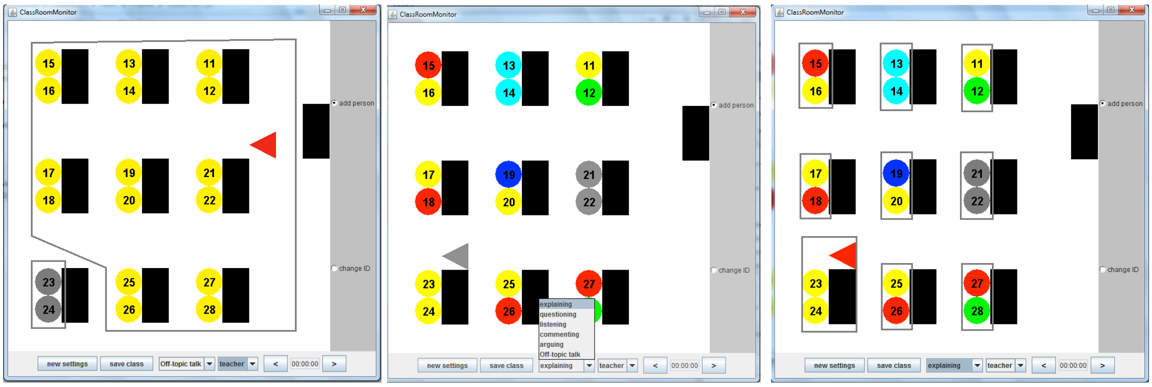

Figure 2. Coding and visualizing classroom situations.

First, based on the coding on the activity dimension, the symbol representing a particular student or teacher is color-coded. E.g., suppose that the coding scheme includes the categories "arguing", "explaining", "questioning" and "listening" (visible in fig.2 middle). ClassroomImaging associates each of these categories with a color, and whenever a student is coded as engaging in one activity, the circle with the number of the student is painted accordingly. The leftmost screenshot of fig. 2 shows a teacher (represented as triangle) explaining (color-coded in red) to the class in a plenary situation with most students listening (color-coded in yellow) and two students in the corner chatting off-topic (color-coded in grey). In the middle screenshot, the teacher's activity is coded using a choice-list of the used coding schema; when choosing the "explaining" code for the teacher, the color of the teacher symbol changes accordingly, which can be seen in the right screenshot of fig. 2. As the flipbook is running, the colors of each actor thus change dynamically, depicting the flow of activities that each single actor has engaged in over the course of the lesson.

Second, to depict changes regarding the social plane (Dillenbourg & Jermann, 2007) on which learning takes place (plenary, small group, individual), ClassroomImaging uses a "frame" representation to bind those actors together who currently form a group. E.g., if two students sitting next to each other form a group, the two circles that represent these students can be connected at the appropriate step of the flipbook (fig. 2 right). If students collaborate online, and if collaborators within a dyad are seated in different areas of the classroom, those two students are connected. If there is a plenary activity, all students who are attentive to this activity are connected with each other (fig. 2 left).

Third, to depict changes regarding the physical position of the actors (e.g., to account for situations in which the teacher is moving from one desk to the next, or in which new groups are formed that temporarily sit together to discuss) and the objects they currently use, ClassroomImaging affords the opportunity to drag and drop actors and objects at any time point of the flipbook. Stopping the run enables interactive manipulation of the respective time segment as described above in the coding section. For example, figure 2 left and middle show that the teacher has moved from the classroom center to the lower left corner where the chatting students are located.

Fourth, to provide the viewer with information on time, the resulting representation includes a time stamp in the bottom right corner (fig. 2). The interval steps in which the animation proceeds is oriented at the size of the segments that were initially set by the user.

Promises and challenges

We believe that ClassroomImaging bears a strong potential to help researchers code complex classroom data and capture the dynamic flow of learning activities within "messy" classroom situations. Regarding coding, ClassroomImaging offers useful features to integrate data from multiple data sources and to access them all through the software itself. The resulting data visualizations can be used for in-depth, descriptive analyses of the learning processes that go on within a given classroom and thus make the effects of certain "orchestrations" intuitively visible. E.g., it would be very interesting to see the immediate effects of a certain teacher activity (such as modeling) on the learning processes of the individual students by simply looking at the changes of the dynamic visualization right after the teacher has exhibited this activity. This detection of impact could also be supported by formal metrics for the differential between two time points. Such metrics can be easily implemented and might be helpful to identify "critical moments" in the classroom flow. Further, resulting visualizations might serve as material for teacher training. By inspecting and discussing a prototypical visualization based on the coding of a real classroom situation, teachers may for example become aware of possible, unwanted side-effects of certain teaching activities and be trained in their development of strategies to prevent those unwanted side-effects from materializing.

Yet, we also see some challenges ahead of us. First, coding remains cumbersome, as every single student's activity at each point in time needs to be coded by aid of a to-be-developed coding scheme. Thus, ClassroomImaging can only relieve time and effort in that sense that it offers opportunities for conveniently accessing multiple data sources within one tool. Yet, combining ClassroomImaging with tools for natural language processing that are able to automatically code verbal data (e.g., Rosé, Wang, Arguello, Stegmann, Weinberger & Fischer, 2008) seems promising. A second challenge is that the richness of the resulting dynamic visualizations is difficult to transfer to static publications, e.g. journal articles. While it is possible to create moment-to-moment visualizations as in fig. 2, this can only cover a very short time sample of a lesson. Currently, ClassroomImaging is much better suited to visualize classroom learning in more interactive formats (e.g., during conference talks). More work is needed to make its potential visible in static publication formats.

Despite these and other challenges, we believe that ClassroomImaging might become a powerful tool to analyze and visualize complex classroom learning that recently received a lot of attraction in the Learning Sciences. In principle, the tool could even be used on-the-fly while observing classroom situations, similar to paper-based observation sheets for group interactions. Such a "real-time mode" would have to be designed and evaluated carefully, but is an interesting extension of the current usage scenario.

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Challenges and Opportunities of Dual-Layer MOOCs: Reflections from an edX Deployment Study

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Abstract: This interactive event is meant to engage the CSCL community in brainstorming about what affordances in MOOCs would enable application of and research extending theories and best practices from our field. To provide a concrete focus as a foundation for this discussion, we present the innovative design of a recent edX MOOC entitled Data, Analytics, and Learning (DALMOOC). We have integrated several innovative forms of support for discussion based learning, social learning, and self-regulated learning. In particular, we have integrated a layer referred to as ProSolo, which supports social learning and self-directed learning. In further support of self-directed learning, intelligent tutor style exercises have been integrated, which offer immediate feedback and hints to students. We have integrated a social recommendation approach to support effective help seeking in the threaded discussion forums as well as collaborative reflections in the form of synchronous chat exercises facilitated by software agents. The event will include an overview, offering the opportunity for active engagement in the MOOC, structured brainstorming, and interactive, whole group feedback.

Keywords: massive open online course, discussion-based learning, self-regulated learning, social learning

Overview

This interactive event is meant to engage the CSCL community in brainstorming about what affordances in MOOCs would enable application of and research extending theories and best practices from the field of Computer Supported Collaborative Learning in particular, and the Learning Sciences more generally. It is one facet of a broader effort we are spear-heading to design and build out MOOC platform affordances for collaborative learning. Our intention is to engage as many alternative perspectives as possible in order to work towards a platform that will enable both accelerated scientific advances in our field in this new context as well as efficient transitions from research into practice.

We termed this MOOC a "dual layer" MOOC because students had the option of following a more standard path housed in the edX platform for moving through the course in one layer or to follow a more self-directed path in the ProSolo environment, that formed a second layer. This MOOC, entitled Data, Analytics, and Learning (DALMOOC), was launched in October of 2014 and extended for 9 weeks in addition to an orientation week as part of in an iterative, design based research process the author team is engaged in to integrate affordances for richer, theory motivated learning experiences into xMOOCs. In each cycle, we base the design of our interventions on analyses of data collected from existing MOOCs, then we deploy those interventions, and then iterate on our designs based on our interpretation of the new data we collected. This interactive event offers the opportunity to engage the CSCL community in our design based research process beginning with one concrete example MOOC. However, the goal is to work towards a broader, longer term vision for work in this area.

Prosolo

In the context of the current DALMOOC deployment, Siemens and Gasevic were responsible for undertaking work in two primary areas: a) increase the social learning experiences of self-regulated learners in MOOCs through social competency approaches to learning and b) develop learner knowledge graphs that reflect what a learner knows and how they have come to know it. This work built on an existing software product (ProSolo) that was integrated in DALMOOC and used by several thousand students in that context as well as other earlier MOOCs and pilots in corporate environments (Volkswagen). This ProSolo layer served as a striking alternative to the more scripted xMOOC approach to MOOC learning, which remained available to students through the edX layer. Learning in ProSolo is social in the sense that students follow and communicate with other students during the process of setting their learning objectives. However, beyond that, the learning experiences students engage in within the ProSolo environment are still largely individual in character.

ProSolo utilizes what is termed a competency-based approach to learning. The content of a traditional course/MOOC is translated into competencies and required learning activities are then attached to each competency. Learners can either take the existing set of competencies for a particular course or they can create personal learning goals. The cycle of planning learning, sharing learning and validating is social - learners share completed competencies, including the pathways and approaches used to achieve those competencies. Additionally ProSolo offers a "credential pipeline" that assists faculty in assessing successful completion of competencies. When a learner has completed a particular competency, she submits the competency with evidence of completion to peers or faculty. Upon review of evidence, faculty/peers can provide confirmation of successful completion or send the competency back to the learner for additional evidence of learning. This process also allows for the inclusion of learning that happens outside of the university. Learning that happens through formal courses, MOOCs, personal hobbies, and work can be included in ProSolo and within the credential pipeline. From a motivational standpoint, ProSolo is meant to give learners the opportunity to identify learning goals, connect with others around shared goals, and create a pathway for recognition of learning. A second aspect of ProSolo is the creation of learner profiles so students can find others with shared interests.

DALMOOC has been designed to model a distributed information structure. As such, learners are encouraged to participate in any space they would like: blogs, Facebook, Twitter, edX discussion forums, etc. A key challenge that arises as learners engage in different spaces is one of fragmentation. Learning is a coherence forming process and knowledge is a state of connecting information pieces. As such, we have adopted an aggregation approach similar to what Stephen Downes pioneered with early MOOCs: gRSShopper. Content is aggregated and shared in a daily email to learners. By aggregating learner content and providing persistent profiles, we anticipate higher levels of learner engagement. An important affordance provided by ProSolo is persistence. The content of the course will remain available for students to access post-course, particularly the summary emails and learner profiles in ProSolo. Learners will have the option to search context relevant resources in ProSolo. The hope is that this will assist in creating a persistent practitioner community where learners will access resources post-course and continue to engage with each other on social media and in ProSolo.

Early results from DALMOOC indicate that learners experience some uncertainty and discomfort in transitioning from instructor-driven to self-regulated learning. Learners within the edX course found the distributed structure of DALMOOC confusing at times. Better scaffolding and support is needed to assist learners in transitioning between structured instruction and open engagement in social systems (either the open web or within ProSolo).

The Cognitive Tutor authoring tools

The importance of immediate feedback and hints on demand during problem solving has been well demonstrated through decades of research on intelligent tutoring systems. As MOOCs have evolved, an important direction for enhancing their ability to keep students engaged and help students check their understanding is to incorporate comprehension check questions, normally implemented as multiple choice activities. In a recent Pyschology MOOC, enhanced learning and decreased attrition were both associated with students who chose to participate in intelligent tutor style structured activities with hints and feedback (Koedinger et al., 2015). In DALMOOC, Baker from Teacher's College in collaboration with Aleven at CMU integrated intelligent tutoring style activities in Baker's unit on predictive modeling. These scaffolded problem solving exercises were implemented using the Cognitive Tutor Authoring Tools (CTAT) (Koedinger et al., 1997; Koedinger & Aleven, 2007), which has been developed with the goal of efficiently authoring intelligent tutoring style learning experiences for students, to be used broadly in online learning.

While these activities were not collaborative, earlier work with student learning in CTAT tutors has been conducted either individually or collaboratively, and thus opportunities for incorporation of additional collaborative learning opportunities around these activities is a potential direction for future work.

The Quick Helper

Earlier research on MOOC discussion forums indicates that the experience of confusion as well as exposure to other students' confusion are both associated with elevated attrition in MOOCs (Yang et al., 2015), and attempts at resolving confusion by making help requests in the threaded discussions are frequently left without a satisfactory response.

In response to these two problems, a specifically discussion-focused intervention, called the Quick Helper, was integrated by Rosé, Ferschke, and the broader CMU team with DALMOOC to support help seeking as well as increase the probability that help requests will be met with a satisfactory response. While virtually all MOOCs offer threaded discussion affordances where students can post help requests, some students are reticent to ask for help, and even when students do post help requests, many of these requests go unanswered. Our help seeking intervention connects students, whose questions may go unresolved, with student peers who may be able to answer their question. The Quick Helper is continuously available to students by means of a button. When they click, they are guided to formulate a help request. The help request is posted to the MOOC discussion board, and the text and metadata are forwarded to our Quick Helper system. Using this help request, a social recommendation algorithm selects three potential help providers from the pool of student peers. The student is then given the option to invite one or more of these potential helpers to their thread as shown in Figure 1. Once selected, an email with a link to the help request thread is then automatically sent to the selected helpers inviting them to participate in the thread. At writing, 77 unique students elected to use our Quick Helper system approximately 127 times. Further discussion of our initial interventions applied to Quick Helper and its results are discussed in a separate paper (Ferschke et al., in press).

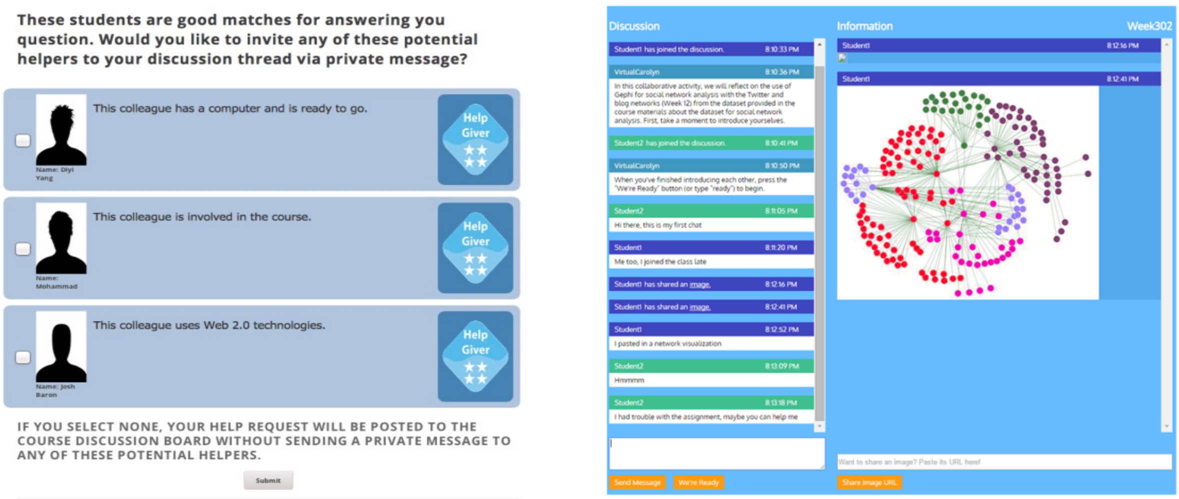

Figure 1. A screenshot of the Quick Helper helpers selection window (left) and the Bazaar Collaborative Reflection synchronous chat (right).

Bazaar Collaborative Reflection

A final intervention, referred to as Bazaar Collaborative Reflection, makes synchronous collaboration opportunities available to students in a MOOC context. Research in Computer-Supported Collaborative Learning has demonstrated that conversational computer agents can serve as effective automated facilitators of synchronous collaborative learning (Dyke et al., 2013). However, typical MOOC providers do not offer students opportunities for synchronous collaboration, and therefore have not so far benefitted from this technology. Rosé's team integrated such activities into DALMOOC by means of a Lobby program. Students click on the Lobby button and are matched with one other student that is also logged in to it.

Upon entering the lobby, students are asked to enter the name that will be displayed in the chat. When successfully matched with another learner, the student and their partner are then presented with a link to a chat room created for them. If another student does not enter the Lobby within a couple minutes, they are requested to return later. A visualization is presented to the student that illustrates the frequency of student clicks on the button at different times of the day on the various days of the week so that they are able to determine the best time to return. Students enter the synchronous chat room via the link, and interact with each other as well as a conversational agent who appears as a regular user in the chat, as shown in Figure 1. This chat setup has been used in earlier classroom research (Dyke et al., 2013; Adamson et al., 2014). In our initial investigation in the edX MOOC, we make use of statically scripted agents who guide the students through course-related discussion questions but future investigations may include agents that dynamically react to the students. Students interact and discuss a topic until the pair selects the "We're ready" button, then the agent then proceeds with the next prompt.

While we have not yet assessed the influence of Bazaar on learning, we performed a survival analysis to evaluate the influence of this collaborative learning activity on attrition. Using the number of clicks on videos and the participation in discussion forums as control variables, we found that the participation in chats lowers the risk of dropout almost by 50%.

Reflections

As we observed learners experiencing the automated and social support integrated with this innovative edX MOOC, we observed students providing benefit to one another when they connected, both in the ProSolo Layer and the more standard edX layer. As we observe a pattern of students gravitating towards the variety of communication media made available through ProSolo and in DAMOOC more broadly, we have begun to investigate the choices students make for where they conduct their social interaction, and what trade-offs we find in terms of the content focus and nature of discussions in the different environments. As we read their communication, we see evidence of confusion and frustration in the process of wayfinding through the choices. Thus, we find many opportunities to better support students in finding and maintaining desirable connections, support, and direction throughout the course. The use of social recommender systems and group collaboration tools (such as Bazaar) are expected to lead to higher levels of metacognitive monitoring, which in turn is associated with an increase of feeling of knowing, increased confidence, judgment of learning, and monitoring of progress toward goals. We continue to seek ways to integrate the technologies we have developed to achieve a more positive experience for students.

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Bodily-Material Resources in CSCL: Children's Embodied and Multimodal Collaborative Learning of Scale around Touchscreens

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Abstract: Within CSCL language is often perceived as the primary vehicle for knowledge building and collaboration, whereas bodily-material resources are explored to a lesser extent. In this data session we explore the importance of gestures and body movements as bodily-material resources in relation to communication, learning and collaboration and how they are used to organise intra- and inter-psychological processes. By presenting two short video excerpts of children working with the concept of scale around a touchscreen, we want to facilitate a discussion on what can be gained theoretically and methodologically from focusing on bodily-material resources in CSCL.

Keywords: embodied interaction analysis, collaborative learning, bodily-material resources, touchscreens

Description of data excerpts

What is the role of bodily-material resources in relation to understanding collaboration and learning within CSCL? This question is the basic framing of our data session, in which we present two data excerpts (excerpt I=26 seconds and excerpt II=36 seconds) of children's collaborative learning around touchscreens in their classroom. The two excerpts we present are part of a larger collection of video footage (150 hours) from two second grade classrooms in a public school in Denmark (Davidsen & Georgsen, 2010). In each classroom, eight 23-inch large single-touchscreens were integrated to facilitate more collaborative learning among the 8-9 year old children. The research project and data collection lasted for a full school year and the children were working in different pairs throughout the project. The two selected excerpts stem from one week near the end of the project, where the children were working with the mathematical concept of scale. In total, 11 hours and 17 minutes of video footage was recorded during this week. We have selected two short excerpts featuring one of the pairs – Nathalie and Peter. In the two excerpts we see how the children build and interpret the concept of scale together through language, gestures and movement. Further, we have chosen two excerpts as to trace children's bodily-material innovations over time e.g. how they develop specific bodily-material tools to accomplish the task. Thus, we also want to address the historical development of the children's bodily-material resources across time.

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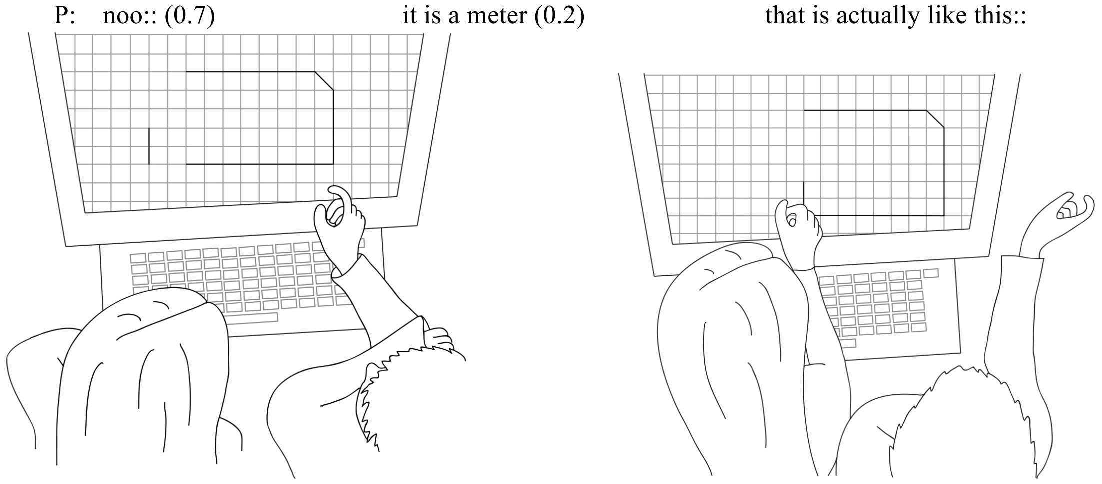

Figure 1. Example of multimodal transcript

Inspired by the Jeffersonian annotation system (Jefferson, 2004), we have developed a multimodal transcription format by converting video stills into pencil drawings (Davidsen, 2014). These drawings are put together as a cartoon to show the subtle details of children's gesture and movement, which is accompanied by a modified Jeffersonian transcript of their dialogue. With the transcript and pencil drawings, we aim to make visible the sequential and simultaneous embodied interactions, which are often left in the background in traditional CA transcripts.

In the process of developing the multimodal transcripts, we used a multi-layered transcription template in ELAN (Davidsen, 2014). The template includes language, right and left hand movements, and body orientations in order to dissect each modality and the multimodal meshwork they create together. Moreover, we used the possibilities of playing the video frame-by-frame in ELAN to comprehend the children's embodied and multimodal interaction around the touchscreen.

Theoretical background and relevance to field and conference

Our methodological stance on interaction analysis is inspired by ethnomethodology (Garfinkel, 1967) and embodied interaction analysis (Streeck, Goodwin, & LeBaron, 2011). Particularly, we are concerned with rendering visible children's embodied methods in CSCL contexts. We envision that this focus may potentially move CSCL forward in terms of the situated uses of CSCL systems and the embodied ways they are used.

In brief, the interaction playing out between the two children and the touchscreen in the selected excerpts illustrates body-material conditions for CSCL on a theoretical and methodological level. We have identified three ways the children use bodily-material resources: 1) as a communicative and illustrative tool, 2) as a cognitive auxiliary tool for processing their understandings of scale, and 3) as a tool for instructing or shepherding each other. In CSCL, bodily-material resources are often left in the background while language is given primary attention, both theoretically and methodologically. With these excerpts, we wish to engage in a constructive dialog with the participants about what can be gained from focusing on bodily-material resources in collaborative learning, e.g. what does this particular focus on embodied and multimodal interaction in co-located settings offer CSCL on theoretical and methodological levels?

Expected outcomes and contributions

CSCL have developed detailed methods and theories for exploring, analysing and discussing language in collaborative learning activities. Part of this development has been informed by Conversation Analysis (Koschmann, 2013), moreover, strong affinities with Vygotsky's work on children's language development (Vygotsky, 1986) has also given this development directions. While language has been foregrounded, it seems crucial for CSCL to turn to bodily-material resources in collaborative learning activities mediated by technology.

With the two excerpts we wish to highlight a focus on bodily-material resources in CSCL as we see a potential for theoretical and methodological development emerging from this perspective. Thus, the participants in the session are provided with an opportunity to discuss bodily-material conditions of CSCL interaction on three levels; 1) how can CSCL benefit from scrutinizing the body-material resources, 2) what can CSCL learn from children's gesture innovations and reconfigurations over time in settings mediated by technology, and 3) what can different ways of representing embodied and multimodal interaction convey to CSCL.

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Tracing Sequential Video Production

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Abstract: With an interest in learning that is set in collaborative situations, the data session presents excerpts from video data produced by two of fifteen students from a class of 5th semester techno-anthropology course. Students used video cameras to capture the time they spent working with a scientist, for one week in 2014, and collected and analyzed visual data to learn about scientists' practices. The visual material that was collected represented the agreed on material artifacts that should aid the students' reflective process to make sense of science technology practices. It was up to the student and the science expert to negotiate the nature of this collaboration. Following the inspirations by Charles Goodwin on action and embodiment and Lorenza Mondada's work on multimodality in interactional spaces, this analysis explores: the nature of the interactional partnership and their transformations through video, nature of the interactional space, and material and spatial semiotics.

Keywords: sequential and multimodal video analysis, embodiment, discourse analysis

Introduction

Examinations of video material provide powerful insights into understanding people's practices (Schwartz & Hartman, 2007). Video can support learning by "mapping uses of video into desirable and observable learning outcomes" (Schwartz & Hartman, 2007, p. 335). While video is used as a pedagogical tool in education including techno-science programmes, focusing on its analytical potential is still very rare (Broth, Laurier, & Mondada, 2014a). We consider video as a form of dialogue that also requires understanding the circumstances of production. The history, of studying the interactional patterns within and across cultures, date back to the late nineteenth century for those interested in anthropological investigations (Barron, 2007). The context of the study is a techno-anthropology bachelor programme where students explored technoscience practices. Students occupied multiple roles during this process, including being behind and in front of the camera. Our research question was: How can we examine the circumstances under which practices captured on video are experienced and articulated verbally and non-verbally and use for teaching purposes?

Theoretical background and relevance to field and conference

Interested in collaborative learning settings, we premise that collaboration involves individual learning but that it cannot be reduced to the individual (Stahl, Koschmann, & Suthers, 2006). We view that collaboration and learning are series of social activities situated in material ecologies (Jordan & Henderson, 1995). This position prompts us to explore sequential and multimodal analysis (Mondada, 2008) to trace how ideas and relationships are captured on video, taking note of who recorded and what aspects were captured. Video has been used to support anthropological and ethnographic investigations, exploring ethnographic videoing for teaching purposes by examining bodily stance (M. Goodwin, Cekaite, & Goodwin, 2012) and contextual configurations of the cameraman with his environment provide new pedagogical possibilities.

Methodology

Ethnomethodology and conversation analysis

EMCA has three characteristics: recording, transcription, and analysis to "reflect the importance of locally situated, and endogenous orders of action" (Broth et al., 2014b, p. 5). Video-based EMCA approaches have investigated how different forms of embodied conduct, including body posture, gaze, language, gesture, constitute a holistic meaning-making through coordinated and synchronized ways (see for example, (Broth et al., 2014b, Chapter 1). Only a few studies have investigated beyond the embodied conduct to include configurations of video recording including environments, objects and/or technologies. For our analysis, we employed Gail Jefferson's conversation analysis convention (Jefferson, 2004), including translations in italics (Broth et al., 2014b). We included non-verbal aspects (Jordan & Henderson, 1995) and took note of bodily stance and embodied configurations (M. Goodwin et al., 2012).

Context and participants

We examined videos produced by two students from a class of 15 who worked with scientists for one week to learn about their practices and produce video diaries and reflections. Students were introduced to Ylirisku & Buur's (2007, Chapters 2–3) ethnographic camera methods (namely, situated interview, shadowing, in-situ acting, and self-recording) and methods of interpretation (namely, interaction analysis lab, video card game, video stories, video portraits, and video collages). Scientists and students collaborated on the task to collect visual data, but achieved this in different ways.

Expected outcomes and contributions

We take an interest in temporal, material and spatial aspects and how they can be represented together with discourse analysis and the analysis of embodiment, to identify a number of outcomes:

- Nature of the interactional partnership and their transformations through video: understanding the needs of the other (i.e. who is the knowledge holder, who takes the initiative in the video recording)
- Nature of the interactional space: taking note of configurations between cameraman and the recorded and the artifacts they identify.
- Material and the spatial semiotics: taking note how solid, enduring material objects in space, but also the video itself provides structures for collaborations and interaction.

We see video used in this example as a result of negotiations between cameraman and the environment, as a form of dialogue and video observation and interaction analysis as a means to develop a pedagogical method.

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The Dialogic Construction of Knowledge in Science Education: Cultural Resources and Topical Orientation in Interaction

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Abstract: The workshop features analysis of naturally occurring talk in a CSCL science classroom. Interaction Analysis is used to study how students topicalize and make sense of science concepts moment by moment and over time, combining detailed analysis of interaction with ethnographic descriptions of trajectories of participation. The data consist of excerpts of classroom interaction where students aged 15-16 years are learning about genes and inheritance. Participants will gain experience in analyzing how science learning is managed and enacted by teachers and learners. In addition, the way cultural and material artefacts mediate human sense making will be addressed throughout the workshop.

Keywords: interaction analysis, dialogic and socio-cultural theory, science education

Introduction

In the workshop we will jointly analyze transcripts of naturally occurring teacher–student dialogues in a CSCL science classroom. We draw on Interaction Analysis in order to study human interactions, focusing on the moment-by-moment and over time constitution of meaningful practices (Derry, et.al., 2010; Jordan & Henderson, 1995; Linell, 2009). Trajectories represent an intermediate level of social organization. This methodological approach to interaction implies a focus both on the immediate and dynamic contexts of interactions as well as ethnographic descriptions of what we refer to as "trajectories of participation." In the workshop we will focus on how students develop understanding of scientific concepts, as well as the ways they appropriate science traditions of argumentation and explanation. The workshop will also consider the learning resources and how they are used and made sense of by participants engaged in collaborative learning activities.

Description of the data

We present excerpts of interaction data from a CSCL science classroom where secondary school students, aged 15-16 years, are learning about genes and inheritance. We have selected interaction excerpts from two episodes taking place during a group work. In the first episode, students work on their own, drawing hereditary charts in order to calculate the probability of inheriting eye color, genetic diseases, and sex. Students manage to come up with a correct heredity chart and reach agreement on a scientific explanation. However, when one of the students finds an article about the issue with contrasting findings, the students' understanding is challenged.

In the second episode, occurring only minutes after the first, the students summon the teacher in order to get help solving their conflict. The excerpt shows how the teacher addressed the students' challenges, and supported them in finding a solution to their conceptual problem. The two excerpts highlight several interesting issues in collaborative learning. We will draw attention to and discuss two particularly interesting issues. The first concerns students' use of cultural resources, such as the hereditary chart, as structural resources in their processes of developing conceptual understanding. The second issue concerns how students deal with discrepancies between versions of scientific explanations from various sources such as textbooks, information found online, and the teacher's mediation of their sense making.

Theoretical and methodological approach

Accounting for time and temporality in the study of learning is challenging when traditional definitions of learning are applied. Our aim with this workshop is to present our approach to studying interaction over time as part of participation trajectories. Trajectories represent an intermediate level of social organization. When the term is used to designate learning, it is often used in the plural and is combined with participation to describe the processes and results of taking part in activities over time (Rasmussen, 2012). According to Lemke (2000) human development is organized on intersecting time scales. An important question for us concerns how moments of sense making in science classes add up to hours, weeks, or even years of engagement with complex topics and concepts. The workshop will address and discuss how moments of interaction relate to or add up to longer trajectories of participation. While an important strand of Interaction Analysis work has studied the situated production of social order, an interest in learning and development requires that we take time into account. We argue that actions, activities, and practices are dialogically related (Linell, 2009). They are nested together (Ingold, 2011).

During the last 15 years we have been involved in analyzing computer-supported teaching and learning practices across disciplinary domains such as math, science (Arnseth & Säljö, 2005; Furberg, Kluge, & Ludvigsen, 2013), and language arts (Lund & Rasmussen, 2008). We take a pragmatic approach to the study of interaction, where we draw on sociocultural and dialogic theory, ethnomethodology, social interactionism, and socio-material theories. Our interest is in the detailed study of how learning is managed moment by moment and across interactional episodes. In terms of unit of analysis, this research interest requires attention to both the immediate and dynamic contexts of interactions as well as ethnographic descriptions of trajectories of participation. We are concerned with how students learn a discipline, that is, if and how they appropriate traditions of argumentation and explanation. This also entails an interest in the learning resources that are used in education, their history, and how they are incorporated into activities and made sense of by participants engaged in collaborative learning. Our task as analysts is to provide detailed accounts of this negotiation work, how historical and institutional issues are made relevant, and how participation and practice mutually transform one another.

Methodologically, our premise is that language is about action. Humans try to accomplish things through the use of language and other semiotic means (Vygotsky, 1978; Wertsch, 1998). We are not only concerned with the detailed study of the structures of social interaction, although we acknowledge that they are central for understanding what is going on. Our main interest is directed towards studying how understanding is negotiated, and consequences of meaning making for learning on both immediate and longer time spans. We argue that working on this intermediate level can provide explanations of the links between process and outcomes over time. Our choice of unit of analysis and analytic practice is motivated by an interest in understanding how people learn. Learning is a complex matter and there are often tensions when students and teachers are making sense of the scientific concepts at issue. We attempt to analyze how these tensions are enacted by taking time into account when analyzing how students make sense of science concepts. The data-session addresses this practically in two ways. First, we start the session by framing the immediate context for the excerpts. Then follows a session where participants analyze the data in groups followed by a plenum discussion. Subsequently, we will introduce ethnographic descriptions and accounts of the interaction taking place based on our interaction analytical approach.

Expected outcomes and contributions

Participants in the workshop will gain experience in analyzing how learning is managed and enacted by participants in activities. We show how we combine detailed analysis of episodes with analyses of changing participation in activities over time, and the ways this provides rich insights into learning in the subjects. Participants will also become familiar with techniques for analyzing learning as an emerging feature of interaction and how to analyze the implications of socio-material artefacts for students' learning.

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Overcoming Limited Access to Assessables at a Game Award: Jurors Envisioning of Limitations of a Potential Nominee for "Best Innovation"

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Abstract: This data session addresses collaborative assessment as part of professional activity in the domain of game development. Drawing on video-recordings from a national game award, the data session explore how invited game developers evaluate a potential candidate for the category "best innovation" and engage in envision interactional problems. The excerpt explored in the session relates to several topics in relation to collaborative learning from a professional setting engaged in assessing digitally mediated materiality.

Keywords: collaborative assessment, game development, jury, digital games, digitally mediated activity

Jurors assessment work at a national game award

Over the last decade, there has been a development in the game development field that has been referred to in terms of professionalization and institutionalization (e.g. Bennerstedt, 2013). One such process is that of practices of assessment. Assessments in game development are at stake in a number of internal and external work practices, such as gate reviews, playtests, and the activity of pitching not-yet-finished-nor-financed games to publishers. Games assessments are a common preoccupation at game companies and game education but also at so-called game awards. The object of criticism of games-in-development constitutes both digitally visual material and designed 'playable/interactive' activities. This means that the qualities of a game cannot only be judged by interpreting the idea communicated in plain words together with some visual layout, it also has to be discovered when engaging with the designed 'experience' and identified in relation to what hinders or make possible appealing experiences during assessment practices. This data session address collaborative assessment practice as part of professional activity and collaborative learning in the "multimodal" domain of game development. The research questions guiding the session are 1) how is assessment work accomplished among game developers' with nonexistent first-hand experience of a game prototype, and 2) what resources are the jurors employing in their assessment work when orienting towards gaming as subject of assessment.

The analytical approach is informed by ethnomethodology (Garfinkel, 1967; 2002). Particularly, assessment conduct in previous EM/CA informed studies (cf. Goodwin, 1986; Lymer, 2013; Lymer, Ivarsson, Rystedt et al., 2014; Pomerantz, 1984) as well as studies of collaborative gaming where online gamers and co-located gamers show that they are adaptable to the local contingencies of the interactional field accessed through an interface by which they are able to project and coordinate next action (Bennerstedt, 2012; 2013; Sjöblom, 2008). The empirical material is drawn from a national game award event that was situated at a game café. Six jurors from the gaming industry where invited to assess 87 student-created game demos over two days. The jurors were to select a restricted number of demos in four categories: Best game, Best serious game, Best handheld and Best innovation. The data is transcribed in CA-style and Transana is the tool used for managing the video material.

This data session focus on the practical work to establish shared access and understanding to one particular game demo and negotiate whether this demo is a potential candidate relevant for the award category "Best innovation". The particular excerpt chosen is from a situation where the jurors' shift their attention from a movie trailer showing the game and initiates assessments of the possibilities and limitations of the game demo. More specifically, it address jurors unpacking of the demo that is displayed as a collaborative and tactile game where players of various ages coordinate interaction through gloves on their hands and are visually supported by an iPad screen. However, the jurors struggle with overcoming knowledge of, and access to, the game and gaming experience as the playable game demo at hand is not functioning properly. Instead they ground their assessment on the commercial movie trailer of the gaming activity and expand on potentials and problems based on their envisioned practical engagement with such gaming technology. The goal of the data session is to unpack ways in which the professionals make use of the restricted material at hand but nevertheless make an informed judgment of a complex mediated collaborative activity. In sum, the data session address collaborative work and learning in the multimodal domain of gaming and game development. The excerpt relates to several topics in relation to collaborative learning from a professional setting engaged in assessing digitally mediated materiality.

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Examining Power Relations in an All-Girl Robotics Learning Environment

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Abstract: In this data session we present a vignette from a group of three girls working collaboratively to solve a robotics challenge. We introduce a novel approach to interaction analysis that coordinates multiple forms of data (video recordings, transcripts, and screen capture recordings) to understand how individuals negotiate opportunities to learn in small group activity. The CSCL issue addressed in this session is the role of power relationships in a seemingly *more* equitable technology learning settings.

Keywords: robotics, collaborative problem solving, group dynamics, girls' power relationships, interaction analysis.

In this short paper, we describe a data session in which we present a short video vignette for interaction analysis (Jordan & Henderson, 1995) by a diverse, interdisciplinary group of scholars. The research context the video vignette was drawn from was a one-day long introduction to robotics workshop for girls, ages 8-13. Girls worked in groups of three to solve robotics challenges using EV3 Lego Robotics kits. All of the participants were working with robotics for the first time. The data collected includes audio and video data of collaborative problem solving activity from six groups of girls over the course of the day, as well as real-time recordings of the participants' computer programs as they created and revised them on provided laptops. The data excerpt is 2 minutes and 16 seconds long. In the excerpt a group of three girls (ages 11 -13) work to solve some First Lego League robotics challenges presented on a game board. The interaction begins at the game board and moves between diagnosing programming issues, planning and discussing solutions, revising the program using a laptop and finally to testing the new program. Each of the three group members are involved in the interactions. Our interest in presenting this excerpt regards group dynamics related to control of the material devices and how such control issues affects participation and opportunities to learn within the group.

Social status and collaborative learning

The success of small-group collaborations is dependent on the creation of a joint problem space (Roschelle & Teasley, 1995) in which members coordinate (1) a mutual understanding of the problem to be solved, and (2) the "interactional challenges and opportunities" (Barron, 2003, p.310) of relations between group members. Barron (2000) argued that such coordination can be achieved through three elements of interaction: shared task alignment, joint attention, and mutuality. Previous research suggests that aspects of social interaction affecting the level of a small group's coordination include competitiveness (Cohen, 1994; Mercer, 1996), cooperation or 'social harmony' (Anderson, Thomas, and Nashon, 2009), level of discourse (Cohen, 1994; Mercer, 1996; Webb, Nemer, Chizik & Sugrue, 1998), and the relative social status of individuals within the group (Cohen, 1994; Sullivan & Wilson, 2015). Status has been shown in recent research to significantly affect individuals' negotiations for opportunities to participate in small group activities (Esmonde, 2009; Sullivan & Wilson), and is influenced by a range of sociocultural factors including gender, friendships, academic achievement (Anderson et al., 2009; Strough, Berg, & Meegan, 2001; Webb, et al., 1998), as well as the dominant knowledge domain in which group activity is taking place (Underwood, Underwood, & Wood, 2000). Boys' gender identification with technology, for instance, has been shown to negatively impact girls' participation in computer-based small group activities (Margolis, 2008). Status may also be used to position group members as more or less competent with the practices of the activity domain, and as such, a group's level of shared task alignment and mutuality in working on a problem may suffer (Esmonde). It is therefore critical for examinations of small group collaborative activities to consider how individuals position themselves, and how they are positioned by others, and how this influences negotiations over participation.

Power relations and the materiality of robotics learning

The issue addressed in this session is the role of power relationships in seemingly *more* equitable technology learning settings. This issue is relevant to the CSCL community because the focus of our analysis is on the materiality of the robotic device and the laptop. We propose that the devices themselves are central to the robotics learning experience, and arguably, learning in robotics is learning how to work with, understand and manipulate the computational devices that instantiate the activity. In this way, the devices are objects of control, which have a direct affect on learning opportunities (Sullivan & Wilson, 2015). Put simply, interaction with the computer-based materials is an important part of learning in the robotics context. If one does not have the chance to use these materials, one's opportunities to learn are foreclosed (Sullivan & Wilson). We are interested in understanding how power relations are formed and expressed in seemingly *more* equitable robotics learning environments and, specifically, the role of the technology in such power-laden interactions. In our previous work, we examined how power relations affected mixed gender groups (Sullivan & Wilson). In this latest project, our work focuses on single gender groups. In eliminating the competition and dominant behavior that may sometimes arise in a mixed gender group setting (Margolis, 2008; Underwood, Underwood & Wood, 2000), we sought to create a robotics learning environment that would offer opportunities to learn for all the participants, one which may be seen as "systemically equitable" from a gender perspective. What we found is that power relations were still relevant, and control of the devices was still an issue for the all-girl groups. This work seeks to understand how the power dynamics arose within the group and how they were negotiated vis-à-vis access to the technology.

An expanded approach to interaction analysis and transcription

In our session, we utilize a novel approach to interaction analysis that coordinates multiple forms of data (video recordings, transcripts, and screen capture recordings) to understand how individuals negotiate opportunities to learn in small group activity. This approach involves the segmentation of group interaction content logs into a timeline of microevents for closely analyzing our large corpus of video-recordings. For each of these microevents, we construct a rich description of interaction utilizing Barron's (2000) markers of high and low levels of coordination (shared task alignment, joint attention, and mutuality). From this microanalysis, we develop a narrative characterization of group coordination during the collaborative activity, including how the group's levels of coordination shifted through verbal interactions, and control of the robotics and programming equipment (for more on this method, see Sullivan & Wilson, 2015).

In addition to our novel interaction analysis approach we are expanding the method of Jeffersonian transcription to include student actions upon the computer program (changes to their robotics program) undertaken during the problem solving interaction. We include this additional transcription in the chronological text of the transcript and we provide screen shots of student created robotics programs. This expansion of the method provides analysts with important additional information that bears on creating a more complete understanding of the learning interaction.

The expected outcome of this research study is a more nuanced understanding of how power relationships are negotiated in seemingly *more* equitable technology rich environments. Given the importance of collaborative learning in CSCL environments, it is crucial that educators and designers understand the multiple ways that inequitable circumstances can arise in student groups and to consider ways to create conditions that will mitigate the effects of such circumstances.

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Tutorials and Workshops

Supporting Synchronous Collaboration in K-12: Initial Experiences Using The WeCollabrify App Suite

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Abstract: K-12 educators are being called on to support students in developing collaboration skills. Towards providing technological scaffolding for synchronous collaboration, we have developed a suite of "collabrified" productivity tools for mobile devices. In this tutorial, then, participants will learn about how classroom teachers are using the WeCollabrify suite of collabrified apps, then the participants will gain first-hand experience in using those collabrified apps, and finally on the basis of those experiences, participants will engage in discussions about curriculum, research, and software development as those topics relate to support for synchronous collaboration in the K-12 classroom.

Keywords: synchronous collaboration, asynchronous collaboration, mobile learning, K-12 classroom experiences

"Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively."

Common Core State Standards:
College and Career Readiness Anchor Standards for Speaking and Listening

Introduction: Technological support for synchronous collaboration

The above is not just one of the standards… it is one of the ANCHOR standards. It is core to the core! It underpins all the other standards!

To address the need to support teachers in helping their students develop collaboration skills, we have created a suite of "collabrified" productivity apps – available at no cost – that can be used across grades and across subject areas. By "collabrified" we mean that the app supports two or more students, working together, simultaneously co-creating, while each student is on his or her own computing device (e.g., an iPad). And, students need not necessarily be co-located: rather than sitting, face-to-face, around a black, sink-based science table, each student in the collaboration group could be sitting at his or her kitchen table – all the while verbally talking to each other through their computing device (e.g., an iPad) using VoIP (Voice over IP).

- WeWrite+ - This app supports students in co-authoring text-based documents. While the Google Docs Editor, the Grand Daddy of collabrified text editors is geared to the secondary grades, WeWrite+ is being consciously designed for grades 1-6.
- WeMap – This app supports students co-creating concept maps.
- WeKWL – This app supports students co-developing KWL charts.
- WeSketch+ - This app supports students co-authoring drawings and animations.

All these apps – available free on the iOS and Android stores – work on iOS devices and on Android devices; indeed, each app interoperates, e.g., three students could be in a collaborative session using WeWrite+, with two students on iPads and one student on an Android tablet. So far, these tools have been used in 1st grade, 2nd grade, 7th grade and 8th grade – in science, social studies, language arts, and math in Michigan and California.

Tutorial Issues: Leaders and their backgrounds

Dr. Cathleen Norris, Regents Professor, Department of Learning Technologies, University of North Texas. Before moving to the University of North Texas, Cathie was a high school mathematics and computer science teacher for 14 years. In recognition of her outstanding teaching, the Dallas Public Schools awarded her the district's Golden Apple Award. Cathie has been President of the International Society for Technology in Education (ISTE), the leading international organization for technology-minded educators. From 1991 to 2001, she was the President of the National Educational Computing Association (NECA) that organized the premier conference on technology in K-12.

Dr. Elliot Soloway**,** Arthur F. Thurnau Professor, Computer Science & Engineering Department, University of Michigan**.** Elliot has published over 200 articles in books, journals, and magazines, and has received numerous national awards, e.g., in 2002 Elliot was selected to receive the ACM SIGCSE Outstanding Contribution to Computer Science Education Award, as well as university awards, e.g., in 2001, the undergraduates at the University of Michigan selected him to receive the "Golden Apple Award" as the Outstanding Teacher of the Year at UM, and in 2004 and again in 2011, the College of Engineering HKN Honor Society awarded Elliot the "Distinguished Teacher of the Year Award." Elliot is the Past Chair and Grand Poobah of ISTE's SIGML – Special Interest Group on Mobile Learning.

Both Cathie and Elliot have given Keynotes, Invited Presentations, and workshops/tutorials at state, national, and international conferences since 1995. A version of our proposed tutorial was given at the following conferences: AACE eLearn 2014 Conference in New Orleans in Oct, 2014; TISE XIX International Conference on Technology and Education, Fortaleza, Brazil, Dec. 2014.

Theme and goals of tutorial

Web 2.0 technologies have been about support for asynchronous collaboration, e.g., SMS, Facebook, etc. support post, re-post, re-re-post-type of interactions. But, Social 3.0 technologies will be about support for synchronous collaboration – where individuals are interacting in real-time, verbally interacting, feeding off-each other's ideas while co-creating artifacts, co-browsing in databases, etc. While the Google Docs Editor has been the leading example of support for synchronous collaboration, there is about to be an explosion in collabrification technologies. Indeed, we predict that with 3-4 years virtually all apps and websites will be "collabrified."

Inasmuch as every leading educational organization promotes collaborative learning, having technological support for synchronous collaboration should bring about substantive changes in how K-12 teaching and learning takes place. For example, in classrooms, teamwork will become easier to do and thus will become the norm. Outside the classroom? Never again should one have to learn alone, e.g., stuck doing a homework problem? Tap connect and a peer or a tutor can join in!

In this tutorial, we will explore the use of the WeCollabrify suite of educational productivity tools for K-12. Participants will use their own mobile devices (iOS, Android) and work synchronously with others to co-author various types of artifacts. Based on those experiences, a significant amount of time in the tutorial will be in conversation exploring the following issues:

1. Curricular issues: How can the current apps be used in classrooms? What other collabrified apps are needed and how can they be used in classrooms?
2. Research issues: How assess the impact of synchronous collaboration on student achievement?
3. Software development issues: What are the issues involved in "collabrifying" existing apps? How can our Collabrify SDK (software development kit) be used by others – for free – to collabrify their educational apps?
4. Free Collabrification Service: Our team is prepared to collabrify other's educational apps for free.

Background: Key components of synchronous collaboration

Synchronous collaboration versus asynchronous collaboration

Web 2.0 was all about supporting ASYNCHRONOUS collaboration, where an individual posted a comment (e.g., in SMS, in Facebook, in Flickr) and another person responded with a posted comment. In Social 3.0, the next turn of the technology crank, there will be support for SYNCHRNOUS collaboration: two or more individuals working together, co-authoring an artifact, in real-time.

In our everyday "analog" world, we are quite accustomed to working synchronously with others; two heads are better than one in solving a problem! Finally, in the digital world, the technology is strong enough – networks are robust and devices are ubiquitous – to enable us to work together ***synchronously***, to feed off each other's ideas, and invent something that is the product of our joint effort.

Collaboration is NOT equal to cooperation!

In the vernacular, we often use the terms collaboration and cooperation interchangeably. But, in education, we need to be more careful.

- Collaboration: working together to develop a shared understanding
- Cooperation: working together, helping each other, to do a task

Collaboration has a cognitive goal; cooperation is about working to accomplish a task. At the end of a collaborative activity, when all the parties walk away, each individual walks away with the same, shared, common understanding. In contrast, after a cooperative activity, the task is completed, but there is not necessarily a cognitive impact.

Learning is IN the conversation

In a collaborative conversation, as the participants work to solve the problem at hand, invariably questions and disagreements arise. It is precisely as collaborators address questions and resolve disagreements that learning takes place. In talking with Sr. Rebecca's 7th and 8th grade science students, they identified two benefits of collaborative conversations:

- A student's ideas become clarified during the conversation
- Students gets new ideas from their peers during the conversation

And the artifacts that the students co-create using the WeCollabrify apps, play a critical role in those collaborative conversations: the artifacts serve to concretize, to reify, the conversation. In effect, the artifacts are both the drivers of the collaborative conversation and the residue of the conversation.

Face-to-face synchronous collaboration versus NON co-located synchronous collaboration

Every learner has had the following experience: working on homework, at the kitchen table/in a bedroom, and hitting a big snag: confusion, a misunderstanding. For example, how frustrating is it to watch a Khan Academy video or a flipped-classroom video for the 3rd time and STILL not "get it" – and still not understand?

While WeCollabrify apps are great for face-to-face support in the classroom, their real potential is to support synchronous collaboration when the collaborators are not co-located, are not face-to-face. Its 8:30pm, you are sitting at your family's kitchen table, the test is tomorrow, and you are confused about how the water cycle really works. Using VoIP on the mobile device, call a friend on Google Hangouts, jump into WeMap together, and create a concept map that lays out the water cycle process. Learn together; it works!

With apps like those in WeCollabrify, one never has to learn alone again. (Oh, for those using Khan Academy videos, check out YesWeKahn on the Android Play Store; watch a Khan video with a friend, or two, while talking AND while drawing/writing/concept mapping!)

Classroom use of the WeCollabrify apps

Here are some stats, noted by our collaborating teachers:

- 1:1 – Each child in the classroom has his or her own device. Two children on one device might sound like two collaborating children, but in fact, whoever has the device "wins" – whoever has the device controls the conversation, controls the learning. What the teachers have told us is this: with each student having his or her own device, each child has an equal opportunity to have his or her ideas, his or her voice, heard!
- 20-40 minutes per session – The amount of class time per use seems to vary between 20-40 minutes. Though, in Sr. Rebecca Mierendorf 's class, she has been known to give her 7th & 8th grade science students 5 minute assignments on WeMap/WeKWL!
- Used across subjects: The 1st and 2nd grade teachers report using WeMap/WeKWL for science, English, social studies – and even math!
- Used weekly: Also, the teachers report using the tools on a regular basis, e.g., 1-2 times per week, every week.

In this tutorial, we will provide concrete examples of how the WeCollabrify suite of tools is being used in K-12 classrooms.

Expected outcomes and contributions

The use of technology support for synchronous collaboration in the K-12 classroom is in its earliest stages. However, with the increased ubiquity of mobile devices in the classroom, the increased robustness of networking support in schools, and the increased ability to create collabrified apps, researchers and educators need to be prepared for the explosion of collabrified software that will become available. This tutorial provides participants with some initial experiences in both using collabrified apps and in reflecting on those experiences in conversation with other researchers.

We fully expect that arising from this tutorial will be an interested cohort of researchers who will continue to converse and explore this new – and fast growing – space. Indeed, summaries of the conversations will be developed and issued as a while paper so that others, not in attendance, might still share in the conversations.

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The Learning Sciences and CSCL: Past, Present, and Future

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Abstract: This tutorial will take a critical and reflective approach to the learning sciences, to CSCL, and to their historical and potential future relationship. The 2015 CSCL is a timely setting for this exploration, because of two new edited books that provide broad overviews of, and diverse perspectives on, the learning sciences. The first is the *Cambridge Handbook of the Learning Sciences (CHLS)*, with its second edition published in December 2014. The second is a forthcoming edited volume, *The Learning Sciences: Past, Present, and Future*, with chapters by leading scholars who played central roles in the creation of the learning sciences, in CSCL, and in their eventual partnership in the ICLS. These two new books provide an opportunity to reflect critically on learning sciences research, on CSCL research, and their historical interrelationship and potential future relationship. This tutorial will be structured around the six thematic areas identified in the 2014 handbook. Participants will gain a deeper understanding of the contemporary state of the art of the learning sciences, its role and relationship with CSCL, and opportunities for future research and collaboration.

Keywords: learning sciences, history of ideas, current issues, future research opportunities

Introduction

The learning sciences is an interdisciplinary field that studies teaching and learning. Learning scientists study a variety of settings, including not only the more formal learning of school classrooms, but also the more informal learning that takes place at home, on the job, while using computer and Internet applications, and among peers. The goal of the learning sciences is to better understand the cognitive and social processes that result in the most effective learning, and to use this knowledge to redesign classrooms and other learning environments so that people learn more deeply and more effectively. The sciences of learning include cognitive science, educational psychology, computer science, anthropology, sociology, information sciences, neurosciences, education, design studies, instructional design, and other fields.

This tutorial will provide an introduction to the current state of the art of the learning sciences, as well as a critical reflection on its historical genesis, current issues, and potential future opportunities. A specific focus of discussion will be potential intellectual and research relationships between learning sciences and CSCL. It is structured based on the six-theme organization of the recently-published second edition of the *Cambridge Handbook of the Learning Sciences* (Cambridge, 2014).

In 2006, the first edition of *Cambridge Handbook of the Learning Sciences (CHLS)* was published. As the first comprehensive overview of learning sciences research, *CHLS* found a broad audience, and was widely adopted as a text in university learning sciences programs. The impact was international, with particularly large numbers of readers in the United States and in Europe, and with translated editions in Chinese and Japanese also selling well.

The second edition incorporates developments in the field since the text of the first edition was finished in 2005. The new second edition, *CHLS 2E*, shows how educators can use the learning sciences to design effective and innovative learning environments—including school classrooms, and also informal settings such as science centers or after-school clubs, on-line learning, and educational software. The chapters in *CHLS 2E* each describe exciting new classroom environments, based on the latest science about how people learn. These classroom environments combine new curricular materials, new collaborative activities, support for teachers, and innovative educational software, often using the unique advantages of the Internet to extend learning beyond the walls of the school. *CHLS 2E* can be used to design the schools of the future—schools that are based on learning sciences research, and that draw on the full potential of computer and Internet technology to improve our students' experiences. The learning sciences are supporting deep links between formal schooling and the many other learning institutions available to students—libraries, science centers and history museums, after school clubs, on-line activities that can be accessed from home, and even collaborations between students and working professionals.

In particular, the second edition describes how to use the new sciences of learning to design effective learning environments, in classrooms and outside, often taking advantage of new computer technology. This aspect is of direct relevance to the CSCL community.

In addition, this tutorial will draw on a second forthcoming edited volume, *The Learning Sciences: Past, Present, and Future*. This book brings together influential scholars who contributed to the historical development of both the learning sciences and of CSCL, with chapters that critically reflect on the current state of both fields and their potential for future productive relationships. One or more of the editors of this book will be present to facilitate the tutorial. The tutorial will thus provide an opportunity to explore the historical genesis of both the learning sciences and of CSCL, to identify common theoretical and methodological elements, and to identify future collaborative research opportunities.

The tutorial will be structured around the six-theme structure of the 2014 handbook, as follows.

Foundations

This portion of the tutorial will present foundational concepts that have been influential in learning sciences research and CSCL research, from the origin of these fields in the 1980s and 1990s. Concepts to be discussed include scaffolding, metacognition, conceptual change, cognitive apprenticeship, and situated activity.

Methodologies

Learning scientists use a broad range of methodologies, including experimental psychological methods. This portion of the tutorial will review innovative methodologies that have, at least in part, been developed by the learning sciences community—often to bring together research and practice, and to bridge the elemental and systemic levels of analysis. Methodologies include design-based research, microgenetic methods, interaction analysis, digital video research, assessment, and educational data mining.

Practices that foster effective learning

This portion of the tutorial will review innovative classroom practices, based in learning sciences research, that have been documented to lead to enhanced learning outcomes. Topics include project based learning, problem based learning, complex systems learning, tangible and full-bodied interfaces, embodied designs, and videogames and learning.

Learning together

This portion of the tutorial reviews learning sciences research that is perhaps most closely aligned with Computer Supported Collaborative Learning (CSCL). A wide range of educational research has found that collaboration contributes to learning. The advent of the Internet and of wireless handheld devices supports students in learning collaborations, so that computers bring students together instead of pulling them apart. This research explores how learning environments can be designed to foster more effective learning conversations. Topics include knowledge building, argumentation, informal learning, CSCL, mobile learning, and learning in virtual worlds.

Learning disciplinary knowledge

This section of the tutorial explores learning sciences research in five specific disciplinary content areas. The discussion will revolve around these questions: What unique epistemologies, practices, and findings—inspired by this discipline's content—change the way we think about learning more generally? How does studying learning in this discipline add to what we know from studies of learning more generally? The five disciplines to be discussed are mathematics, science, history, literacy, and arts.

Moving learning sciences research into the classroom

Globally, many education systems are looking to learning sciences research to help them redesign their schools for a 21st century knowledge and innovation age. Learning sciences researchers are prepared to offer practical solutions, because the discipline works to bridge research and practice. This portion of the tutorial summarizes the key messages from learning sciences and CSCL research for education policy makers, and explore what might happen when we take these research findings and use them to reform schools, classrooms, and teacher practices. Topics include policy design and implementation, motivation and engagement, learning in cultural context, and teacher learning research.

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Tutorial on CSCL in Vocational Education and Training (VET): The Current Critical State and Future Solutions

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Abstract: In the future, to tackle the complex problems being faced in the workplace, adults will need the ability to network and engage in shared problem solving activities, rather than solely individual skills. Vocational education and training (VET) systems are challenged to prepare current and future workers not only to excel at routine work but also to be able to adapt to complex and changing work environments. In the future, employees with VET background will participate in various problem-solving processes inside and across work organisations and professions. So far, technology-supported vocational learning has been under-represented in this field of study in the CSCL community. This is critical from the viewpoint of empowering vocational education to better meet the emerging needs of the global workplace. Therefore, CSCL research calls for innovative approaches to foster VET. This tutorial session will contribute to this challenge by presenting and discussing opportunities for and the challenges of technology-supported vocational education in different contexts.

Keywords: CSCL, vocational education, boundary-crossing, VET adults' problem-solving skills

Theme

Work environments are undergoing radical social and technological changes. Workers need to learn how to operate in such changing environments (Dall'Alba, 2009), i.e., how to use mass-production technology and more flexible production methods in industry, how to use new technologies in the health care sector, etc. There has been an increasing demand from employers for workers with more integrated knowledge that allows them to understand the whole labour process and to deal with new and unpredictable situations (Ertl, 2004). Vocational education and training (VET) systems are challenged to prepare current and future workers not only to excel at routine work but also to be able to adapt to complex, changing work environments. For apprentices, technology can serve as a boundary-crossing platform that supports learning theoretical and practical knowledge across different learning contexts such as vocational schools and workplaces (Illeris, 2009). For adult workers, these structural changes often mean changes in their job requirements as routine tasks are taken over by technologies (Goos, 2013). As a direct result, many of today's workplaces require creative problem solving instead of routine activities. The ability to work on and solve problems in technology-rich environments (TREs) plays an increasingly important role (Frey & Osborne, 2013; Goos, 2013). Related to this change, workers' problem-solving skills (or the lack thereof) may have a short-term influence on how well they are able to manage their work tasks and a long-term influence on their welfare and competitiveness. As a direct result of this advancement, problem solving in TREs is one of the most important skills for future working life (Goos, 2013). In line with these emerging requirements, it is generally agreed that there is a need to develop workers' skills and abilities to better meet the changing needs of the workplace in terms of problem solving in TREs, for example, through formal education (Billett, 2008; Teichler, 2007; Fuller & Unwin, 2004), lifelong (Loveder, 2011), and workplace learning (Billett, 2008; Tynjälä, Häkkinen, & Hämäläinen, 2014).

This tutorial will bring together experts in technologies for training apprentices and adults in different VET contexts. For example, researchers in the DUAL-T project develop and implement technologies as boundary-crossing tools that can bridge the gap between school and workplace contexts. The central hypothesis is that digital technologies will improve school effectiveness by connecting workplace experiences to classroom reflective activities. Several different DUAL-T technologies have been developed to meet the specific needs of apprenticeship programs for different professions, including bakers, cooks, dental assistants, and commercial employees. Research on adult VET learners is being represented by findings from the PIAAC dataset. So far, no international large-scale assessment data have been available for VET. The PIAAC data comprise the most comprehensive source of information on adults' skills to date. The recent study of Hämäläinen and colleagues (2014) (N=50 369) focused on gaining insight into problem-solving skills in TREs of adults with a VET background. The results indicated that at a general level, when examining VET adults' problem-solving skills in

TREs across 11 European countries, adults with VET perform lower on average than adults with other educational backgrounds. As problem-solving skills in TREs are becoming increasingly important in work life (Goos, 2013), the findings are in line with the critical notion that there seems to be a gap between what is learned in VET and what is required in workplaces (Baartman & de Bruijn, 2011).

Relevance to field and conference

In the future, to tackle the complex problems being faced in the workplace, adults will need the ability to network and engage in shared problem solving activities, rather than solely individual skills (Hämäläinen & Vähäsantanen, 2011). More and more, employees with VET background participate in various problem-solving processes inside and across work organisations and professions (Billett, 2006; Noroozi et al., 2013). Thus, extensive collaboration skills are needed, as problem-solving proficiency will not only be a function of sharing knowledge but equally will require jointly building upon this shared knowledge. So far, technology-supported vocational learning has been under-represented in this field of study in the CSCL community (e.g., as of November 11, 2014, only eight studies conducted in vocational education contexts were found for the search term "vocational" in ijCSCL). This is critical from the viewpoint of empowering vocational education to better meet the emerging needs of the global workplace. Therefore, CSCL research calls for innovative approaches to foster VET. This tutorial session will contribute to CSCL by presenting and discussing opportunities for and the challenges of technology-supported vocational education in different contexts.

Goal

This full-day tutorial session will demonstrate the advances of CSCL for VET by bringing together recent theoretical and empirical endeavours in this area. Facilitated by experts, participants will actively explore and collaboratively discuss the affordances of different technologies developed for VET. Groups of participants will work collaboratively to learn about different VET platforms by taking on the roles of different stakeholders (teachers, supervisors, and apprentices). Discussions will identify the challenges and opportunities of conditions for collaborative learning through platforms in VET. The goal of this tutorial session is to facilitate in-depth discussions between experts in the field of VET technologies and the CSCL community. In particular, we aim to explore how to apply research-based knowledge to enrich vocational education and workplace learning as well as how new technologies can enhance VET. Opportunities and challenges of technology-supported tools for VET in different contexts will be demonstrated and discussed. The session will bring together researchers and other experts working on formal (school- or work-based) VET as well as on lifelong and workplace learning. In practice, we will have pre-selected short position papers (provided by the tutorial organizers) that illuminate different approaches to enrich VET. Additionally, we will solicit case studies from other participants (open call). These position papers will form the foundation of the tutorial and the discussions around the future challenges of VET. We open this tutorial to all members of CSCL. In particular, we welcome those who have initiative ideas on research in the area of VET and CSCL.

Tutorial position papers

The indicators for VET adults' problem-solving skills differences based on the PIAAC data

Raija Hämäläinen, Bram De Wever, Antero Malin, and Sebastiano Cincinnato

Nowadays, workers with VET need flexible abilities to solve problems in technology-rich work settings. This study builds on PIAAC data to understand VET adults' skills for solving problems in TREs. The study focuses on identifying adults' (N=4503) problem-solving skills in TREs in Finland. The results indicate the critical issue that more than two-thirds of VET adults have weak skills or lack the skills in solving problems in TREs. Furthermore, the results show that over one-fifth of VET adults are at risk. Finally, this study indicates that the likelihood of having weak problem-solving skills is six times higher for adults with VET than for adults with at least upper secondary qualifications. Since the need for TRE problem solving is likely to increase in the future, this study also identifies the indicators for problem-solving skills differences. In this paper, the models predicting problem-solving skills on the basis of theoretical assumptions as well as empirical support are presented. Our results indicate that in Finland VET adults' lower performance does not seem to be associated with the VET system itself but is mostly due to age, education in years, occupation, and gender, as well as work-related and everyday-life factors. In practice, the models help to develop new approaches to enable novel forms of problem solving in technology-rich environments based on current workplace needs.

DUAL–T: Technologies for initial vocational training

Beat Schwendimann, Alberto Cattaneo, Jessica Dehler-Zuffrey, Jean-Luc Gurtner, Mireille Bétrancourt, and Pierre Dillenbourg

Initial vocational education training taking place in the dual contexts of workplace and school often lacks integration of practical experiences (made at the workplace) with theoretical knowledge (taught at vocational school). The interplay between workplace and school contexts and their often antagonistic priorities calls for a specific pedagogical model that transforms these divergences into learning opportunities and connects different forms of knowledge into an integrated body of knowledge that contributes to developing vocational competence. The DUAL-T project developed a multi-dimensional pedagogical model for the design and implementation of educational technologies as a way to foster this integration in initial dual VET. The model describes a digital space – called an 'Erfahrraum' – that serves as a shared space for capturing and reflecting on experiences made in different contexts in which VET takes place. The model particularly emphasizes the importance of shared reflection processes in turning concrete experiences into relevant, integrated knowledge. In the tutorial session, participants will explore different implementations of the 'Erfahrraum' developed for different professions using a range of different technologies.

Triggering CSCL with game-based environments

Kimmo Oksanen and Raija Hämäläinen

Technological developments permit evermore diverse ways of designing digital learning spaces for future vocational education. In practice, these virtual learning environments enable new kinds of activities to supplement traditional classroom practices. With the help of these new learning spaces and environments, vocational students can practise different work–life situations. For example, there is a long history of using simulations and games in support of individual learning in vocational learning (e.g., training pilots). Currently, in addition to individual learning, there is also a growing interest in the study of collaborative learning and of how social skills can be more effectively rehearsed in game environments. This position paper illustrates two scripted 3D learning games ("Voltage" and "GameBridge") for vocational education. Voltage meets the needs of authentic context. Within the game, players are solving tasks in the area of electric installation in a house. Thus, the aim was to enhance understanding of electrical installation in a house and to support collaborative learning processes. The game provides approximately two to three hours of goal-oriented activities. Collaboration scripts are integrated in the game design process in a way that higher levels can be reached by solving problems set for the players (see Hämäläinen, 2011). GameBridge, in turn, focuses on work–life skills needed to improve human sustainability. Its aim was to create favourable conditions for collaborative learning and to structure learners' actions to boost and maintain social interaction and collaborative activities. In the game design, special attention was paid to the use of game mechanics (see Oksanen & Hämäläinen, 2014).

Expected outcomes and contributions

The tutorial session will bring together researchers and other experts working on VET and CSCL. Demonstrations of current technologies will stimulate in-depth discussions about the challenges and opportunities for collaborative learning through technologies in VET. Contributors to this tutorial session will develop a joint publication on CSCL and VET.

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Tutorial on Crowd-Sourced Learning and Assessment in MOOCs

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Abstract: Massive, Open Online Courses represent a valuable new laboratory for the exploration of collaborative learning. This Tutorial enabled participants to develop practical insight into the nature of teaching and learning in a MOOC. They reviewed the field of learning analytics and the tools it provides to investigate learning; reviewed an empirically verified theoretical learning progression defining the nature of skills required by learners to crowd-source their learning from open forums; used qualitative techniques to profile learner skill; experienced hands-on qualitative and quantitative approaches to investigate and assess learning behaviors; and discussed issues arising such as privacy, ethics,. The tutorial was based on research from the University of Melbourne (UM) MOOC program and on research at the University of Aalborg (AAU) on analysing feedback and assessment.

Keywords: MOOCs, crowd-sourced learning, learning analytics, feedback, assessment

Background

Massive, Open Online Courses (MOOCs) represent a valuable new laboratory for the exploration of collaborative learning. They are cloud-based, operate at scale, and are open to people of all ages, language, cultural and educational backgrounds. They demand that learners are self-regulating and able to operate without personal guidance or direct contact from an authoritative teacher. They make extensive use of crowd-sourced collaboration between participants especially through forums and in peer assessment.

This tutorial was based on research emerging from the University of Melbourne (UM) MOOC program and on research at the University of Aalborg (AAU) on analysing feedback and assessment. The UM MOOC program has as at December 2014, run 14 MOOCs on the Coursera Platform (University of Melbourne, 2014), and has been the focus of a research and development program, conducted under the auspices of the Science of Learning Research Centre and the Assessment Research Centre. Topics of investigation include how learners crowd-source learning in MOOCs, how learning can be attested to reliably, how learners can be better supported, particularly in areas related to higher order learning for professional practice (Milligan & Griffin, forthcoming), how assessment including quizzes, tests, free text assignments, peer assessment and peer evaluation can support collaboration among peers, and how all this can be analysed.

The tutorial included exploration of techniques in learning analytics and data visualisation in this context. Participants used their own data or data derived from one particular UM MOOC ¬ entitled Assessment and Teaching of 21st Century Skills (ATC21S). This MOOC is unique in the UM context in targeting professional learning for experienced educational practitioners. It originated from a long-term research program on collaborative problem solving. It was designed to allow MOOC participants to engage with the research findings, to learn in company of a global cohort of their peers, and to work through implication for their own practice. The ATC21S MOOC initial running in 2014 attracted over 18,000 participants from 176 countries, and issued certificates to nearly 1000. Participants contributed more than 8000 posts and comments into 1200 threads; and completed over 7500 peer evaluations on 2500 assignment submissions. Collaboration levels were amongst the highest across the UM MOOC program

The tutorial tapped into key themes that underpin the UM research program and also the MOOC content itself: that people living and working in the digital, knowledge-based era need ‘digital era learning skills’ to prosper (Binkley et al., 2012; Griffin & Care, 2015). They need the ability to use digitally-mediated methods to stay abreast of higher order learning in a field; to learn wherever they are, whenever they want; to be self-regulating and self-motivating; to learn from and with people around the globe, and from and with those with different perspectives and backgrounds. Further its seems that such ‘digital-era learning skills’ are native to MOOCs, in much the same way that industrial production processes were native to schooling as it emerged in the 19th century. MOOCs require these ‘digital-era learning skills’; and furthermore, the process of participation in a MOOC helps refine these skills. This thinking has led to development of a Skills Progression for Crowd-Sourced Learning (Milligan,2014), based on the Dreyfus skills taxonomy (Dreyfus & Dreyfus, 1980), which will be used to frame some of the hands-on work in the Tutorial. The Tutorial will also review assessment frameworks in MOOCs, especially automated peer assessments and peer evaluations; discuss if and how these support collaborative learning and feedback (Hattie, 2008); and identify the underlying pedagogical principles in the assessment frameworks (Jones, Dirckinck-Holmfeld, & Lindström, 2006; Ringtved & Milligan, 2015).

Tutorial objectives

The tutorial aimed to develop for participants a range of competencies to help them understand, explore and make explicit skills that learners require to learn in collaboration with others through crowd-sourced learning. Activities included:

- sharing practical insight into the nature of teaching and learning in a MOOC
- reviewing the field of learning analytics and the tools it provides to investigate learning
- critically reviewing an empirically-verified theoretical learning progression defining the nature of skills required by learners to crowd-source learning from open forums
- using qualitative techniques to profile learner skill using de-identified data derived from a MOOC
- experiencing hands-on qualitative and quantitative approaches with real data, to investigate and assess learning *behaviors* and outcomes in digital, scaled environments
- discussing issues arising in this new field, including those relating to privacy, ethics and professional development.

Format and schedule

The sessions included the following components:

Introduction

Sharing backgrounds, perspectives and desired outcomes for the day.

MOOC background briefing

An introduction to the UM MOOC program and the ATC21S MOOC: its successes and failures in generating higher order learning for participants; lessons on learning at scale.

Briefing on learning analytics and visualisation

Canvasing a range of different types of data and data tools useful in visualising collaborative learner behaviour.

What is meant by 'Crowd-Sourced Learner Skills'

Exploration of a construct 'Crowd-Sourcing Learner Skills: This session shared research which defines the skill-set of learners as they progress form novice through various stage to expert when using large scale forums to support learning in MOOC forums.

Identifying learner skill in practice

Participants worked in groups using qualitative (de-identified) data of the sort provided to instructors by MOOC platforms and other LMS systems. They were used to interrogate and understand behaviours of participants to make explicit the level of skill of learners.

Practical hands-on session in data visualisation

Participants used quantitative data sets provided by the organisers, or their own data relating to forums and other collaborative activities, to explore how they can be analysed to illuminate learning. Tools such as Excel and Tableau will be examined.

Pooling views

This session was a collaborative knowledge-building session exploring questions such as: Can crowd-sourced learner skills be defined? Can they be taught? Can they be assessed? Can they be analysed? Are there privacy and ethical concerns? What next?

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The Orchestrated Collaborative Classroom: Designing and Making Sense of Heterogeneous Ecologies of Teaching and Learning Resources

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Abstract: The physical face-to-face classroom still represents the core educational setting in which everyday CSCL practice takes place. However, current classrooms are not limited anymore to books, blackboards and other physical artifacts: laptops, tablets, digital whiteboards, wikis, shared applications and simulations have also become part of this learning landscape. These last ones add new layers of complexity to the everyday educational practices and the dynamics of the classroom. CSCL researchers have traditionally proposed standalone systems or innovations, focusing their evaluation on the effects and management of a single system/intervention. However, everyday classroom activities involve multiple subject matters, different pedagogical approaches as well as a variety of technologies. The assumption that our innovation is alone no longer holds. The multiplicity and heterogeneity of resources (digital and legacy) pose a unique set of opportunities and challenges for the CSCL research community, which are bound to become stronger as time goes by. This collaborative workshop brought together technology designers, researchers and practitioners, in an attempt to match CSCL technologies to the pedagogical needs and contextual constraints of practitioners, identify a set of guidelines to design and connect existing CSCL systems with each other and with legacy classroom resources, and help teachers and students to make sense of these heterogeneous learning ecologies.

Keywords: classroom, orchestration, design guidelines, heterogeneity, ecology of resources

Organizers' names and backgrounds

Luis P. Prieto is a Marie Curie postdoctoral fellow at the Computer Human Interaction for Learning and Instruction (CHILI) Lab in EPFL (Switzerland). He has done research on open architectures to communicate heterogeneous learning technologies, and currently he is modelling teacher orchestration load during collaborative work in technology-enhanced classrooms. He has organized multiple collaborative workshops for professional development of teachers, as well as for scientists in the context of research projects.

Yannis Dimitriadis is a Full Professor at the University of Valladolid, Spain, where he leads the GSIC/EMIC research group. His research interests include the technological support for orchestration of learning, from learning design to enactment and evaluation. He is an experienced workshop organizer, including several workshops in past editions of the CSCL and ICLS conferences, professional development workshops for teachers, and workshops in the context of research projects.

Andreas Harrer is currently leading the Human-Centered Information Systems group at the Technical University Clausthal. His research areas include collaborative technologies, interaction analysis and formal models for learning processes. He has co-organized and attended multiple CSCL workshops and symposia.

Marcelo Milrad is a Full Professor of Media Technology at the Linnaeus University in Sweden. His current research interests include the design of environments to support learning about complex domains, collaborative discovery learning and the development of mobile and wireless collaborative learning application. Professor Milrad has a wide experience organizing workshops and symposia in several events in Europe, Asia and the Americas. These include activities in past editions of the CSCL, ICLS and ICCE conferences, as well as professional development workshops for teachers and various activities in the context of international research projects.

Miguel Nussbaum is a professor at the Computer Science Department of the School of Engineering of Pontificia Universidad Católica de Chile, member of Chile's Agency for Quality in Education since 2012, and from January 2015 he is co-editor of the Computers & Education journal. His work in instructional design, which integrates the use of technology, is focused on how to change teaching practices in the classroom to make children the protagonists of their learning experience. His scientific developments have been implemented in schools in Argentina, Brazil, Chile, Colombia, Costa Rica, the United States, Great Britain, Guatemala, India, Sweden and UK, and have received the support of UNESCO. He also studies the use of educational games in the classroom, and school effectiveness.

James D. Slotta is an Associate Professor of education at The University of Toronto, where he holds the Canada Research Chair in Education and Technology. Since 2005, he has directed the ENCORE lab (http://encorelab.org). ENCORE's research studies are often situated in smart classrooms, featuring user-contributed content, aggregated and emergent forms of knowledge, and a variety of scaffolds for the orchestration of individual, small group, and whole class activities. His current research is concerned with collective epistemology, immersive simulations, collaborative knowledge building, learning across contexts, and tangible and embodied forms of learning. Prof. Slotta participates in ICLS and CSCL workshops annually, and has organized or co-organized several of them, as well as interactive demo sessions and panels.

Workshop theme and goals

One of the major concerns of the CSCL research community in latest years is the apparent gap between the advances made by researchers, and the practice of computer-supported collaborative learning in everyday educational settings (Chan, 2011). This gap can also be related to the divergence between the relatively simple material conditions of learning in which many CSCL evaluations occur (to more clearly see the effects of such innovations), and the increasing heterogeneity and diversity of resource ecosystems (Luckin, 2008) that teachers and students face in their everyday learning. This diversity is apparent, not only in their physical classrooms (which no longer are solely a realm of books and blackboards), but also in other learning contexts that also end up connecting back to the classroom (mobile learning in museum visits, field trips, etc.). Such gap between research and practice has led some researchers within CSCL to focus on "orchestration" research (Dillenbourg, Järvelä & Fischer, 2009) as a way to study collaborative learning innovations within the multiple constraints of everyday educational settings (Roschelle, Dimitriadis & Hoppe, 2013).

The design, application and evaluation of CSCL innovations in everyday settings has been widely recognized as one of the grand challenges of technology-enhanced learning (Sutherland & Joubert, 2009), and it is a complex problem that involves multiple stakeholders from different perspectives:

- For educational technology developers, who need to find ways of integrating CSCL technologies with each other and with novel and legacy tools present in this "extended classroom". This includes both standards-based solutions such as LTI (IMS Global Learning Consortium, 2012) as well as ad-hoc integrations of technological tools with a pedagogical purpose.
- For user experience designers and other HCI practitioners, to design novel interfaces that allow both students and teachers to make sense of the learning processes across the multiplicity of learning resources that are now available at their fingertips (e.g., Rick, Horn & Martínez-Maldonado, 2013).
- For learning scientists, to find technologies most adequate to support certain kinds of collaborative learning processes, or better yet, that support the multiple pedagogical approaches that often have to coexist in an authentic classroom.
- For all kinds of CSCL researchers, to find feasible yet rigorous techniques and methodologies to study learning and teaching processes within these resource ecologies, and to evaluate CSCL innovations applied to them (e.g., Prieto, Dimitriadis & Asensio-Pérez, 2014).
- For teachers, school leaders and also researchers, to understand and share their deep knowledge of the constraints and everyday practice of concrete classroom contexts, which very often will decide the success or failure of any attempt to scale up CSCL innovations (Roschelle et al., 2011).

This workshop brought together these five sub-communities within CSCL, with the goal of contributing, refining and critiquing expert guidelines for orchestrated collaborative classroom research that can help guide future CSCL research in everyday (formal) educational settings with an important face-to-face component. The value of these principles was illustrated during the workshop through their application to address the challenges of concrete authentic classrooms contributed by practitioners and other participants. This application also helped participants to uncover still unsolved challenges and future research lines in orchestrated classroom research, and served to spark discussion among the aforementioned collectives, and prompted new joint research efforts. All these outcomes are being made available through the workshop's own website (1), where the CSCL community can benefit and still contribute to refine them.

Theoretical background and relevance to CSCL

Traditional CSCL research that laid the foundations of current CSCL approaches has often focused on the study of applying a single technology or tool to foster collaborative learning. Examples of such efforts can be found on Belvedere (e.g., Suthers, 2003), CSILE and Knowledge Forum (e.g., Scardamalia & Bereiter, 1994) and many others. While this kind of single tool/intervention study is essential to understand the effects of each novel element introduced in educational settings, as researchers we should not restrict ourselves to those approaches. The study of CSCL innovations within the authentic conditions of learning for many students (face-to-face classroom and its extension to field trips and other organized activities), and the unexpected interactions between the different technologies and pedagogical approaches bound to appear there, also remains essential if we are to scale-up our innovations beyond small-scale studies (Looi, So, Toh & Chen, 2011).

This tension between more controlled, deeper studies and a more ecological, systemic perspective, has a long history in the different research perspectives that made up CSCL: Nardi & O'Day (1999) advanced the notion of "information ecologies", and in the realm of HCI, Hollan, Hutchins & Kirsh (2000) proposed distributed cognition as a novel way to conceptualize how we interact and learn with computers. Within recent CSCL research, this pull towards research within the constraints of authentic (formal) educational settings and the need to scale up the results and innovations of our community has been exemplified by systemic approaches to CSCL innovation (Chan, 2011; Looi, So, Toh & Chen, 2011), and by the increased attention of researchers on the notion of "orchestration" as the study of the specific usability challenges within the authentic conditions and constraints of formal learning (Dillenbourg et al., 2011).

A new wave of CSCL studies and proposals, featuring the integration and combination of multiple tools to enable novel pedagogical situations, has been reported recently: the SAIL Smart Space (Tissenbaum, Lui & Slotta, 2012), CollBoard (Alvarez, Salavati, Nussbaum & Milrad, 2013) and GLUEPS-AR (Muñoz-Cristóbal et al., accepted) are only a few examples. However, so far many of these efforts have developed independently and in an isolated manner, without a shared corpus of principles, and often are implemented as one-off prototypes and ad-hoc integrations, studied in a limited number of case studies.

This workshop aimed at sharing and further developing our community's knowledge about how to design, implement, evaluate and apply CSCL innovations within the constraints of everyday "extended classrooms", which often feature heterogeneous resource ecologies. While this workshop can be considered a follow-up to a consolidated line of CSCL and ICLS events on the topic of orchestration, in this case the focus was more on the collaborative knowledge building process of eliciting principles and applying them to concrete classroom cases, by using well-known collaborative techniques such as jigsaw scripts, problem-based learning and the figure of critical friends (Stenhouse, 1975).

Expected outcomes and contributions

Participants contributed, before the workshop, an initial set of expert principles that could be reusable by the rest of the CSCL community, clustered around four main aspects of the orchestrated classroom: a) Integration and communication of heterogeneous learning technologies; b) Designing interfaces and spaces for heterogeneity; c) Methods and techniques to research heterogeneous ecologies; d) Linking pedagogy and heterogeneous technological resource ecologies. A fifth kind of contribution described concrete cases of such classroom ecologies and their challenges.

During the workshop event itself, participants clustered into expert groups to refine the initial contributions made under each of the aforementioned aspects, and later formed multidisciplinary groups to apply those principles to the concrete classroom resource ecologies proposed. From these collaborative knowledge-building activities, several outcomes emerged (1):

- A set of *expert guidelines* for research in orchestrated collaborative classrooms, distilled during the workshop
- A set of *concrete cases* of application of the expert principles, to illustrate their usefulness and prompt for further discussions within the CSCL community

- A set of *unsolved challenges* in addressing the heterogeneous ecologies of current and future classrooms, which indicate *future research directions* within this area of CSCL
- The seed for further joint efforts was sowed, to actually implement the solutions proposed to the concrete illustrative cases, and to pursue the research directions and unsolved challenges elicited

Endnotes

(1) See https://sites.google.com/site/occw15/.

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Designing Futures for Learning in the Crowd: New Challenges and Opportunities for CSCL

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Abstract: The Internet and other media technologies have ramped up collective collaboration into an entirely different phenomenon called crowdsourcing. Many people, connected through the Internet, are contributing ideas and information to several projects in business and science. Crowdsourcing can offer individuals and opportunity for sharing their expertise, express their creativity, and learn new knowledge and skills. However, this model of technology-enabled collective collaborative process, where a known few are replaced by an indefinite many, has deep and diverse implications for education, especially for self-directed learning. Crowdsourcing can be disruptive and this disruption can have both positive and negative consequences for teaching and learning. This workshop will bring together researchers and practitioners interested in crowdsourcing, to discuss challenges and opportunities for learning in an interdisciplinary manner with the goal of articulating an agenda for future research.

Keywords: citizen science, crowdsourcing, learning, mass participation

Workshop theme

In recent years, the Internet and other media technologies have ramped up collective collaboration into an entirely different phenomenon called crowdsourcing. Crowdsourcing can be defined as a type of participative online activity in which a group of individuals of varying knowledge, background and number – that is, a crowd – is invited, via a flexible open call, to engage in the voluntary performance of a task or the solution of a problem (Estellés-Arola & de-Guevara, 2012). Many people, connected through the Internet, are contributing ideas and information – not monetary contributions, though – to several projects in business and science. For example, a large subset of crowdsourcing is referred to as *citizen science,* a term used by the American researcher and educator Rick Bonney to refer to public participation in scientific research (Rosner, 2013). In recent years, several projects labeled as "citizen science" but encompassing different forms of public participation have been developed. Such forms range from projects mobilizing masses of people performing large quantities of small, simple and standardized tasks at a scale only possible using computers, to DIY projects in which participants move away from doing "traditional" science, develop creative uses of existing equipment and find new solutions to existing problems, to deliberative democracy exercises involving citizens in deliberation and change of opinion on scientific issues. Amongst the most well-known examples of citizen science projects, we can include Galaxy Zoo (http://www.galaxyzoo.org/), an online astronomy project that invites members of the public to help in classifying over a million galaxies, and FoldIt, an online game developed by scientists at the University of Washington, in which participants try to predict protein folding, one of the hardest computational problems in biology.

Crowdsourcing can offer individuals in the crowd an opportunity for sharing their expertise, express their creativity, and learn new knowledge and skills. Therefore, it can be argued that the technologies providing a backbone for running crowdsourcing applications also give rise to several forms of learning. Some popular forms of crowdsourcing for learning can be found in question-and answer sites, such as Quora and Yahoo Answers, and other approaches to problem solving and crowdsourced work, such as Amazon's Mechanical Turk and Innocentive (Dron & Anderson, 2014). These examples provide instances of crowdlearning. In a recent report aimed to explore new forms of teaching, learning and assessment, Sharples et al. (2013), defined crowd learning as "the process of learning from the expertise and opinions of others, shared through online social spaces, websites, and activities" (p. 20). The authors also characterized crowdlearning as a form of learning often occurring informally and spontaneously, and where virtually anybody can be a teacher or source of knowledge.

We argue that this model of technology-enabled collaborative process, where a known few (teachers, for example) are replaced by an indefinite many, has deep and diverse implications for education, especially for self-directed learning. Crowdlearning can be disruptive and this disruption can have both positive and negative consequences for teaching and learning. For example, the increasing access of people to the expertise and opinions of others can challenge the balance of control between educators and experts and the wider public. Thus, it is important to be aware of how increasing levels of access to distributed information and knowledge affect the type and levels of participation, and whether this limits potential value of education. Furthermore, for some scholars, e.g. Nickerson (2013) and Anderson (2011), crowdsourcing is an approach that leverages the individual strengths of human and machine processing. Nickerson referred to the use of the term *human computation* to describe crowdsourcing as a phenomenon where humans performing tasks act as computational nodes in a network, and computers aggregate the results. Furthermore, we can argue that there is a "paradox of learning" in some crowdsourcing projects. For example, several citizen science projects rely on low threshold cognitive abilities and exert a control over participants' learning. In these cases, participants do not need to have any specific subject knowledge or particular skills, but are expected to follow detailed instructions and are discouraged from bringing their own experience and world knowledge to bear on the task at hand. Learning is thus unwanted from the perspective of neutral observations. These projects do not seem to entail crowdlearning as defined by Sharples et al.

Apparently, learning in crowdsourcing settings is still a largely unexplored topic in CSCL. For example, browsing the content of the *International Journal of Computer-Supported Collaborative Learning* (ijCSCL) since its inception, we have found one article on mass collaboration. As Cress, Jeong, and Moskaliuk noted in a call for contributions to an edited book on mass collaboration and education, less than 10% of the articles appeared in ijCSCL addresses groups that exceed the size of a school class. Furthermore, usually the studies of these groups are more closely guided by instruction than being situated in informal settings, in which most phenomena of mass collaboration are located. At the CSCL conference held in 2013, a symposium on "Mass Collaboration – an Emerging Field for CSCL Research" addressed the aspects of mass collaboration that have potential for education and learning and are thus of interest for the learning sciences (Cress, 2013). As Cress pointed out, the lack of attention for this topic is unsurprising, given that CSCL as a research field has always privileged the study of small groups of students in a neatly arranged situation. During that symposium, three examples of mass collaboration were presented, including citizen science.

Recognizing a clear continuity with the symposium organized by Cress in 2013, this workshop aims at carrying forward the dialogue about the current challenges and opportunities for CSCL research in the context of crowdsourcing.

Goals of the workshop

We intend to address critically these issues in an interdisciplinary manner, and/or present visions of how to enhance learning in crowdsourcing settings. To this end, we invite different types of contributions from empirical, theoretical, conceptual, and design based approaches. Guiding questions and topics can include but are not limited to:

- What is the nature of learning in crowdsourcing and how is it different from learning in other settings, both formal and non-formal? Which theoretical perspectives can be fruitful to examine and support learning in crowdsourcing settings?
- What is the nature of learning in the different forms of crowdsourcing (e.g. mass mobilization, DIY)?
- What kind of activities better support learning in crowdsourcing settings? Convergent or divergent tasks? For example, convergent tasks lend themselves to yes/no answers, but divergent tasks, such as idea generation, do not.
- What is the role of artifacts in coordinating activities conducted by vast numbers of people?
- Minimizing the distinction between teachers and learners is not without risks. A potential danger of crowdlearning is that it could provide users with massive volumes of unvetted "information" which turns out to be unclear, misleading, or just plain incorrect. How can internal systems of reputation and reliability help solve this problem? How can knowledge be "validated", especially in absence of traditional markers of expertise?
- Crowdlearning is fast and personalized. However, it depends on a kind of volunteerism from others: a group of well informed, interested, and invested knowledgeable people who will contribute their knowledge, even without any formal compensation. How can this form of volunteer contribution be sustained?

- Platforms designed for crowdlearning try to motivate learners to participate and inspire their contribution through the use of gamification (for example, use of medals, points, titles, etc.). Which learning design approaches can be fruitful to improve these platforms and support learners?
- What is the potential of learning in crowdsourcing settings for empowering people and, in a wider perspective, what are the implications for democratic participation? Another related aspect is how these two elements, that is, the potential for empowerment and democratic participation, can be institutionalized or coupled with already existing institutions.
- How can we control learning in crowdsourcing settings?

Workshop activities

The workshop is planned as a full day event involving max 25 participants. It will also involve additional online activities organized both before and after the workshop.

Pre-workshop activities

At least one month prior to the workshop, the accepted papers will be circulated among the participants, who will be invited to read them before attending the workshop. Accepted papers will be posted to the workshop website before the workshop to prepare the attendees for discussions during the event.

Workshop program

Part 1: Opening plenary

Members from the CSCL community as well as from other research areas will present their perspectives.

Part 2: Introductions and Lightning Talks

In 1 minute, participants describe who they are and why they are in the workshop. In additional 5 minutes, participants present the main point(s) of their papers.

Part 3: “Designing Futures” Workshop Approach:

- *Critique*: Participants generate 30-second statements of issue(s) currently faced in crowdsourcing in relation to learning. These statements can be drawn from their workshop submissions.
- *Vision*: Turning critiques into brief 30-second positive statements addressing “What would you make different?” Participants will be encouraged to not think of obstacles at this stage. Participants will vote on a small subset of visions to work on the next phase.
- *Implementation*: Participants will spend the bulk of their time in this phase, collaborating on plans to carry out the vision. This may involve generating project plans, articulating design principles, or paper outlining. In small groups, the implementations will be presented/shared with other workshop participants.

Post-workshop activities

Summary: the outcome of these discussion summaries will form ongoing collaborations leading to a special journal issue on crowdsourcing and learning. This special issue would feature expanded versions of the authors’ workshop papers.

Participation procedure

Authors are invited to submit a short “vision” paper (max. 3 pages, following the CSCL conference template) that possibly connects to the guiding questions and topics listed above. In this vision paper, authors can choose a setting or specific scenario related to crowdsourcing and learning. Submissions should address three questions:

- What main issue(s) do you see in relation to crowdsourcing and learning?
- What is your vision for addressing those issues?
- How would you plan to carry out that vision?

In addition, please provide a 100 to 150-word biography to describe your interests in relation to the theme of the workshop. The workshop welcomes different kinds of contributions addressing challenges and opportunities for learning in crowdsourcing settings. Such contributions can include conceptual frameworks, descriptions of case studies and empirical work, and position papers. A program committee will be drawn from collaborators and colleagues, who will review all the submissions based on the relevance to the workshop theme, supporting a diversity of topics and disciplinary backgrounds. We will accept up to a maximum of 15 papers to ensure that each participant can make a short presentation. Papers reviewed and selected by the program committee will be published on the workshop website.

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Changing Teaching and Learning Practices in Schools with Tablet-Mediated Collaborative Learning (#TMCL15): Nordic, European and International Views

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Abstract: In this interdisciplinary workshop, we shared and discussed ongoing research and existing results with regard to studies revolving around tablet-mediated collaborative learning in schools (#TMLC15). The guiding question was: Is the expanding use of media tablets on the way to change teaching and learning practices in schools? If yes, which are these emergent practices, how are they developing, and in what ways do they contribute to renew computer-supported collaborative learning? Existing studies in the area show that the launch of small, portable, flexible devices is changing teacher-student engagement and creative collaboration in the classroom. These studies raise an important set of issues and potentials for research in CSCL as they point at the examination of teachers' and learners' sociotechnical practices that are enacted in the classroom on a daily basis.

This half day workshop did aim at discussing issues pertaining to theorizing and designing for CSCL practices. The outcome of our knowledge building process did result in a) a summary of existing research outcomes so far, that did in turn inform b) new research questions and methodologies applied in the research area and created conditions to leverage c) a set of strategies for networking on the topic of changing teaching practices in tablet–mediated collaborative learning. In particular, we did aim at leveraging a joint research proposal, have initiated a wider research consortium, and we are working on a joint publication (e.g., edited book such as Springer CSCL series).

Keywords: media tablets, empirical studies, design, change, sociotechnical-pedagogical practices

Organizers' background

The five organizers represent research of ICT in educational institutions and CSCL from different Nordic countries and they together bridge North American and European communities. All of us are experienced in organizing workshops at several International conferences such as EC-TEL, ACM GROUP, NordiTEL, Designs for Learning, Kaleidoscope TELEARC, Mobile HCI, EARLI and CSCL.

Intended audience

In the workshop, the audience represented a diverse field of researchers, designers and practitioners (e.g. teachers) who are working in the area of tablet-mediated teaching and learning, conducting research projects and/or empirical school studies and coming from different disciplines such as Educational Science, Computer Science, Cognitive Science, Learning Science, Science and Technology Studies, Educational Technology.

Introduction

Over the last three years, an increasing number of research studies have started to explore the potential of tablet-mediated learning in Nordic schools (Cerratto-Pargman et al., 2014; Nouri and Cerratto-Pargman, 2014; Cerratto and Milrad, in press; Eliason et al. 2013; Meyer, 2013; Jahnke, Svendsen, Johansen & Zander, 2014 and Jahnke, Norqvist, & Olssen, 2014). These research studies are in part a consequence of the great interest of Danish, Swedish, Finnish and Norwegian schools in embracing web-enabled tablets in their teaching practices. For instance, Jahnke, Svendsen, Johansen & Zander (2014) and Jahnke, Norqvist, & Olssen, (2014) in a study comprising more than 32 classroom observations in Denmark, have reported on innovative uses of tablet-mediated learning across almost all school subjects (except sports). In Sweden, the work conducted by Nouri and Cerratto-Pargman (2014), Nouri (2014), Eliasson (2013) and Vogel et al. (2014) have among others pointed at the intricacies of understanding and designing for outdoor mobile learning activities in the school subjects of mathematics and natural sciences. In Finland, Järvelä and her colleagues have been working for designing socially shared regulation tools (in media tablets) for promoting 21st century learning skills (Järvelä et al., 2014). Further, research projects on the use of media tablet in schools have been recently granted by the Swedish Research Council, a) Purposeful learning activities across contexts (Cerratto-Pargman et al., 2013) and b) Digital Didactical Design (Jahnke et al., 2014), and the Finnish Academy (Strategic regulation of learning through learning analytics and mobile clouds for individual and collaborative learning success, Kirschner, & Järvelä, 2014).

Preliminary findings obtained by Cerratto-Pargman et al., (2013) and Jahnke et al. (2014) point that the adoption and use of web-enabled small flexible devices in classroom has led to the emergence of new activities wherein these devices are both embracing and changing teaching and learning practices in Nordic schools. This is an important observation as traditionally, Information and Communication Technology (ICT) has been segregated from the classrooms, placed for instance in computer labs (Henderson & Yeow, 2012) and studied as disembodied from teaching and learning practices (Johri, 2011). This reality seems nowadays to be challenged as the use of smaller portable devices like media tablets (Kaganer et al., 2013) and smart phones are becoming part of everyday schools practices. We are thus witnessing a historical turn that allows us to trace the emergence and development of sociotechnical-pedagogical practices in education. More precisely, teachers' embracement of media tablets and its applications in their teaching practices reflects a change in teachers attitudes vis-à-vis technologies going from a weak attitude towards ICT to a confident, affirmative one including in particular media tablets (Ifenthaler & Schweinbenz, 2013).

Theoretical approaches (relevance to CSCL) and themes

Research on mobile technology and media tablets in education has reported different implications of using mobile devices in formal learning activities. For instance, there is evidence of a correlation between the use of mobile devices and the enhancement of student engagement as well as progress of students' achievement (Roschelle et al., 2005; Chou, Block, & Jesness, 2012). Others have pointed at the proliferation of learning activities including interactive content creation (Melhuish & Falloon, 2010; Hutchison, et al, 2012). Moreover, the open and easy access to information afforded by mobile devices while sitting in the classroom (Sharples et al., 2013) as well as support for user-generated contexts (Pachler, et al., 2010) seem to modify power relations between teachers and students (McCombs & Liu, 2011) making an impact on learners' epistemic agency (Damsa, 2014). Further, studies also point at the potential role of mobile technology fostering student creativity and student collaboration (Buchem et al., 2012).

These studies have very much contributed to the understanding of the pedagogical value and specificities of using media tablets in teaching activities, however, most of them have focused on affordances of the media tablets as disembodied from its use and thus they do not provide a fully explanation of emergent teaching designs (Wegerif, 2005) and classroom practices. Moreover, models available for conceptualizing technological, pedagogical and content/subject knowledge dimensions (e.g. TPaCK models), illustrate how these dimensions are intrinsically tight to each other (Koehler et al., 2007), although they do not always help to spell out how teachers appropriate, coordinate and collaborate through technology at the level of *practice* (Kuutti, 2013). Still under-explored and under-researched is how Tablet-Mediated Collaborative Learning, impact the teacher's practice and the re-organization of sociotechnical processes for enabling quality learning.

Summarizing, the purpose of this workshop is to discuss findings, insights, thoughts gained from empirical studies with a focus on teaching and learning practices deployed; where media tablets and teaching spaces are merging into something new –expanding existing communication spaces. By referring to teaching and learning practices we draw on the work of Lave (1988), Wenger (1998), Chaiklin and Lave's (1993) focus on teachers' activities acting in and upon the social material world of these activities. More precisely, we refer to sociotechnical-pedagogical processes (as social practices) deployed in classrooms with the purpose to enable collaborative learning (e.g. Järvelä & Hadwin, 2014).

Guiding topics for knowledge building at the workshop were:

- Theories, pedagogies, models, methodologies for studying tablet-mediated collaborative learning practices
- American Instructional Design and European Didactical Designs for tablet-mediated learning
- Learning design approaches
- Teaching design approaches
- Socio-material approaches on learning
- Development methodologies for studying changes introduced by tablet-mediated learning in schools
- Innovative mobile applications and tools for fostering tablet-mediated learning
- Innovative mobile user interfaces

- Socio-technical system design approaches
- User stories, case studies and evaluations of tablet-mediated learning
- Media tablets and wearable technology
- Future visions for tablet-mediated learning including frameworks and methodologies

Goals

Three goals motivated the workshop: A) Sharing and discussing existing studies and ongoing projects of tablet-mediated teaching and learning in Nordic countries presented by the organizers and from other European and International countries presented by discussants. The aim was to identify and compare different teaching and learning practices bound to the use of tablets around the world. B) Identifying theoretical and methodological commonalities and contrasts across the represented disciplines regarding tablet-mediated teaching and learning. C) Focusing a set of developments for initiating a research network on this topic, in particular, through the preparation of a joint research proposal and formation of a wider research consortium.

Workshop format (half day)

The workshop was composed of three sessions: a *morning inspiration event*, a *working group* session and *plans* for the future. The morning inspiration event consisted of participants' presentation of their position statements in the Pecha Kucha format. The Pecha Kucha event was based on a simple idea: each presenter presented 20 slides in 20 seconds each (approx. 6' 40" in total). It is a presentation format that gave more presenters the chance to share their research.

During the *working group session*, discussions were supported by the workshop organizers utilizing the method of the "World café" which did entail short round tables discussing prepared questions developed from the morning session (10 mins. per table), then the groups did mix up in new groups going to another table with another question. The inputs from the Pecha Kutcha session were used to inspire discussions in small groups. The plans for the future session brought the groups in the plenum together and discussed ideas and outlines for a research proposal and consortium. The workshop format required 4 hrs and 30 mins. in total including breaks.

Outcomes, contributions, dissemination

We invited different types of contributions ranging from work in progress, demonstrations and results from research and practice, academia and school practice. Participants were invited to submit original unpublished research as extended abstracts (max. 2 pages). It included a description of the theoretical concept, including a definition of tablet mediated collaborative learning and empirical research results (if available). Since the approach of TMCL is interdisciplinary, the workshop attracted different participants, including students, researchers in schools, designers, practitioners and developers. The workshop brought together international researchers that work on tablet-mediated teaching and learning. Extended abstracts by the participants were reviewed and selected by the Program Committee. The abstracts and the presentations are published online on the main website: http://sites.google.com/site/tmcl2015/ .

The participants of the workshop have done original research in the field of tablet-mediated learning; but they were also interested to exploit the potential of their recent research. In preparing the workshop, we did analyze the submissions for deriving typical clusters of recent research and to use them as framing for scaffolding the knowledge building during the workshop.

The workshop outcomes were a) new knowledge in the field of tablet-mediated collaborative learning (such as research methods, pedagogies, models, results), b) we initiated a research network (consortium) around TMLC (tablet-mediated teaching and learning) and c) a joint publication (edited book in Springer CSCL series).

The organizers and participants spread the workshops information in different Social Media formats, including Twitter, *#TMCL2015*, Facebook group (https://www.facebook.com/groups/TMCL2015/), personal blogs and our workshop website http://sites.google.com/site/tmcl2015/. These activities were important to attract high quality submissions from various communities and to build an International network of stakeholders. Resources from the workshop, including accepted abstracts, Pecha Kutcha presentations, have been made available online on the website in order to guide further discussion in the community and spin off creative initiatives.

Program Committee, includes the five organizers, and

- Chee-Kit-Looi, Singapore
- Eva Mårell-Ohlsson, SWE

- Jan Dolonen, Norway
- Lars Häll, SWE
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Verbal Data Analysis Workshop: Introducing Geisler's Systematic Coding of Text, Talk, and Other Verbal Data

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Abstract: This verbal data analysis method systematically analyzes text data to produce reliable, meaningful, and in-depth results in the form of tables, figures, and basic statistics, using Microsoft *WORD* and *EXCEL*. Researchers are able to see the content themes, frequencies, relationships among the themes, and their change patterns over time. The data samples we present are posts on a social network forum, *Edmodo,* by youth learners and adult facilitators who were in a design-based after-school STEM education program. From the chat log files, the results included the youth learners' posting contents, word length, frequency, content change patterns over time, and relationship with facilitators' posts. The approach could apply to various verbal data, including text from chat logs, text-based artifacts, and transcriptions from audio or video recordings.

Keywords: qualitative research, verbal data analysis, educational research, text, workshop

Introduction of data excerpt

Our study used naturalistic investigation to collect data on youth usage of the social network forum (SNF), *Edmodo*, in a design-based science-learning program, *Save the Black Footed Ferrets*. Through this eight-week program, youth learned how the electricity plants and power transmission wires influence the natural environment, and how communities could produce and build storage for their local electricity needs. Youth were encouraged to use *Edmodo* to communicate with each other, and share ideas, photos, videos, websites, and other related resources. This study used the text data only from the *Edmodo* site, including posts published by 27 learners and 3 adult facilitators during the program period from February 3 to March 18, 2014. Youth had eight days of class only during this eight-week period, but posted on 15 days, which suggests that learners and facilitators posted during and after sessions. The total of 283 posts resulted in 504 minimal meaning units for further coding, among which learners posted 452 units while facilitators posted 52 units. Below is an example of raw data excerpt, which was transformed into an *EXCEL* spreadsheet and coded during the analysis.

BC.	Great way to start a Monday and STEM in February! Black footed ferrets (BFF) are really cool. but answerer me a question do they have thick coats on the prarie?
GC.	I didn't think that something so cute could be so vicious.
BC.Replies	rEALLY!@!@!!!!!!!!

Theoretical background and relevance to field and conference

Educational research has a long tradition of qualitative study, using interviews, reflections, blogs, reports, case studies, and observations to understand phenomena related to learning and teaching. Researchers tend to believe that qualitative data are associated with "words rather than numbers" (Miles & Huberman, 1994, p.1), and the results of textual analysis tend to be quotes and summaries of utterances. On the contrary, the verbal data analysis method could transform text data into quantities and visualizations, helping explore the text content themes, relationships between themes, and their change patterns over time to better describe and improve teaching and learning.

Geisler's (2004) verbal data analysis method is consistent with and capitalizes on protocol analysis, content analysis, conversation analysis (Koschmann, 2013; Zemel & Koschmann, 2013), and discourse analysis. Her book provides step-by-step guidance to master this method, which applies to potentially a wide range of verbal data sources. This method could provide educational researchers means to more meaningful results from verbal data, particularly in CSCL where significant amounts of data are automatically logged on a computer or server.

The application of this method in our study explored the youth learners' posting behavior on a social network forum (SNF), *Edmodo*, and its relationship with metacognitive acts. Metacognitive acts are a key to academic learning outcomes (Flavell, 1979). Exploring learners' posting behavior is the first step to understand its relationship with metacognitive acts and metacognition prompting strategies to enhance appropriate behavior and reduce inappropriate behavior later in the practice.

Expected outcomes and contributions

The outcomes of our study included the number of youth who posted, the average number of posts per each youth learner, the average length of each post, the number of initiative posts and reply posts, the average length of initiative posts, the average length of reply posts, the average word count of minimal meaning units, the contents of students posts, the frequency of the contents, the change pattern of the contents, the contents of facilitators' posts, the strategies of facilitators' posts, the impact of different strategies of facilitators posts on learners' posting behaviors. The results of these analyses produced tables of coding dimensions, figure of frequency of the contents, figure of change patterns, figure of comparison of learners' posting behaviors versus facilitators' posting behaviors. Below are some example results figures.

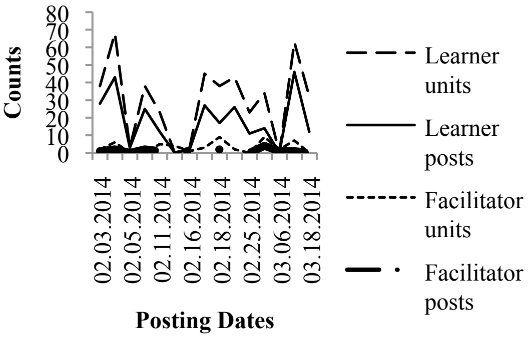

Figure 1. Learner verses facilitator posting count

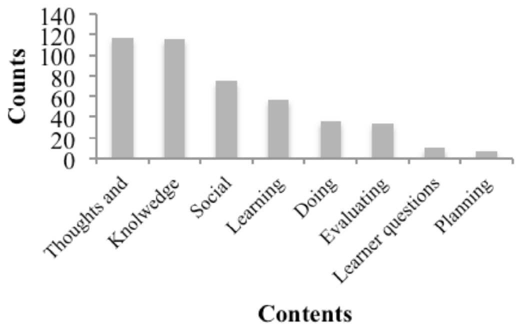

Figure 2. SNF posting content and count

Figure 3. Change pattern of thoughts and emotions

Figure 4. Change pattern of planning

The major contribution is to provide CSCL researchers with a systematic tool to analyze verbal data and show reliable, meaningful, and in-depth results in terms of content types, relationships, and change patterns. The analyses could be adjusted depending on the particular research questions.

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Maker Movement in Formal Education: Workshop for Research Design, Practices, and Technologies

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Abstract: This workshop seeks to generate knowledge in a collaborative setting, focusing on one particular and less-developed aspect of the global maker movement, namely maker activities in formal school environments. Our emphasis in the workshop falls in the domain of teacher-student computer-supported collaborative learning. We will introduce and solicit discussion around the research basis for interpreting the learning affordances with collaborative tinkering, building, and making, and then focus on activities that can produce interactional shifts that will characterize future classrooms. Workshop participants will include both those who carry out research in digital media making in service of formal school learning, or those interested in carrying out such research. A forum will take place in advance of the workshop as an informational precursor introducing different research contexts for media making in formal school settings.

Keywords: maker movement; mathematical cognition; metacognition; identity

Introduction

The maker movement, often also referred to as the do-it-yourself or DIY movement, has captured growing attention for fostering inventiveness, engagement, and learning by tinkering and experimentation (Honey and Kanter 2013, Resnick and Rosenbaum 2013). The maker movement, seen in events such as the Maker Faires, engage school-age individuals, but generally outside of day-to-day school activities. It invokes some of the most seminal work of the past century, including that of Dewey, Bruner, and constructionist approaches of Seymour Papert.

The maker movement is known for promoting learning by tinkering, experimentation, inventiveness and problem solving (Honey and Kanter 2013, Resnick and Rosenbaum 2013). It is almost exclusively, however, a movement that takes place outside of formal classroom settings, and is rarely if ever connected to formal school curricula or standards. This CSCL workshop proposal seeks to harness the excitement, energy and creative power of the maker movement within formal school systems by gathering researchers to workshop research designs, practices, and technologies. That is, the workshop activities proposed here seek to connect the maker movement to day-to-day classroom teaching and learning (Hamilton, Chaves et al. 2011).

Our example: Collaborative media-making in the classrooms

This workshop introduces one example of research on 'making' in formal classroom settings, involving research funded by the US National Science Foundation (Hamilton 2010, Hamilton 2011). This body of inquiry involves teacher-learner collaboration in the creation or production of interactive digital videos that are designed to draw other learners into school curriculum (Hamilton, Chaves et al. 2011). The research, in part, explores advancing learner mathematical cognition and fluency through making interactive digital videos. It seeks to create conditions that test conjectures related to creativity, intergenerational collaboration, mathematical and scientific cognition, and high engagement or flow - like experiences.

Earlier work related to media-making for formal school environments support findings about the value of phenomena such as peer-tutoring and self-explanation, when learners make videos. The potential significance of this work, though, extends beyond these findings and practices. A major area of inquiry involves the prospect that intergenerational collaboration between students and teachers in media making points to the possibility of sizable shifts in traditional student-teacher interactional dynamics in future learning environments. Those observing and studying the maker movement both implicitly and explicitly recognize the potential for making becoming a far more energizing and prominent component of formal school environments. This research suggests that one path to that potential goes through the collaboration of teachers and students in making activities. Research on collaborative media-making for formal school environments allows observation not only of shifting dynamics between teachers and students within classroom settings, but of the convergence of multiple dimensions of a learner's growth, including identity formation, technical and technological fluency, imagination, and the evolution of conceptual competencies in science and mathematics. Several important prominent patterns have emerged independent of how the participants structured their media-making activities. For example, it turns out that teachers and students in these activities consistently report experiencing the sensation of loss of a sense of time consistent with deeply engaging activities, in a manner consistent (though not always as viscerally expressed) with the earlier interview excerpt.. Additionally, their reports are consistent with other phenomena that track closely with classical features of flow experience (Csikszentmihalyi 1996, Weber, Tamborini et al. 2009).

Another compelling phenomenon was pervasive in interviews and tracks closely with the "R" or "repeated reasoning" dimension of Guershon Huarel's "DNR" three-dimensional theory of design principles to improve mathematical cognition (Harel, Fuller et al. 2014). This theory emphasizes the notion that repeated exposure and manipulation of mathematical structures, in multiple perceptual and conceptual variations, leads to more usable and lasting learning of those structures. It turns out that editing a video, far from being a technical or procedural task to clean up or polish a media artifact, requires and accelerates repeated reasoning and benignly coerces the formation and expression of structural connections between ideas. Producing an effective video may involve dozens of iterations, each of which may entail reflection on how the core ideas may be represented in a different light, with different conceptual entry points, or different conceptual consequences. The lesson study groups further alter the process in that participants continually report that anticipating critiques from peer students and teachers tends to increase the care and precision with which they create their media.

One important direction the data appears to suggest is that the deeply immersive experience of creating and editing videos may function as a scaffolding or staging for growth in self-regulated engagement in learning. The prompt to create a wholly new learning artifact based on one's prior knowledge of a complex conceptual model sets in motion multiple metacognitive reflections, including the need to confirm both what one knows well enough to share or explain and the need to address gaps that sharing exposes – that is, the ideas that remain patchy or inconsistent. Shifts in sense of identity, from being a person to whom things are only explained to being one who helps explain to others, appears to nurture a confidence in an individual that he or she transfers to the process of creation. Using prior knowledge as a pathway to new knowledge is a well understood part of cognitive processing. However, what is unique to this learning context is how the additional factors of autonomy, mental focus, and a tangible sense of personal control over the creation process in addition to the prompt, intensify an individual's level of engagement, precipitating a state of flow.

Objective: Build a portfolio of research examples

The example above is offered as one example of research on the maker movement in formal classroom settings. A central task of the workshop is to invite and share as many other like-minded approaches that are the topics of research by CSCL participants. It is in a richer portfolio of such maker paradigms for schooling that a research foundation for school-based pedagogy for making can emerge.

Thus, the workshop seeks to generate knowledge in a collaborative setting, using the case above as an example of maker activities in formal school environments. Our emphasis in the workshop remains in the domain of computer-supported collaborative learning. Through the example above and examples furnished by participants, we will introduce and solicit discussion around the research basis for interpreting the learning affordances with collaborative tinkering, building, and making, and then focus on activities that can function seamlessly in formal classroom settings.

Workshop participants who carry out research in digital media making in service of formal school learning will have an opportunity to contrast their approaches with those of other participants, with the expectation that broader discourse around the possibilities for computer-supported collaborative making (e.g., involving interactive digital artifacts, games for learning, robots and other devices, and software networks) might emerge, and with it opportunities for reshaped dynamics for formal classroom settings.

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CSCL Mid-Career Workshop

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Introduction

The Mid-Career Workshop is a new event this year. Whereas the Early-Career Workshop provides an opportunity for CSCL and learning sciences researchers early in their careers to discuss their own research, to discuss early-career challenges with peers and senior mentors and to initiate international networks related to their research topics, the Mid-Career Workshop focuses on issues that become relevant later on (e.g. approximately 10 years after the doctorate, during the tenure seeking process, or right after obtaining tenure) in academia, but also in museums, NGOs and in R&D positions in the private sector.

Upon reaching the mid-career stage, researchers enjoy a built up reputation, a storehouse of experience and expertise, an elaborate professional network, and frequently more security than experienced at earlier career stages. By this stage, researchers have produced a substantial body of impactful research, and yet, they may feel their early career work was constrained by concerns related to periodic reviews and political vulnerability. The mid-career stage may be experienced as a new opportunity for risk taking towards more ambitious research agendas, with the promise of greater impact. Yet, this new found freedom is paired with greater administrative responsibility, and further challenges come in the form of increased frequency of invitations for external professional involvement that may eventually be experienced as "too much of a good thing". How does one navigate this new landscape without becoming over-committed? How does one achieve a healthy balance of community service and personal research?

Tentative program

Our vision is to co-construct the day we spend together with the participants. Some activities will be shared with the Early Career Workshop and Doctoral Consortium. Ideas that have come from organizers, mentors and accepted attendees include the following:

- what I wish I knew at an earlier stage
- social impact of a research program
- building a research team
- the boundaries of our research community, defining the field, meta-analyses: what uses?
- navigating the promotion review process
- the habilitation in Germany and in France
- taking more risks in research post-tenure
- balancing administration, teaching and research
- publication planning
- scaling up the research agenda
- mentoring junior colleagues
- enhancing leadership skills
- learning to self-promote

Participant Summaries for Special Workshops

Early Career Workshop

Participatory STEM Learning in Children and Families

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Learners often perceive science, technology, engineering, and mathematics (STEM) formal learning as disconnected from their everyday lives (e.g., Atwater, 1996). Advocates for STEM learning need to focus on *enabling participation* in youth and supporting *participatory cultures*. Participatory cultures support artistic expression, civic engagement, creation and sharing, informal membership, mentorship, and community belonging (Jenkins, Clinton, Purushotma, Robinson, & Weigel, 2006). Specifically, new digital technologies are changing the way youth are participating in STEM, such as developing affinity groups in online communities building with e-textiles and using social media to engage in science learning. However, families play a large role in the lives of youth, but less it known how digital media supports STEM participatory learning in families. In particular, I am interested in the phenomenon of joint media engagement (JME), whereby family members come together (synchronously or asynchronously) to engage together with media content and how these personal interactions around digital media shape learning and participation around STEM (Stevens & Penuel, 2010). However, the challenge remains in understanding how families already learn together, what obstacles prevent participatory learning, and how we design new sociotechnical systems that are natural for STEM learning in families. My research is grounded in ecological systems theories that recognize that learning around information communication technologies are shaped by family practices, local institutions, and cultural norms. I draw upon a learning ecology framework (e.g., Barron, 2006) that acknowledges and conceptualizes learners' activities, practices, and relationships within and across their learning spaces and time. Specifically, families represent one of the primary and most important *communities of practice* in which youth participate very early on and quite intimately (Wenger, 1998). Parents and close relatives can act as learning partners with children's interest-driven technological activity (Barron, Martin, Takeuchi, & Fithian, 2009). It is in this family space that I examine how technology can act as a bridge to support connected STEM learning between different environments (e.g., homes, schools, afterschool programs) and people.

Research plans

Science Everywhere

I am the co-principal investigator on a four-year National Science Foundation Cyberlearning project called *Science Everywhere* (#1441523). Researchers believe that technology can support learning across settings and time, but we still do not understand how learners can bridge their learning across different settings. Science Everywhere is a STEM program comprised of partnerships between children, families, teachers, and community stakeholders that will help learners develop scientifically literate practices across their communities. To bridge the different contexts, this project will design and implement ubiquitous technologies that utilize mobile social media that stream information to tangible, interactive community displays and home media devices. The ecosystem of devices will help to improve and coordinate information flow across the different contexts and stakeholders so that learners can connect their learning across spaces and time. My role on this project is to examine how the combination of the Science Everywhere and ubiquitous technologies support JME within families around STEM learning. I am also utilizing co-design methods with children to design and implement these new learning technologies.

Search and Brokering

Children from immigrant families often need to search for information, teach their families how to use technologies, and translate information from English to their native language (Katz, 2014). Combining this new understanding with prior work I had done on youth information search on the Internet (Foss et al., 2013), I began an exploratory study examining how children from Latino immigrant families search and broker information they find on the Internet. Working with other researchers, we interviewed 10 children (ages 11 – 13) that spent time searching, comprehending, and translating information for their parents. We also conducted focus group interviews at the end (2 to 3 per group) on their experiences brokering Internet-based information for their parents. In this study, I noticed that children not only have a difficult time navigating through adult-based information, they do not always understand the information they find and often rely on translation tools to directly translate English into Spanish. In the future, I am planning to develop new information systems that can help children search and broker information for their immigrant families and plan to develop new socio-technical systems that bridge STEM learning (e.g., health literacy, information literacy) to help children become better searchers and brokers.

Cooperative Inquiry

Finally, my research also seeks to design solutions to improve STEM learning participation with families and children. I seek to build an understanding of how to incorporate human-computer interaction participatory design (PD) methods (e.g., Muller, 2008) with design-based-research (e.g., Collins, Joseph, & Bielaczyc, 2004) from the learning sciences. I use *Cooperative Inquiry*, a PD methodology in which adults and children (ages 7 – 18) work together as full design partners to develop innovations (e.g., Druin, 2002). My design research includes developing new methods for Cooperative Inquiry with children and families (Walsh, Foss, Yip, & Druin, 2013; Yip, Foss, et al., 2013) and studying the process of co-design to develop new learning technologies and environments (Yip, Clegg, et al., 2013; Yip, Ahn, et al., 2014).

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Using Real-time Trace Data to Predict Collaboration Quality and Creative Fluency in Design Teams

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Abstract: In this study, sixteen Engineering students were assigned to small groups (n=4) to work collaboratively on engineering design tasks. Using wearable sociometric devices, we collected real-time non-linguistic speech data on team interaction including turn-taking, successful interrupts and overlaps. Results from 2-stage regression models indicate that speech and conversational dynamics such as turn-taking and successful interrupts are significant in predicting the perceived collaboration quality and creative fluency of design teams.

For a fuller summary of Niger Zhou's work, see the poster description published in this proceedings with the same title as above. Zhou is the first author. The poster may be found by looking in the author index.

Devising Technological and Pedagogical Supports for Metadiscourse in Knowledge Building

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Knowledge building and metadiscourse

Knowledge Building has been defined in its most general sense as "productive work that advances the frontiers of knowledge as these are perceived by a community" (Scardamalia & Bereiter, 2003, p. 1370). It represents an effort to refashion education as a knowledge-creating enterprise, with students taking *collective cognitive responsibility* for advancing community knowledge through engagement in solving ill-structured problems over extended periods of time (Scardamalia, 2002). As knowledge builders, students function as epistemic agents—setting goals, monitoring progress, recognizing dead ends, rekindling interest, planning next steps, and so forth—all for the sake of improving ideas and producing new knowledge. Knowledge Forum, a pioneering computer-supported collaborative learning environment, was designed to support Knowledge Building pedagogy by providing a collective, online space for learners to carry on knowledge-building discourse.

Since Knowledge Building aims towards creation and growth, a critical issue in knowledge-building discourse is whether the discourse is making progress toward a collective knowledge objective (for instance, "understanding how static electricity works"). Central to taking cognitive responsibility in knowledge building, therefore, is to evaluate a group's knowledge progress, recognize problems, and change discursive moves to address recognized gaps. This means students need to conduct productive metadiscourse to make advances in knowledge buiding. This term "metadiscourse" is used here in its philosophical sense, as "discourse about the discourse," but not the more restrictive use of the term in linguistics (Resendes, Scardamalia, Bereiter, Chen & Halewood, accepted). The general concept of metadiscourse covers a wide range of meta-level issues, but in the context of knowledge-building discourse, the key intention of metadiscourse is for students to reflect unpon their community's progress in understanding: Are we addressing our problems of understanding? Are we getting stuck? What are hindering progress? How can we address them and move forward? Metadiscourse calls for a capability of taking a detached view of the first-order discourse and engaging in metacognitve, high-level, second-order discourse. It also requires students to reflect upon the whole group rather than themselves as individuals. These requirements raise the question of whether elementary students in knowledge building classrooms are capable of conducting metadiscourse and, further to this, what kinds of supports, both technological and pedagogical, might facilitate metadiscourse among them.

Group-level learning analytics

My preliminary work in supporting metadiscourse has been primarily focused on devising learning analytics, coupled with pedagogical supports, for elementary-level students. Learning analytics generate knowledge about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs (Long & Siemens, 2011). This field leverages advances in data science to turn educational data into actionable knowledge for teaching and learning. Traditional learning analytics research is sharply focused on the individual learners (Baker & Yacef, 2009). Assessment of group variables comes from aggregating individual scores. In many contexts such as college student learning pathways and massive open online courses, learning analytics remain responsive to the dominant model of educational accountability which stresses individual achievement (e.g., Arnold, 2010).

However, because Knowledge Building is predominantly a group endeavor, the appropriate focus of learning analytics for metadiscourse is on the group's success in advancing knowledge. Analytic questions tied to metadiscourse relate to issues that are inherently group-level. Besides questions mentioned above, metadiscourse is also concerned with: Are students aware of each other's contributions? Are they collaborating to refine their group understanding? Are their collaborative efforts leading to significant advancement? Such questions cannot be adequately answered using only individual metrics. For instance, the effectiveness of collaboration is not simply a function of individual activities; it depends on temporal, spatial, and cognitive interactions among individual actions. By the same token, a productive discussion is not merely a group of students talking about meaningful things; rather, it should demonstrate efforts to produce knowledge advancement that exceeds the sum of individual contributions. Current learning analytics studies have started to attend to some of these challenges by focusing on analysis of social networks or group dialogues (e.g., De Liddo, Shum, Quinto, Bachler, & Cannavacciuolo, 2011; Ferguson & Shum, 2012). However, more efforts are needed to tackle some of the very challenging issues surrounding metadiscourse in Knowledge Building, such as the growth of collective understanding.

Methods

My doctoral research has focused on devising group-level analytics to support metadiscourse. This work has led to two technological tools: (1) Epistemic Discourse Moves Tool—a visualization giving students a meta-level perspective about the frequencies of different discourse moves, e.g., questions, explanations, evidence (Resendes et al., accepted); and (2) Promisingness Tool—a tagging facility engaging students in identifying "promising ideas" in their community so that they could refocus their efforts on potentially fruitful directions (Chen, Scardamalia & Bereiter, submitted). Pedagogical supports for each tool were designed in collaboration with teachers to engage students in metadiscourse in meaningful contexts.

A *design-based research* methodology, which involves iterative revisions of analytics and pedagogical practices based on feedback from real-world testing, has been employed in this line of research (Collins, Joseph, & Bielaczyc, 2004). Working with teachers and researchers, I tested these tools in elementary classrooms from Grade 2 to 6. A mixed methods design was employed in all studies. Research data were collected from both online and face-to-face knowledge-building discourse. Data analysis was primarily focused on (1) the nature of metadiscourse in classrooms; (2) the impact of such metadiscourse on dynamics of the first-order knowledge-building discourse; and (3) the impact of metadiscourse on achieved knowledge advancement.

Future plans

Both analytic tools were preliminary in supporting metadiscourse. My short term plan involves further refining them based on insights gained from previous pilots. I have applied two grants at my institution to support this work. The first goal in the grants is to integrate *epistemic-oriented* metadiscourse supported by the Epistemic Discourse Moves Tool with *content-oriented* metadiscourse focusing on concepts (as well as the relations among concepts) covered by student discourse. The second goal is to apply a multi-level analysis of discourse using text mining, network analysis, and information visualization techniques to model new ways of assessing and representing group discourse. With luck if these grant applications were accepted, I would apply the same design-based research methodology to develop new tools and test them in real-world settings to establish empirical evidence of tool effectiveness. Results from design experiments would offer insights for developing future external grants to support this line of work.

In a long term, I am envisioning a dynamic environment that brings multiple aspects of knowledge-building discourse—e.g., epistemic moves, semantic content, social interactions, and temporal relations—into harmony to support metadiscourse. This system would greatly rely upon advanced learning analytics. It would also depend on active engagement and participation of students and teachers. It should reflect some characteristics of Knowledge Building evident in the literature—such as self-organization and emergent complex system—but not being explicitly addressed in current knowledge building environments. It should also be able to fine-tune itself for knowledge building in different settings—in elementary classrooms, massive online collaboration, and corporate knowledge creation.

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Bridging the Fields of Language Technologies and the Learning Sciences

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I study collaboration at scale and seek to understand how collaboration works in communities through the lens of language and computational linguistics. This includes both indirect ways of observing collaboration through language artifacts produced as a byproduct of collaboration as well as direct ways of viewing collaborative processes through language interactions. In that case, language serves as the medium through which much collaborative work is accomplished. Even the language itself encodes within it echoes of social processes as they have unfolded throughout history as lexical choices or phonetic transformations take on social meanings as a result of their usage as tools both in everyday life at one end of the spectrum and in literature at the other. Language technologies are a powerful tool for modeling the structure in language at all these levels. It offers the possibility of monitoring and supporting collaborative processes and thereby influencing the production of artifacts, which ultimately offers the opportunity to achieve societal good. As such, my research is deeply interdisciplinary and situated at the intersection of computer science, the humanities and education. My aim is to combine the strengths and complementary viewpoints of these fields with an eye towards positive human impact both in terms of production of high quality artifacts that have value as well as shaping social processes that impact important outcomes such as learning.

The focus of my previous research was to operationalize the information quality management process in Wikipedia with the help of natural language processing. This involved defining information quality in this particular application context, automatically measuring the quality of the collaboratively created articles along multiple quality dimensions and analyzing the coordination efforts of the collaborators. I now want to broaden the scope of my research to investigate online conversation as the main driving force of collaboration in different online contexts such as collaborative online learning. I am furthermore interested in the linguistic properties of online conversations across different social media platforms, the conversational cultures that have emerged from these platforms, how they interact which each other and how this affects collaboration.

My initial work focused on contemporary corpora with a particular emphasis on collaboratively created texts using the example of Wikipedia. Rather than merely regarding texts as finished products and analyzing static text artifacts, I investigated the processes that are involved in their creation. In a collaborative environment, the production and reception processes are intertwined in a way that they greatly influence the development of the texts so that these processes have to be considered as an integral part of the corpus. To this end, I developed methods that allow investigating the revision history of Wikipedia articles as a means to observe the production processes and approaches to analyze the discussions of Wikipedia users as a means to investigate the article reception over time (Ferschke et al., 2011).

A major collaborative goal in Wikipedia is maintaining and improving article quality. I developed and integrated a multi-dimensional article quality framework that not only takes into account the intrinsic quality of the article content, but also linguistic and stylistic properties, structure and organization (Ferschke, 2014). Based on this model, I developed an approach to leverage crowd-generated labels of article deficiencies as training data for building machine learning classifiers that can automatically identify these quality flaws in unseen articles (Ferschke et al., 2012b, 2013). This work served as the foundation for a new text classification framework I developed in joint work with my colleagues (Daxenberger et al., 2014).

In order to analyze the work coordination efforts in Wikipedia, I developed a multi-level coding scheme for analyzing the user discussions in Wikipedia (Ferschke et al., 2012a). It operationalizes the building blocks of the collaborative process through which interested parties within that community of practice deliberate over choices that impact the extent to which the articles reflect the agreed upon values of the community.

While my earlier work regarded language technology as a catalyst for coordinating a community-wide collaborative authoring effort, my current research considers language technology as a catalyst for building community around online learning environments in order to provide opportunities for productive engagement in learning. In particular, I am interested in how conversational agents can be employed to assist students in massive open online courses (MOOCs) to have reflective conversations with an educational benefit, whether these agent-guided conversations improve learning and how these discussions influence group formation and student retention. First results of a deployment study of a recent MOOC, which are described in a long paper accepted for publication at CSCL 2015, suggests that there is value in providing a diverse set of discussion contexts to learners but that it also creates a need for greater efforts towards effective bridging between media (Ferschke et al., 2015). I found that chats provide a complementary venue to the established asynchronous discussion spaces in a way that they encourage a more intensive exchange of deep reflection on course content. Survival analyses furthermore confirmed that these interventions have the power to significantly reduce attrition with students who participated in the collaborative chats.

One of the central problems in effective participation in communities or collaborative groups is coordination. At an individual level, this problem can be conceptualized in terms of an individual engaging in a self-regulatory process of identifying opportunities to contribute, and in those contexts to see their own contributions in light of how they could contribute to the whole. Within this system, language technologies are a useful lens, enabling vision over a far more expansive landscape than would be possible without automated assistance, both for identification of opportunities and for assessment of the effect of contributions on the quality of the whole. Collaborators position themselves within the interaction in ways that are consistent with their own self-conception and fit with their perception of their interlocutors. They need to identify places in the interaction where they have something to contribute. I will investigate approaches that leverage language technologies to provide contextually appropriate support to collaborators. As a first step towards this goal, I will investigate synchronous collaboration activities supported by intelligent conversational agents and enhancements to threaded discussions to support work coordination by leveraging recommendation technology. In online learning environments, for example, conversational agents can scaffold discussions between students but might also aim to expand the diversity of views expressed in the conversation or encourage weaker conversational partners to contribute to the discussion. In the context of collaborative platforms like Wikipedia or Wiktionary, I aim to derive work recommendations from user discussions in order to assign users to activities they are most suited for or interested in.

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The Design of Learning Environments and Learning Technologies

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Abstract: How can we create a support system for students and teachers around transforming teaching and learning with technology? This guiding question connects my two main lines of research. I am interested in understanding how the designs and affordances of collaborative spaces and technologies facilitate teaching and learning. I also investigate how peer support networks contribute to addressing issues during the creation and/or use of learning environments and learning technologies.

Research agenda

My research agenda broadly focuses on the design of learning environments and learning technologies. Within this area of interest, I am engaged in two main lines of research: 1) the designs and affordances of collaborative spaces and technologies, and 2) debugging as a practice of peer technological support.

Designs and affordances of collaborative spaces and technologies

My first line of research involves my postdoctoral work at the Krause Innovation Studio. Our research team is investigating how the designs and affordances of collaborative spaces and technologies facilitate teaching and learning. I am involved in four current projects: 1) conducting design-based research around the development of a data collection tool for learning spaces research; 2) describing the continuum of collaboration that exists in informal group spaces; 3) understanding students' experiences of group work in an open, collaborative, and hyper-public learning space; and 4) examining the affordances of tablets in supporting a one-to-one initiative in preservice teacher education. I have prepared presentations (at the *American Educational Research Association*) and publications in this area of interest. I have one manuscript in press at the *Journal of Learning Spaces* (Rook, Choi, & McDonald, in press), and I expect to have drafts from the other projects by the end of 2015.

Debugging as a practice of peer technological support

My second line of research focuses on the notion of peer technological support, or what I refer to as debugging. Building on my experiences in both computer science and K-12 education, I am interested in learning how peers assist each other with learning-technology issues. My dissertation identified and studied the experiences of students who provided assistance to their peers in a teacher-education professional-development school. I recently presented the findings from my dissertation at the annual conference for the *Association for Educational Communications and Technology* and I am preparing this work for publication.

I draw connections between my two lines of research when thinking of the ecology of learning environments and learning technologies. In my first line of research, I seek to understand the designs and affordances (both pedagogical and technological) of spaces and technologies. My second line of research (peer technological support) informs the first line of research by understanding how peer support networks contribute to addressing issues during the creation and/or use of learning environments and learning technologies.

Theoretical framework

In my work, I draw from both design scholarship (Nelson & Stolterman, 2012) and design-based research (DBR Collective, 2004), and also sociocultural (Vygotsky, 1978) and social (Wenger, 1998) theories of learning. I understand design as "the act of evoking the yet-to-be-imagined and the not-yet-existing" (Nelson & Stolterman, 2012, p. 147).

In my research on the collaborative nature of informal group spaces and the experiences of students in open and collaborative spaces, I borrow Vygotsky's view of learning. Vygotsky explained learning as being mediated by others in a social environment (Karpov, 2005). The use of the word "mediated" is important because it implies that there is a social dimension of learning as well as an individual dimension. The social dimension of learning is culturally and historically contextual. That is, learning is specific to and embedded in the cultural and historical norms of the environment. According to Vygotsky (1978), the social dimension of learning involves interactions with people who assist us through development.

My research on peer technological support draws from both Vygotsky's understanding of the zone of proximal development (ZPD) as well as Wenger's notion of a community of practice. The ZPD seeks to identify all of an individual's development as it occurs in an environment and culture. Vygotsky's notion of development could be compared to ethnography (i.e. the study of culture), because Vygotsky is concerned with capturing continuous development acted upon by the environment and culture in which an individual participates (Newman & Holzman, 1993). Stated another way, the ZPD is neither a framework nor a model, but rather a way to explain the interaction of peers and more capable peers in a community and culture.

Wenger defined learning as "participation" (Wenger, 1998, p. 13). Through participation in a community, a learner increases both individual knowledge and community knowledge. The activities that contribute to learning are situated within a community structure. One of the activities, members' negotiation of identity, becomes a central activity of the community and the learning process. Members negotiate their identity "by changing all at once who (they) are, (their) practices, and (their) communities" (Wenger, 1998, p. 227).

Methods

In my research on the development of a learning spaces data collection tool, I seek to "produce an instructional tool that survives the challenges of everyday practice" (Shavelson et al., 2003, p. 25). Design-based research (DBR) is a useful method because it is interested in exploring "novel learning and teaching environments," discovering learning theories that are contextual, contributing to our understanding of design, and finally, providing an opportunity for innovation (DBR Collective, 2004, p. 8). Innovation in DBR can come in the form of "ontological" innovation that involves the iteration of implementations and descriptions of the details of the iterations (diSessa & Cobb, 2004, p. 100).

In my other work, I often investigate the lived experiences of participants to answer my research questions. I employ hermeneutic phenomenological methods (Heidegger, 1927/1962). van Manen (1997) defines hermeneutic phenomenology as "a descriptive methodology because it wants to be attentive to how things appear, it wants to let things speak for themselves; it is an interpretive methodology because it claims that there are no such things as uninterpreted phenomena" (p. 180). In hermeneutic phenomenological methods, an emphasis is on interpretation based on cultural, social, and historical contexts. Every experience should be described and understood in relation to the prior and current contexts within which it resides.

Future plans

My future plans involve continuing my two lines of research in the following ways. In my investigation of the designs and affordances of collaborative spaces and technologies, I expect to present a proof-of-concept of a data collection tool for seed funding, subsequent development iterations, and external funding. The tool will be used to understand the educational experience in open, collaborative, and informal spaces. I envision the tool would be available for any space to repurpose and reuse for research and/or evaluation.

With my work on peer technological support, I plan to follow the initial participants from both my dissertation work and a second follow-up study through multiple stages of their careers. This longitudinal study will allow me to understand peer technological support as a negotiation of identity and participation throughout a teacher's career.

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A Synergistic Approach to Studying Computer Supported Authentic Inquiry and Genetics Understanding in K12 Students

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Introduction

My research program integrates my molecular biology expertise with the learning sciences to create a synergistic program of study. Specifically, I am examining use of computer supported authentic inquiry experiences, namely the Science Classroom Inquiry simulations (Peffer et al, 2015), in K12 settings (Research Aim 1). In my second area of research, I propose a developmental approach to redefine genetics education (Research Aim 2).

Research aim 1: Examining authentic science inquiry in K12

Although science inquiry is often presented as a series of linear steps, authentic science inquiry rarely occurs in a prescribed linear fashion. For instance, students are often instructed to follow a "scientific method" in which they generate questions and hypotheses, conduct experiments, and draw conclusions. While this approach may have advantages in the classroom for saving valuable time and reducing demands on the teacher (e.g., those related to scaffolding), a prescribed linear approach may have negative impacts on the learner, namely in interfering with the learners' *understanding* of authentic science practices (Chinn & Malhotra 2002).

Recent calls in the United States emphasize the importance of science inquiry in the classroom, particularly the authentic inquiry practices utilized by scientists (NRC, 2012). However, successful classroom-based authentic science inquiry is challenging to implement because it requires appropriate scaffolding (Hmelo-Silver, Duncan & Chinn 2007). To provide students with a computer-based, non-linear, authentic science inquiry experience that contains adequate scaffolding and fits within the confines of the typical classroom, we designed the Science Classroom Inquiry (SCI) simulations. Our previous work demonstrated that middle and high school students report that SCI simulations positively influence their learning and altered their perceptions of what science looks like in the "real" world (Peffer et al, 2015). As students work through SCI simulations, the simulation engine saves their decisions and inputs within the non-linear structure. Consequently, unique, student-created "paths" are generated. These paths, aligned with other models of student success in inquiry, may provide insight into students' cognitive models of authentic science inquiry practices (Peffer & Renken, 2015). Continuing this line of work, I am engaged in a research program that examines the following: (1) SCI-generated predictors of student success on STEM outcome measures at the individual and group level; (2) Role of participation in SCI in altering students' understanding of authentic science practices and science epistemologies; (3) Transfer of science inquiry abilities from the simulated SCI environment to real-world research.

Research aim 2: Redefining genetics education through a developmental lens

2014 marked the arrival of the highly anticipated $1000 genome, a development with the potential to revolutionize medicine. Consequently, a working knowledge of human genetics is imperative in order for individuals to participate in an educated dialogue with their physicians and policy makers. In spite of the importance of members of society having a working knowledge of genetics, and the inclusion of genetics knowledge in national science standards, students continue to lack a basic understanding of genetics (Shaw, Horne, Zhang & Boughman 2007; Henderson & Maguire 2000).

Research indicates a need for curricular reform in genetics (McElhinny et al 2012, Dougherty 2009). Furthermore, although students prior to undertaking genetics coursework have a fairly accurate understanding of the influence of genes and environment on phenotype, a curricular focus on Mendelian genetics distorts these more accurate naïve beliefs, resulting in a lack of student understanding of the complexities leading to phenotype (Doughtery 2009). In contrast to *oversimplified* curricula, conceptual understanding of genetics is *difficult* to achieve. This may be in part due to high demands on the learners' spatial reasoning, since genetics understanding requires reasoning across four spatial scales—molecular, cellular, organismal and population (McElhinny et al 2012). Notably, spatial reasoning is a skill set essential to success not only in genetics, but also in all STEM fields (Newcombe 2010). In response to these challenges, I propose an interdisciplinary approach to address the following: (1) The role of SCI in addressing students' common genetics misconceptions and students' ability to engage in an argument task related to genetics; (2) The relationship between students' spatial reasoning aptitude and types of common genetics misconceptions; (3) An interaction between SCI and spatial reasoning to address students' common genetics misconceptions.

Methods

Employing experimental methodology, middle and high school students will be divided into SCI and direct instruction groups. Students participating in SCI will be tasked as biomedical researchers seeking to determine the nature and cause of a mysterious illness. Within the simulation, students will examine genetic and environmental evidence. Based on this evidence, will students propose a putative nature and potential cause(s) of the illness and make recommendations to community leaders. Students in the direct instruction groups will also write recommendations to community leaders.

Student arguments will be coded with an argumentation rubric that includes items such as accuracy of claims, supporting evidence, and development of counterclaims. Argumentation scores will be calculated and used to determine the accuracy and strength of student arguments. To address the role of collaborative learning, students will work in groups of 2-3 on the same simulation, but using individual computers. Individual level simulation data will be collected via each individual virtual laboratory notebooks, and aggregate simulation activity will provide group level data.

For Research Aim 1, students will complete pre/post test measures relating to science epistemology, nature of science, and science inquiry. Unique student-generated paths through the SCI simulation will be analyzed according to the evidence-centered design (ECD) method of assessment (Mislevy et al 2002, Mislevy 2011). The ECD method allows for assessment of a wide variety of success variables including domain knowledge and inquiry process via comparison to "expert" level paths. For Research Aim 2, students will complete a pre-test containing (1) Assessment of their spatial reasoning (Wai, Lubinski & Benbow, 2009) and (2) Assessment of genetics misconceptions based on Shaw, Horne, Zhang and Boughman (2008) and Henderson and Maguire (2000). Following the experimental intervention, students will repeat the genetics misconceptions assessment, but not the spatial reasoning assessment since SCI is not designed to improve spatial reasoning.

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Visual Learning Analytics in Computing Education

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Abstract: My research broadly lies within the area of computational technologies for learning, specifically focused on how technologies can be designed and applied to be more effective in computer science education. The core research questions include: what are the challenges of adaptive educational systems in assisting problem solving & peer instructions; what measures, design principles and impacts of these challenges can be addressed. My research methodology involves Artificial Intelligence and Human Computer Interaction approaches in researching effective educational technologies (open student modeling & visual learning analytics), which the theoretical background is guided by self-regulated learning, social comparison theories and learning sciences: learning from observing.

Keywords: learning analytics, visual analytics, computer science education, computing education, student modeling, visualization, personalized learning, adaptive navigation support, open student modeling

Introduction

Fast-growing technology literally brings education to students' fingertips. To harness the promise of information technology enabling and enhancing learning outcome, the adaptability, visualization & learning analytics are increasingly important. I study the impacts of adaptive educational systems in assisting problem solving & peer instructions. I examine the design principles of visual learning analytics and how those challenges can be addressed. My research methodology involves Artificial Intelligence and Human Computer Interaction approaches in researching effective visual learning analytics, which the theoretical background is grounded by self-regulated learning (Azevedo, Guthrie, & Seibert, 2004; Zimmerman, 1990), social comparison theories (Darnon, Dompnier, Gilliéron, & Butera, 2010; Huguet, Dumas, Monteil, & Genestoux, 2001) and learning sciences: learning from observing (Muldner, Lam, & Chi, 2014).

Adaptive navigation support for personalized learning

My early work investigated how adaptive navigation support can be implemented and be utilized in a complex knowledge domain to facilitate problem solving. I developed an intelligent tutoring system, which supports design, deliver and evaluate problem solving in the context of object-oriented programming language learning. I studied the effectiveness of adaptive navigation support guides students to work on different complexity levels of problems. (For instance, complex problems of easy topics will be provided with dimmed visual cue; complex problems of difficult topics will be provided with limited-access cue). Three-semester long classroom study results confirmed that adaptive navigation support provided effective personalized guidance, which prevented students from venturing too fast or who got bored with too easy problems (Hsiao, Sosnovsky, & Brusilovsky, 2009). In addition, adaptive navigation support revealed that it bridged the knowledge gaps between weak and strong students (Hsiao et al., 2009; Hsiao, Sosnovsky, & Brusilovsky, 2010).

From open student modeling to visual learning analytics

Engaging students with social learning technologies has become an important trend in modern e-learning. One of the biggest challenges is to provide adaptation in the context of social learning, while at the same time allowing students to feel in control. I have begun studying and extending the benefits from adaptive navigation support to broader audience by incorporating social learning technologies. I designed and studied various visual approaches of open student modeling interfaces that provide students with easy-to-grasp and holistic views of their progress and knowledge. I call it *Open Social Student Modeling* visualizations. Specifically, I focused on the visual representations in the context of social learning, which can be considered as Visual Learning Analytics. Results revealed that combining personalized and social learning technologies through social visualizations enhanced the learning quality in increasing their motivation and engagement (Hsiao, Bakalov, Brusilovsky, & König-Ries, 2011, 2013; Hsiao & Brusilovsky, 2012). The visualization unveiled the traces that were left by stronger students as social guidance for weaker ones to follow. This stream of work pinpoints several challenges in user modeling and information visualization, such as open user model optimization for mass user generated content, automatic decoding and encoding of big data for visual analytics etc. I have begun investigation in these research issues and making progress (Awasthi & Hsiao, 2015; Hsiao, 2015, accepted; Hsiao & Awasthi, 2015).

Future directions

My aim is to make an impact in the world that allows people to see the beauty and joy of learning programming in this information-overloaded space. Specifically, I am focusing on better understanding the social and pragmatic nature of computing, and using this understanding to build tools that can adapt to each unique user. To work toward this aim, I continue moving forward my research agenda based on my interests and expertise in conjunction with existing and provisional projects. In my short-term research agenda, I am proactively exercising and communicating my research findings through national and international classrooms and communities. My long-term goal is to tackle the challenges in designing generic personalized technologies in open-corpus and less-content-specific areas. Overall my research agenda strives to deepen our understanding in personalized learning and how visual learning analytics can be designed more effectively.

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Designing Games for Learning

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Games afford learning in a variety of ways. For example, game structures, such as their mechanics can affect player biological responses (Dye, Green, & Bavelier, 2009) and the development of mental models (Clark et al., 2011; Corredor, Gaydos, & Squire, 2013). Games' tendency to create interest-driven social spaces may lead to the development of game-based discourses and identities (Gee, 2003; Steinkuehler & Duncan, 2008). Game representations or their narratives may promote learning through secondary mechanisms of motivation and interest (Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005; Dickey, 2006). The aims of my research are to understand how to synthesize these varying affordances and their outcomes so as to reliably develop games for education and learning. In other words, I seek to understand the application of learning theories to educational game based contexts and use the theoretical lens of *design* in order to do so.

Design

Design is generally acknowledged as essential for the development of education technology interventions that pursue effecting authentic, local, and possibly large-scale change, while simultaneously affording rigorous research (DBRC, 2003; Fishman, Penuel, Hegedus, & Roschelle, 2011; Penuel, Fishman, Cheng, & Sabelli, 2011). Despite its importance, design itself has been relatively under-theorized in games and learning research. As game-based learning evolves from a field that investigates *whether* games are good for learning to *how* games can be good for learning, what's needed is a better understanding of how and why the designed components of an educational game came about, especially with regards to the intended and unintended components as well as the conditions of development and use.

To guide how designs are communicated, I adopt Schon's (1984) definition of design as a process of *reflection-in-action*, in which designers draw connections between the immediate problem and their own prior experiences, relying on prior experience such as other similar design problems. By drawing connections between prior work and the problem at hand, designers frame and re-frame the problem so that it is familiar and understandable. And while the designer seeks similarities between the current design and prior work in order to propose solutions, the conditions of the world "talk back" to the designer, triggering a re-framing of the problem based on evolving constraints that the design must meet, including differences between the current and prior situations. When a problem is well-defined, generating design solutions means meeting the initial constraints of the project. However, when working in an ill-defined problem space, such as game design for classrooms, the designer must actively identify the similarities and differences between the current design and prior work in order to evaluate potential solutions' relevance or applicability.

Methods

Design-based research approaches are used in order to simultaneously conduct design and research, as they warrant what Anderson & Shattuck (2012) describe as a "cautious optimism" in their ability to generate testable theories and practical tools that can be used to improve learning. Because design based research provides an overall framing of theory generation and testing, more specific methods must also be used in order to prescribe the data that will be collected, why it will be collected, and how it will be analyzed, especially with regards to student learning. Discourse analysis and concept maps will therefore be used to supplement the design-based research approach.

The discourse analysis approach that will be applied focuses on the student's game and non-game-based identities. Discussions that occur before, during, and after game play will be collected, coded, and analyzed thematically so as to understand how students make sense of the game through identity lenses (Gee, 2003; Steinkuehler & Duncan, 2008; Zuiker, Anderson, Lee, & Chee, 2008).

Concept maps are graphical representations of knowledge, often represented as boxes containing propositions, connected to one another with a line or explicit description of the relationship (Moon, Hoffman, Novak, & Cañas, 2011). Concept maps have been previously used to show how the mental models students developed through digital game play better reflected the dynamism of the modeled system as compared to the models learned with static, non-digital media (Corredor et al., 2013). In this study, we similarly use concept maps to investigate changes in how students represent what they've learned through play and will ask students to construct them at the start and end of the unit.

Moving forward

Because game-based educational technologies continue to gain popularity in formal and informal educational environments, theories and guidelines regarding the parameters of future designs are increasingly necessary, both to improve research and understanding of how games affect learning, but also to improve the designs themselves. What's needed are something like "design frameworks" (Edelson, 2002), which can be produced through design studies and present "generalized design solutions" to address the problems identified by a prior research whilst using design methods to get there. While design research has regularly focused on the development of domain theories and improving design methods, design frameworks, including how design solutions are generated, remain under-developed or at the very least, not well-shared within games literature. The primary aims of my research are thus to address 1) how we share designs and design theories (e.g. what sorts of structures or forms would be useful?) and 2) how we theorize design in the context of educational game development, including what constitutes good design and how does it relate to learning.

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Designing for Learning in Makerspaces: Opportunities and Challenges

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Abstract: Makerspaces and making have captured the imagination of education researchers all over the world. With grand promises of disruptive technological innovation that changes the way students learn in classrooms, it is easy to forget that, in many ways, we have seen a lot of this before. Still, important questions still need answering: it sure looks like fun, but *what* are they learning, and *how*? In this early career workshop, I outline work that I have planned, to develop a curriculum argument and accompanying learning theory for making based on tacit, embodied knowledge, and embodied cognition.

Keywords: makerspaces, tacit knowledge, embodied cognition

Introduction
Makerspaces have come to the forefront of much media attention in the last several years; as sites for the dramatic reinvention of the goals of schooling. In large part reimagined (mechanical or electronics engineering) workshops, part of the reason for the recent resurgence must be due the advent of more accessible advanced manufacturing technologies and tools. t. For learners, makerspaces have also been seen as possible sites for the acquisition of dispositions like resilience, risk tolerance, creative confidence, and the innovative mindset required for meeting the unknowable challenges of the uncertain future.

Much as the promise of makerspaces have been recognised by the community, there does not appear to be sufficient research into appropriate curriculum goals and pedagogical design principles that ought to accompany makerspace activities. Further, in the words of a recent article published in *Science Education*, the field has yet to decisively answer the question: “It looks like fun, but what are they learning?” (Bevan, Gutwill, Petrich, & Wilkinson, 2014). To be sure, there is much in makerspace activity design which derives from constructionist principles first elaborated over twenty years ago (see, e.g., Kafai & Resnick, 1996; Papert, 1993). Yet, if there are any lessons that may be drawn from our history, it is that social and political movements tend towards a form of techno-fetishisation which overpromises and under-delivers (Cuban, 2001). Certainly, the goal of my research is not to disparage these recent efforts in educational reform; on the contrary, I acknowledge that there is much to be excited about makerspaces and making in school classrooms, but there are also historical lessons to learn, and research opportunities to discover new knowledge from these contexts. Toextend the question posed earlier, my research agenda intends to investigate: *how* are they learning? and; what are some design principles for learning in makerspaces?

Theoretical framework
Popular research approaches are primarily concerned with the acquisition of knowledge, skills, and dispositions of STEM and design. These approaches either consider makerspaces as sites of high student engagement as an end goal, or as sites where constructionist principles are exemplified. While I do not deny the utility and effectiveness of these lenses, knowledge of the underlying mechanisms that explain the effectiveness of embodied experiences in the acquisition of abstract conceptual knowledge remains an area suitable for further research. My research draws firstly from observations of the nature of technical knowledge and expertise: from as far back as the contributions of Gilbert Ryle (1945), who proposed philosophical anti-intellectualism that is still currently being discussed (Fantl, 2008); to Michael Polanyi’s (2009) now famous conceptualisation of tacit knowledge as our ability to know more than we can tell; to contemporary studies in the sociology of scientific practice (Collins & Evans, 2007). The suggestion here is that, in the anti-intellectual tradition we need to know how to know, before we can learn what it is that we ought to know.

One interpretation of embodied cognition posits the principle of the spreading of ‘epistemic credit’: if some part of a task were to be performed in the world as it would have functioned ‘in the head’, then that part would necessarily need to be recognised as a cognitive (sub)process (Clark & Chalmers, 1998). Thus, just as we offload and extend our sensory perceptions with tools like callipers, microscopes, or gas chromatographs, we certainly can offload cognition to ‘devices’ (generally speaking) outside of the physical brain. In education, recent applications of this idea of cognitive externalism include: evidence that gesturing in mathematics classrooms provides evidence for the embodied nature of mathematics learning (Alibali & Nathan, 2012); a software application that gets students to learn fractions by using their arms to accurately estimate proportionally related quantities (Abrahamson & Lindgren, 2014); the use of an abstract gesture to connote a mathematical process of addition of a subgroup of numbers (Novack, Congdon, Hemani-Lopez, & Goldin-Meadow, 2014); and the use of 'mixed reality' activities combining sophisticated body-and-gesture sensing interfaces in games for education (Lindgren & Johnson-Glenberg, 2013).

Methods
Considering the embodied cognition perspective, a specific researchable task at this phase of the project would be the characterising of epistemic actions that occur within the makerspace context. What are the types of actions that, [with what artefacts, and under what circumstances] perform as cognitive functions? Are there means to classify these epistemic actions? To answer these question, I propose to use a video-based ethnographic approach to inductively generate categories of epistemic actions in a first phase. In a second phase, I will rely on clinical task based qualitative interviewing in order to elicit learners' in-depth phenomenological reporting of their cognitive functioning.

Moving forward
This project has already received funding from the Ministry of Education, Singapore. Makerspaces are quickly attaining fad status in many places around the world. It is imperative that a more rigourous examination of its educative value be established, before lethal mutations limit the kinds of learning possible in makerspaces. Beyond the immediate goal of understanding makerspaces, this project aims to bring illumination to the empiricist-intellectualist debate from our current insights in embodied cognition research. It is perhaps narcissistic to consider a resolution of the age old problem, but certainly given the current status of manual work in contrast to the privileging of abstractions, and the recent theoretical and empirical advance in the cognitive sciences, much work needs to be done.

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Developing Next Generation Learning Environments

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Theoretical framework

My research focuses on how to radically redesign learning spaces to support learners and teachers engaging in authentic inquiry. Despite a growing shift in the way we think of classroom learning, the physical space of the classroom itself has remained largely unchanged. Current classrooms still tend towards the "sage on the stage" metaphor, with the teacher standing at the front of the class and students working individually. Despite the considerable promise offered by digital technologies to transform education (Pea & Maldonado 2006), most designs still approach learning as being confined to a particular device (e.g., a computer or tablet), with individuals or groups huddled around a single screen. Such designs generally fail to consider the role the physical space itself plays in mediating student learning and the unique learning opportunities in which digital information is layered upon and across the physical space. To this end, there is considerable potential to re-think the design of the classroom towards dynamic and responsive environments to support inquiry.

In response, researchers have begun investigating ways of digitally embedding aspects of the community's inquiry in the classroom's walls, ceilings, and floors. For instance, immersive displays have turned classrooms into rainforests that allow students to investigate flora and fauna changes over millions of years (Lui & Slotta, 2013). Coupled with personal, portable, and connected devices, students and teachers can be freed from traditional classroom configurations, fostering instead a dynamic "smart classroom" model where students move throughout the space and engage in real-time collaborative activities (Tissenbaum & Slotta, 2014).

Introducing smart classroom frameworks into traditional learning spaces can also allow the digital surfaces and devices to quickly adapt to the class' real-time curricular goals (Tissenbaum & Slotta, 2013). Embedded displays can dynamically shift between simulations and aggregates of student work to support class discussion. There is also growing interest in the role of ambient displays – displays at the periphery of the class' attention that provide specific lenses into learner knowledge – in supporting inquiry. Providing multiple adaptable and reconfigurable external representations has been shown to be a valuable means for scaffolding student inquiry, supporting self-regulation and providing timely feedback (Ainsworth, 2006).

The enactment of complex real-time inquiry activities place a high load on teachers, requiring them to simultaneously manage changing student roles and groups, assign activities, and organize materials, including potentially large and diverse community-generated content (Tissenbaum & Slotta, 2014). Supporting teachers and students in such activities is often termed *orchestration* (Dillenbourg, Jarvella, Fischer, 2009), and is highlighted as a major learning sciences design challenge (STELLAR, 2011). In response, technology enhanced spaces may offer a means for supporting the orchestration of such curricula, including tracking students within the room, providing procedural scaffolds, and making real-time decisions (Tissenbaum & Slotta, 2013). Within these environments the goal of implementing orchestration supports is not to remove teachers from the flow of activities, but instead to support them in addressing students in-the-moment needs.

There is a growing need within the learning sciences to understand how the community's intelligence is distributed through technology rich learning environments (Pea, 2004). The community's intelligence doesn't reside within the "skull" of any one member; rather, it is distributed amongst the members and the tools they use to contribute to the community and to collaborate (Hollan, Hutchins & Kirsh, 2000). As such, it is critical to understand the role individual and collaborative devices, aggregated and ambient representations, and intelligent software agents and data mining all play in supporting and developing the community's intelligence.

Research questions

In order to address the theoretical challenges above, two main questions have driven my research:

1. How can future learning spaces support the pedagogical requirements of distributed, collective inquiry?
2. How can such environments support the orchestration of knowledge communities and inquiry learning?

Recent research

My doctoral research showed that augmenting physical classrooms with new digital tools could effectively support teachers and students engaged in authentic inquiry. My study established a knowledge community for grade 11 physics students who performed activities across multiple contexts (home, playground, classroom, and a smart classroom), with student-contributed content serving as a primary resource. The design of the curriculum built upon the teacher's desire for students to recognize "physics in their everyday lives" and consisted of two main phases: a 12-week curriculum where students collaboratively developed a shared repository of examples of physics in their everyday lives (through videos, pictures, and text); and a culminating smart classroom activity in which students leveraged the knowledge base to solve ill-structured problems using Hollywood movies as their domain (see Tissenbaum & Slotta, 2014).

The culminating activity featured several innovative approaches for supporting student inquiry: (1) an intelligent agent and data mining framework to support the design and execution of real-time pedagogical logic; (2) spatially oriented interfaces, including tablets and interactive whiteboards, which provided location specific materials, and allowed for *ad hoc* collaboration; (3) aggregate and ambient displays providing information about the state of the room and activities; and (4) teacher technology scaffolds (on a tablet computer) to help the teacher orchestrate the complex sequence of activities and conditions (i.e., the script). Using a blend of assessments, including student-contributed content, captured video, server data logs, and exit interviews I showed` the efficacy of the designed learning environment to support students in integrating the community's knowledge into their discourse and problem solving. This study also showed how we could alert teachers at critical moments in the script towards helping individuals and small groups to refine their science thinking.

Currently, as a postdoctoral research associate with Matthew Berland at the University of Wisconsin-Madison, I am helping develop analytical approaches for a multi-modal exhibit at the New York Hall of Science (NYSCI). Developed in partnership with Leilah Lyons at NYSCI/University of Illinois at Chicago, the exhibit (named Oztoc) is an immersive environment that situates participants as electrical engineers helping fictional scientists who have discovered an uncharted aquatic cave teeming with never-before-documented species of fish. The exhibit uses a digital tabletop interface to support participants as they engaging in authentic engineering practices. Large displays provide aggregated representations of individual and group progress to support real-time feedback and collaborative discussion. I am currently investigating how different aspects of the environment help learners self-monitor, set goals, and take on different roles (e.g., collaborator or tutor). Building on my PhD work on orchestration, we are currently developing a tablet that provides museum guides deeper insight into the tinkering practices of participants based on preliminary models of unproductive perseverance. Our goal is to provide guides unobtrusive ways of knowing when museum participants may benefit from some intervention and providing them with supporting strategies without "giving too much away".

Future research

I am committed to continuing to develop research into how we can redefine learning spaces to support new forms of distributed collective inquiry. I aim to further research into the role of persistent and ambient representations in these spaces – how they can show community idea growth, consolidate asynchronous activities for real-time discussion, and represent knowledge dispersed across multiple locations. For instance, what new forms of inquiry could students engage in if their classroom walls in Toronto showed a real-time feed of an African savannah? How can we represent a class' evolving knowledge within the room to provide new opportunities for reflection, discussion, and avenues for inquiry? How can we leverage where learners are in a space to support dynamic, emergent, and embodied forms of learning? Finally, how can we integrate emerging technologies like ubiquitous computing and the Internet of Things (IoT) into curricular and classroom designs to extend learning beyond classroom walls and to support new forms of distributed authentic inquiry?

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Digital Game Design for Collaborative Learning

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Abstract: This summary aims to describe my current research interests, including the theoretical and methodological framework. My research interests centre primarily on the areas of Computer-Supported Collaborative Learning (CSCL) and Digital Game Based Learning (DGBL). In particular, I am interested in how digital game design activities could contribute to collaborative learning in formal and informal educational settings. My research aims to study the impact of digital game design activities in small group collaborative learning settings. Digital game design is a complex task which could integrate interdisciplinary learning objectives and some of the 21^{st} century skills such collaborative problem solving (PISA 2015), creative collaboration and computational thinking. In this summary, I introduce two current projects aiming to advance the understanding of digital game design in the context of primary education and in the context of intergenerational learning.

Digital game design as a creative collaboration activity

Digital game design is often considered as a professional activity restricted to multimedia professionals, but has now been democratized by the increasing number of visual programming game authoring tools (Canossa, 2013; Howland & Good, 2015; Marchiori et al., 2012). From *Scratch* to *GameMaker* (Hoganson, 2010; Resnick et al., 2009), there is a growing number of game authoring tools that allow game authoring through visual programming. There is no need to learn a specific programming language to create games in visual programming environment; but using them allow to develop the computational thinking (Grover & Pea, 2013; Howland & Good, 2015), including "problem formulation, logically organizing and analyzing data, representing data through abstractions such as models, automating solutions through algorithmic thinking, implementing effective solutions" (Basawapatna, Koh, Repenning, Webb, & Marshall, 2011). In formal educational contexts, game authoring could be integrated as a learning activity helping to achieve the curriculum objectives (Romero & Barma, 2015). In this summary, I introduce two research projects that I'm currently developing. The first research project aims to analyze the usage of game creation to develop the learning and competence objectives of the primary education in Québec. The second research project aims to study digital game design as an intergenerational learning activity and will allow children and seniors to engage in a joint creation of a game. Seniors will act as narrative directors while children lead the game authoring activity. The theoretical, methodological framework and prospective are introduced in each of the project descriptions.

Research project 1: Digital game design in primary education

Game creation is a learning activity with multiple opportunities for the primary education curriculum, which could be exploited as an interdisciplinary project in history and geography (game contextualization), arts (game and characters design), first and second language (narrative, character development, scenario and dialogues…), mathematics (algebra, geometry …) and science (game items interactions, physics) (Romero & Barma, 2015). The game authoring platforms *Scratch* and *Ren'py* are specially adapted for introducing children to game development, which contributes to their digital literacy skills, their algorithmic, algebraic and geometrical mathematical knowledge; but also to the narrative development of the language curriculum by creating a scenario for the game and their characters (Robertson & Good, 2005). There are many studies in which children were engaged in collaborative game authoring in order to develop their creative and teamwork competences (Kangas, 2010; Kiili, Kiili, Ott, & Jönkkäri, 2012). Kafai (1996, p. 74) discuss the opportunities of the game creation learning activity that allows children to be placed "in a situation that requires them to design, plan, reflect, evaluate and modify their programs on a constant basis", which could contribute to "development of children's abilities to deal with complex tasks". Game creation and programming has been introduced as learning activities in many schools. For instance, *Hour of Code* was used to promote programming skills among K-12 children in the USA and www.code.org's tutorial "teaches basic coding principles through gameplay" (Computer Society Connection, 2013, p. 99). Little by little, these initiatives of informal education are becoming formal; in July 2013, UK has become the first country to integrate programming as an official objective of the primary education curriculum (Curtis, 2013). In order to successfully deploy digital game design for the primary education curriculum in Québec, I teamed up with Barma, a senior researcher with a strong field experience. We have recently applied for a funding to the Canadian Social Sciences and Humanities Research Council (SSHRC), since our goal is to develop strategies for the integration of digital game design in primary education (2017-2019). The project is based in a *Developmental Work Research* approach (Engeström, 2005) that facilitates social transformation through a theoretical framework based on the *activity theory* (Engeström, 2005; Jonassen & Rohrer-Murphy, 1999; Stahl, Cress, Law, & Ludvigsen, 2014; Timmis, 2014).

Research project 2: Intergenerational digital game design

The second research project aims to study digital game design as an intergenerational learning activity that would allow children and seniors to participate in a joint creation of a game. Seniors would act as narrative directors and while children would lead the game authoring activity. This project is developed in the context of the CRSH international partnership "Ageing + Communication + Technologies" (ACT, 2014-2021), where the Silver Gaming working group aims to study the different DGBL activities in later life. Engaging seniors in digital creation activities (Hyvönen et al. 2013; Uzor et al. 2012) is required if we aim to design games they really want to play and profit the benefits (Loos, 2014). *Participatory design of digital games* (Blat et al., 2012; Vanden Abeele & Van Rompaey, 2006) should allow them to engage in game creation activities instead of using games that have been designed for them by younger generations. The goal is not the game as a product, but the game as a creation process. We developed a first intergenerational game design experience last December in Québec, in which an older person shared his life narrative as an immigrant (and acting as narrative director during the whole process). There were also eight secondary level students (as game designers) and a pre-service secondary teacher (who acted as an instructional designer) who helped to link the senior's experiences with the curricular learning objectives of the curriculum (MELS, 2011). This pilot was based on an *intergenerational participatory design approach* (Newman & Hatton-Yeo, 2008) to promote an open discussion on the topic of migration and a guided interactive DGBL life narrative construction. The plans to move forward this initial pilot is the organization a summer school in August 2015 where a second pilot will be conducted. The Silver Gaming Intergenerational Summer School (#SGISS15) will be held next 20 and 21st August 2015. SGISS15will reunite elders and secondary level students in a creative game creation experience during two days. The summer school will also engage a group of researchers and graduate students working in the area of DGBL and active ageing (silver gaming) and teachers. Elders will be engaged in an intergenerational creative collaborative activity inviting them to create their own life narratives through the use of technology. Secondary students will collaborate with elders in the creation of their digital life narrative and learn from the elders' experience. Researchers and graduate students will support the intergenerational game creation experience and discuss the opportunities of intergenerational learning through game creation. Teachers will discuss the opportunities of transferring similar game creation experience in the classroom. Depending on the success of the SGISS15in terms of scientific and social impact, I will try to consolidate it as a yearly event.

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A Visualization Tool to Enhance Design-Based Research

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Abstract: When doing design-based research (DBR), keeping track of large amounts of data generated by a designed intervention. Visualizations are powerful means to represent large amounts of data in ways that show relationships between and within data and allow interesting patterns to emerge. This paper provides an overview of the Workflow Visualization System (WVS), a tool with the potential to support DBR and learning analytics research.

A significant challenge of design-based research is keeping track of the data and the relationships between and within large amounts of data generated in a "design experiment." Here I give an overview of the design and development a visualization system to support design-based research, with the functionality to also potentially support learning analytics research. The prototype Workflow Visualization System (WVS) is an add-on to the open source course management system Moodle and allows people who design units of instruction (i.e., a lesson, a workshop/seminar, a course - also called interventions) to create a drag-and-drop "sketch" of the intended workflow and associate data with each element of the intervention. For example, broadly speaking a "lesson" usually includes having students read a chapter or articles about a topic or concept and then applying what they read to solve a problem. Problems might involve more information presented on a webpage or video or other more specific readings, and they might involve students working individually or in a group to compare things, accept or reject an idea, or calculate a solution. Interventions have many dynamic parts and the WVS allows teachers and design-based researchers to see how all the parts are connected, see lesson resources (i.e., readings, videos, websites), and artifacts students create while working on the lesson as well as data about how students participate. They can use this data to make changes to improve lessons or as evidence for how/why a design or an implementation did or did not work.

Researchers who do design-based research are interested in developing theories that explain principles for successful teaching. This involves multiple iterations of adjusted designs. An accurate description of the design and changes across each iteration provides a level of "control" of the experiment because it accounts for the variables and the changes to the design. The WVS facilitates documentation by letting users associate resources and student produced artifacts to a workflow, and by letting users add annotations in pop-up boxes. It will also allow users to do statistical analyses of data of interest and visually display results. Researchers and teachers may also want to focus on particular elements of a design or how the performance of a particular individual or group changes when elements of the "intervention" change. The system will allow this through an interface that supports a wide range of queries. In summary, the Workflow Visualization System allows users to:

- create multi-level visualizations of a intervention (i.e., lesson)
- associate resources and data to individual elements of a lesson
- annotate individual elements of a lesson.
- keep track of changes made in lessons
- represent the results of statistical analyses
- isolate or compare particular kinds of data through a flexible query interface

Theoretical framework

The WVS is grounded in the ideas of *intermediate representation* and *information visualization principles* (i.e., Tufte.) Intermediate representations are either created during data collection or are derived from an initial *macro*-analysis of video records. Representations utilize textual and visual features and include: *content logs* (i.e., field notes that index data as it is collected); *table-based flow charts* that chronologically catalog group learning events and highlight significant events for deeper analysis; *descriptive diagrams* that illustrate participants' interrelations to one another and resources; and *conversation maps* that show the flow of discourse in a learning situation and help to identify patterns of differential responding to problem-solving proposals. Information visualization is "*the use of computer-supported, interactive, visual representations of abstract data in order to amplify cognition.*" Visualizations harness the perceptual capabilities of the human visual system and allow a viewer to (a) examine a large amount of data, (b) keep an overview of the whole while pursuing details, (c) keep track of many things by using the display as an external working memory, and (d) produce an abstract representation of a situation through the omission and recoding of information. Research on how humans visually process the world as we solve problems has led to design principles - macro/micro readings, layering and separating, use of color and small multiples - that help viewers gain insights into the information on display. A key problem for information visualization designers involves identifying *visual metaphors* for representing information and understanding the analysis tasks they support. Designers of visualizations tend to capitalize on metaphors that can give users a sense of intuitiveness and/or familiarity. From a user's point of view such a visualization is either easy to understand or easy to learn through interaction. The essential elements of interacting with graphically presented information are: 1) overview first; 2) zoom and filter; and then 3) details on demand. The all important function of an overview is to depict interrelationships among units of information. Information space metaphors are popular because they invite navigational operations such as zoom, pan, or rotate that allow users to understand information intuitively or understand it quickly through interactions with the visualization. A review of literature from business and applied science that described the evolution of workflows in both fields led us to identify characteristics and principles that make workflow representation an ideal visual metaphor for designed educational interventions. Finally, programmers utilized technologies from open source drawing, analytics, and database programs to develop a tool that would allow for the creation of workflows and the association of intervention data with elements of the workflow.

Methods

Broadly speaking this is a *design study* of a methodology and tool to help researchers do design studies of learning interventions applied to complex, dynamic, multi-dimensional classroom and online environments. The methodology and tool are also intended to facilitate sharing of interventions for adaptation and reuse by educators, or for collaboration among researchers. Initial phases of the study consisted of "proof of concept" and design and development cycles in which designs were created and vetted with a small group of researchers using *case study* methodologies. The online prototype Moodle interface tool was built through collaboration with the Custom Applications Group of the Division of Information Technology (DoIT) at the University of Wisconsin – Madison. (See a demonstration of the Moodle/WVS interface at https://workflow.ad.education.wisc.edu.)

Currently we are beta-testing the tool in three case studies – two (Hackbarth and Derry) involve creating workflows of Moodle interventions and one (Puntembekar) that is testing an interface between the WVS and a non-Moodle study. The Moodle studies will test the efficacy of the designed tool to accurately represent an intervention and inform design-based research. The non-Moodle study will test the portability of the WVS tool to studies that use a project specific database infrastructure.

Next steps

I am in the third year of a three year EXP grant for which the goal was to build and beta test a visualization tool and summarize its potential as a tool to support design-based research. The project is on track and the outlook is positive, not only as a tool for design-based research, but the WVS has also attracted a good deal of interest as a potential learning analytics tool. Next iterations of the design and development of the WVS potentially include: refinement of the query functionality to allow users greater flexibility to select and compare data within and across instances; improving the interface to increase portability to non-Moodle studies, including expanded methods for uploading data to the system from mobile sources, refining the lexicon and the visualizations, expanding the lexicon to include the ability to represent the elements of the design-based research study associated with an intervention's design (in addition to the design and iterations of the intervention,) and recruiting partners to test scalability of the tool. This will obviously require securing additional sources of funding.

Design, Adoption and Diffusion of Techno-Pedagogical Innovations for Fostering Collaborative Creativity and Criticality in 21st Century Learners

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Research interests and lines of inquiry

My primary research interests lie in the design, implementation and evaluation of techno-pedagogical innovations aimed at fostering 21st century literacies and learning dispositions in students. The learning innovations that I have worked on to date are predominantly in the domain of English and new media literacies. They are characterised by peer networked collaborative and dialogic learning principles that typically leverage on the affordances of contemporary digital tools. The 21C literacies and learning dispositions of particular interest to me are collective creativity and criticality, collaborative problem-solving and networked learning agility. In the most recent two years, the evaluation component of my research work has prompted me to delve deeper into the development of measures and learning analytics for analysing the aforementioned 21C literacies and dispositions. My secondary interests centre on identifying the enablers of, and impediments to, the wider adoption, engagement and diffusion of these technology-enriched learning innovations in formal schooling, particularly from the perspective of a critical stakeholder group—students. In addition to identifying significant predictors of students' use and engagement with learner-centred computer-supported collaborative learning initiatives, what particularly fascinates me is unearthing the 'hidden' cultural imperatives entrenched within the prevailing social order of schooling, and documenting the resultant pedagogical tensions that arise in the process of integrating contemporary digital learning innovations in mainstream teaching and learning practices.

Research projects

Digital kids, analogue students: A mixed methods study of student engagement with a school-based Web 2.0 learning innovation *(2007-2009, completed)*

My doctoral dissertation was based on this research project co-funded by the Centre for Learning Innovation and the Institute of Creative Industries at Queensland University of Technology, Australia. The project involved the design, implementation and evaluation of a student-generated, networked collaborative learning initiative, known as the Student Media Centre (SMC), which was incorporated into the curriculum of a long-established, well-resourced and high performing senior school in urban Australia over a period of two years. The SMC was designed to be a transdisciplinary whole-school learning initiative that aimed to engage students in self- and peer-regulated knowledge construction within an online social media environment, and in turn foster their collaborative, creative, information and ICT literacies. Apart from the learning design aspect of the study, a key focus of inquiry was to examine the adoption process and the constraints and affordances experienced by the students in engaging with such a learning initiative as part of their conventional schooling. Findings indicated that while students endorsed the usefulness of the SMC for enhancing multimodal engagement, extending peer networks and acquiring 21C real world skills, a number of social and cultural imperatives at play in the school militated against the realization of these design affordances in practice. Consequently, the SMC failed to achieve widespread uptake and engagement among students.

Key implications of the study suggested that the SMC's pedagogical design, while well-intentioned, contrasted starkly with the prevailing conventional teaching and learning mindsets and value propositions within the school (i.e., mastering curriculum content and achieving well in high stakes exams). To have more purchase, the SMC needed to be more closely aligned and integrated with the formal curricular and assessment mechanisms within the school. This was a postulation I hoped to empirically test in my ensuing research endeavors, e.g., is there and if so where lies the optimal balance between an incremental vs. disruptive learning innovation design that would yield both high student uptake/engagement *and* productive 21st century learning outcomes (beyond students' pursuit of high academic grades).

The pedagogical design of the SMC was informed by a multiliteracies pedagogical framework, connectivism and CSCL theories, in turn largely premised on Vygotskian socio-cultural and dialogic perspective of learning. The study employed a design-based research approach, buttressed by a mixed-methods two-phased sequential exploratory design, with data collected using a student self-report questionnaire and focus groups. Incremental predictive models of SMC engagement were conducted on quantitative data using non-parametric

Classification and Regression Tree, while ethnomethodology-inspired membership categorization analysis was applied to analysing the qualitative student focus group data.

Collective creativity and collaborative problem-solving among secondary school students *(2013-current)*

This was the first research project I undertook upon returning to academic educational research in late 2012 (after a 3 year break from academia immediately following the award of my doctorate in late 2009). It is funded by the Office of Education Research in NIE, and is part of the Assessment & Teaching of 21st Century Skills (ATC21S) international research program to develop a suite of online formative assessment tasks for collaborative problem-solving (CPS).

This study focused on extending the work of ATC21S by conceptualizing, developing and validating a discourse-analytic framework and coding scheme for measuring students' *collective creativity* (CC) in online CPS tasks. The project's dialogue-based approach to assessing CC learning processes and outcomes sits squarely within the field of CSCL, where the pedagogical premise is that knowledge and competencies are fostered through social interactions and dialogic negotiations. CC was conceptualised as encompassing a suite of metacognitive, cognitive and socio-communicative competencies, manifest in the interactions of student teams in their problem-solving process. The proposed CC framework and discourse-analytic coding scheme was applied to student teams' (N=153) online synchronous chat logs generated throughout their CPS process on two tasks. Results to date indicated favourable inter-coder reliability, and identified statistically significant differences in the dialogic features and patterns of successful and unsuccessful CPS student dyads. The study is now looking into translating the CC discourse-analytic framework and coding scheme into teacher and student learning resources that can be used to help foster students' CC competences, in online CPS tasks and beyond.

*Wi*READ: Enhancing students' 21C critical literacy skills through a web-based collaborative reading and learning analytics environment *(2014-current)*

My most recent project, funded by Singapore's National Research Foundation, reflects a consolidation of the preceding two studies. It focuses on the design, implementation and evaluation of WiREAD, a techno-pedagogical innovation aimed at enhancing secondary students' collaborative criticality in the literacy domain. Informed by a Multiliteracies pedagogical framework, WiREAD aims to blend the affordances of a web-based collaborative reading environment with meaningful learning analytics modules, in the hopes of enabling both teachers and students to monitor learning progress and adapt strategies that stimulate deep multimodal engagement and rich peer-to-peer interactions around texts. The implementation and adoption process will be documented to identify individual, technological and socio-institutional enablers and inhibitors to students' productive engagement with this CSCL innovation in formal schooling. The pedagogical and research design of this project is largely similar to the SMC with a few key distinctions:

1. While SMC was a transdisciplinary learning initiative that utilized non-core project work time, WiREAD is closely aligned with and integrated as part of the upper secondary English syllabus. It is designed to run parallel to and extend the formal English lessons, by allowing students to further the productive peer dialogues started in class (but did not have sufficient time for deep engagement from all students in the class) around critical deconstruction of multimodal visual, narrative and informational texts.
2. WiREAD is exploring the use of meaningful and timely learning analytics, as an integrated part of the collaborative reading environment, to provide pertinent formative feedback that can help students and teachers track critical reading progress (measured by type and quality of online dialogue) and engagement levels (measured by frequency and volume of use, and social learning networks patterns online), and potentially modify learning behaviors and pedagogical strategies to improve outcomes.
3. This is a 3-year design-based research study that comprises 3 trial cycles (one per year) with incremental cohorts of student participants to be involved in the study. It combines a quasi-experimental design with intervention/control groups and pre/post-tests to ascertain change in student learning outcomes of interest as a result of engaging with WiREAD.

Going forward, I hope to extend this line of work, but work at developing richer, more authentic and complex learning tasks and problems that articulate/align better with real-world disciplinary practices. I also hope to extend the research context and participant cohorts to include tertiary teaching and learning, not only in Singapore but also beyond through international research collaborations.

Doctoral Consotrium

Subjective Validity Ratings to Support Shared Knowledge Construction in CSCL

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Abstract: CSCL can be supported by providing information about the learning partners' cognitions fostering cognitive group awareness. My Ph.D. project comprises three empirical studies, which combine cognitive target information with its metacognitive evaluation. By adding a measure of subjective validity to objective validity, I intend to improve analyses and description methods of knowledge states, benefitting learners as well as researchers. Integrating metacognitive research traditions might bring an additional perspective to the research of group awareness in CSCL. Thus, the project takes into account that assessing and presenting (meta-)cognitive information may in itself alter learning processes. Research in individual and collaborative learning settings shall provide more insight in the mechanisms of how group awareness tools support learning.

Keywords: cognitive group awareness, metacognition

Background and goals

Research on CSCL has shown that it can be highly demanding for learners to structure their common learning processes. One approach offering rather implicit guidance is to provide learners with information about their learning partners' cognitions to foster (cognitive) group awareness, i.e. the salient perception of specific aspects of group members, e.g., knowledge, hypotheses or opinions (Bodemer & Dehler, 2011). Carefully designed cognitive Group Awareness Tools (cGATs) provide learners with such information, thereby supporting them in their efforts to efficiently model and control group processes (Chavez & Romero, 2012).

Engelmann and colleagues (Engelmann, Dehler, Bodemer, & Buder, 2009) differentiate tools that primarily present content information from those that primarily deliver contextual cues. Content information may be used to contrast opposing views and opinions. Such conflicts can facilitate learning processes by encouraging learners to elaborate their points of view and come to a joint solution (Johnson & Johnson, 2009). By contrast, context-based tools provide primarily information about the learning partners' knowledge (but not its content). This usually requires the learners to explicitly evaluate their knowledge, resulting in subjective measures. These are ultimately authentic and can be useful to detect individual needs for clarification (Engelmann et al., 2009). Accordingly, Dehler and colleagues (Dehler, Bodemer, Buder, & Hesse, 2011) found that uneven distributions of (perceived) knowledge can encourage learners to ask questions or give spontaneous explanations. However, the success of using subjective evaluations of knowledge to control learning processes highly depends on the learners' individual skills to accurately monitor their learning (e.g., Dunlosky & Rawson, 2012). Even though metacognitive monitoring and control of learning processes are seen as a motor for regulating learning (e.g., Winne & Hadwin, 1998), the impact of providing metacognitive in addition to cognitive information in group awareness research to combine the benefits of both methods has not been studied systematically. My Ph.D. project shall close this gap drawing on information gathered from both CSCL research on group awareness as well as research on metacognition.

The overarching goal of my Ph.D. is to enhance cGATs by combining – possibly exceeding – the benefits of providing metacognitive context information and cognitive content information. By merging two distinct research fields, it also aims at improving the ways to analyse and describe individual and collaborative knowledge states by adding a measure of subjective validity (confidence) to objective validity (correctness). By asking learners to evaluate their own hypotheses and integrating this information in the cGAT, the tool should be able to convey a more accurate picture of the learning partners' knowledge. Drawing methodologically from two research traditions, I mix individual and collaborative studies to disentangle the effects of displaying partner information via cGATs from those of individually assessing the information in the first place.

Empirical studies

My first Ph.D.-study was conducted in an individual, computer-based setting and targeted the impact assessing and visualising metacognitive information have on individual learning processes. 92 participants were randomly assigned to one of three experimental conditions. After studying a text on blood sugar regulation and answering learning tasks, only two groups were asked to provide confidence ratings for each answer; cf. figure 1 (left). In a second learning phase, all participants were presented with their answers and were able to demand additional information (designed to foster correct solutions) on each learning task, but only learners in one group were further presented with their confidence ratings. Amongst others, results show that learners who provided confidence ratings requested more information. Furthermore, participants who had their ratings available during learning seemed to use them to guide their search for information. These participants were also more confident in their answers after learning, followed by those who merely provided the ratings. All groups scored equally high in a knowledge-post-test. In conclusion, even merely assessing metacognitive judgments may alter learning processes, but if available during learning, learners use those judgments to clear up uncertainties.

The second study will largely resemble the first. However, the second learning phase will be replaced by a collaborative scenario with two learners discussing the tasks face-to-face on a multi-touch table. The aim is to research the impact providing learners with metacognitive in addition to cognitive partner information (cf. fig. 1, right) has on learning processes and outcomes. The implementation was already tested in a Master's Thesis, its results will be available in June. A third study will focus on further improving the cGAT.

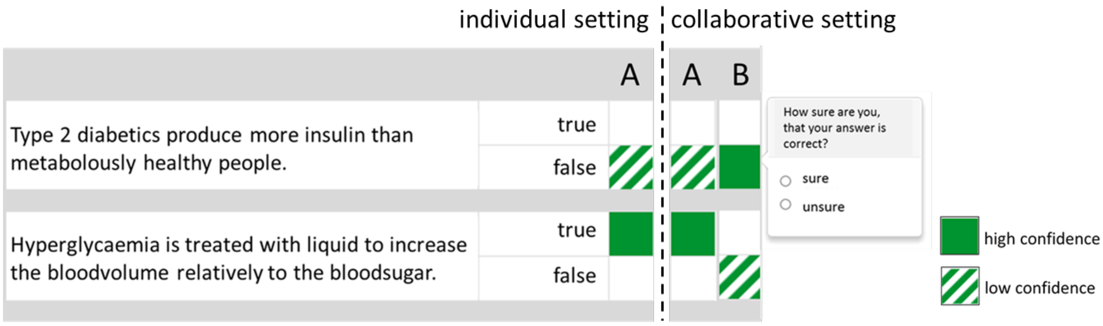

Figure 1. Tasks with metacognitive awareness information in individual (left) and collaborative setting (right)

Issues to discuss

First and foremost, I would like feedback on my work and discuss the implications the mix of methods and scenarios has on the project. My first study was conducted in an individual setting and is deeply rooted in metacognitive research. However, the other studies will be clearly grounded in the CSCL context. While this procedure contributes to understanding how effects of cGATs are composed, it still raises the question of how best to separate these components (statistically or by design). Merging two distinct research fields is a great asset of my work, but also a great challenge. I expect to profit a lot from coming together with peers and experts to discuss methodological-statistical issues (e.g., how best to analyse video data in conjunction with trace data or the combination of subjective and objective validity measures) and to incorporate the results in my future work. Furthermore, I can bring some distinct experiences myself and thereby contribute to other CSCL-related issues.

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An Innovative Approach to Promoting Anonymous Argumentation in Science: Introducing the Double-Blind-Review Process to Middle School Students

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Abstract: Engaging in effective argumentation fosters critical thinking skills. However, the unfavorable effects of interpersonal factors associated with peer critique make argumentation challenging for young students. As a proposed solution, I have designed a collaborative argumentation tool called the *4R Approach*. This tool simulates the double-blind review process, thereby relieving the social pressures associated with being identifiable. A quasi-experimental design consisting of control and intervention groups is used to study the efficacy of this tool.

Keywords: argumentation, peer review, collaborative tool

Introduction

Argumentation is widely recognized as central to achieving scientific literacy and developing critical thinking skills. Centered on a constructed explanation, argumentation is a collaborative activity where explanations are evaluated for coherency, plausibility and comprehensiveness (Osborne & Patterson, 2011). As a result of this process, the product of argumentation is a robust explanation. However, students face numerous challenges during argumentation such as during the process of receiving and providing critique. Factors such as race, gender, and inter-person dynamics negatively impact the process of critiquing (Lu & Bol, 2007). Additionally, a lack of detachment of the individual from their contribution hampers the process of critiquing, particularly for females and minority students facing negative stereotypes about their intellectual capacities (Cohen, Steele & Ross, 1999).

To promote effective critiquing, researchers have suggested the use of anonymous systems in classrooms. Many such systems are widely used by professionals, such as the double-blind review system that is widespread in academia. As a solution to promoting effective critiquing, my research explores if employing the double-blind review during argumentation could help in the construction of robust explanations by students.

Background of the project

The *4R Approach (*4R: Respond, Review, Revise, Reflect) is a novel design incorporating the features of anonymity by simulating the double-blind-review process. I designed and progressively refined the *4R Approach* through testing and piloting in classrooms over the course of one year.

The *4R Approach* is used as CSCL argumentation tool within a curriculum. During the 4R Approach, students are presented with information followed by a question. Each student responds to the question by using the information to construct a written explanation. Once all the students have submitted their explanations, the online system anonymously assigns one reviewer for each explanation. Guidelines for review are provided to scaffold the process of reviewing. After the review is submitted, I assume the role of an editor and use the peer review to provide the author with guidelines for revision. Next, each author reads the peer and editor's review and uses it to revise and resubmit their explanation. Lastly, students engage in self-reflection on their peer reviewing skills. Here, each student revisits the review that they gave and reflects on how they can improve their reviewing skills. By engaging in argumentation through the 4R Approach, students' collaboratively work to evaluate others explanations, and revise their own explanation to make them robust.

Research questions

The research questions addressed in this work are:

1. Did students participating in the 4R Approach demonstrate learning gains that were different from students that did not participate in the 4R Approach?
2. What patterns and characteristics are observed in students' written products generated during the 4R Approach?
3. How do students describe their learning experience pertaining to the 4R Approach?

Methods
Data includes pre/post assessments, demographic information, data from the 4R Approach activity, and student interviews.

Student and school sample
There are 450 middle school students participating from five schools located in the southern, mid-western and eastern states of the U.S.A. The schools are located in rural, urban and suburban areas. The control group consists of 230 students while the intervention group has 220 students.

Analysis
Multiple linear regression analysis is employed to study the score differences for the control and intervention groups at various time points

For analyzing the patterns and characteristics of the *4R Approach* artifacts (research question 2), an inductive approach is employed, condensing raw data into categories based on common characteristics. This approach uses the constant comparative method. Additionally, deductive reasoning is also employed, generating categories and codes from existing literature.

Capturing students' learning experience (research question 3), utilizes purposeful sampling of twenty students. Sampling is based on demonstration of varied levels of growth in development and critique of arguments. Semi-structured interviews are conducted with the participants and a set of codes is inductively developed from the data.

Findings
Preliminary findings are promising. Findings suggest that when compared to the control group, students in the intervention group show significant improvements in the quality of the explanation by the posttest time point.

Analysis of the artifacts produced during the 4R Approach reveal findings in agreement with research on challenges associated with construction of explanations, such as quality of evidence and appropriate reasoning. Peer feedback, reveals interesting trends that indicate that students most often provide effective feedback with respect to relevant evidence, but are less likely to provide feedback on appropriate reasoning. Additionally, I observed that over time, self-reflection on reviewing skills became more detailed.

Interviews on student perspectives revealed that they considered participation in the 4R Approach helpful in learning science and considered it as an authentic activity undertaken by scientists and other professionals. Students also provided examples of how they could use the 4R Approach in other disciplines, such as history and mathematics. Additionally, some students drew parallels between the 4R approach and non-academic activities such as rehearsing a song.

Conclusions and implications
My research will be the first study that examines scientific argumentation through written discourse for middle school students. The feature of anonymity will provide useful insights on ways to promote effective written argumentation. Additionally, by simulating the widely accepted process of peer reviewing, the 4R Approach will provide an opportunity for students to learn disciplinary language and participate in peer reviewing practices of professionals.

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Adaptive Support for Face-to-Face Collaborative Learning at Tabletop Computers

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Abstract: While collaborative learning has demonstrated benefits, students do not always know how to collaborate effectively, preventing them from realizing those benefits. Collaborative learning environments that can detect problems and adapt to the needs of the group can provide just-in-time support to scaffold students toward effective collaboration. In my research, I am exploring ways to provide this kind of adaptive support in interactive tabletop environments.

Keywords: modeling collaboration, tabletop computers, adaptive support

Research goals

Researchers and designers of educational technology have long sought to create personalized learning environments that can provide targeted, just-in-time support to learners (Lonchamp, 2010; Martinez, Collins, Kay, & Yacef, 2011). Collaborative learning environments represent a particular challenge in personalization, as they must take into account interactions between multiple learners. While much has been done to bring adaptive support to asynchronous, text-based online collaborative learning environments, face-to-face collaborative learning environments such as tabletop computers bring further challenges, as much of the learning takes place in the verbal interactions between group members that are invisible to the computer.

The process of collaborative learning is complex and many factors contribute to learning outcomes. The effectiveness of the group learning experience can be influenced by the personalities and motivations of individual students, their background knowledge, and the nature of the task. Students do not always know how to collaborate in a manner that is productive and conducive to learning for all members (Rogat & Linnenbrink-Garcia, 2011). In the classroom, the teacher will often circulate among groups, but she can only visit one group at a time, meaning that struggling groups may not receive the help they need in a timely manner. Tabletop software that can adapt to a group's collaboration needs and abilities in real-time could prove useful in scaffolding collaboration while the teacher spends time with other groups.

Social regulation, "the social processes groups use to regulate their joint work on a task" (Rogat & Linnenbrink-Garcia, 2011), is a key concept in this work. Rogat and Linnenbrink-Garcia (2011) showed the quality of social regulation processes to be very important to small group collaboration.

The goals of this work are 1) to uncover what physical interactions with a tabletop computer reveal about the social regulation processes taking place above the table; and 2) to develop tabletop software that can adapt to scaffold effective social regulation.

Methodology and preliminary results

To date, a lab study and two field studies have been conducted. The purpose of the lab study (Evans & Wobbrock, 2014) was to identify patterns of touch interactions that were associated with high- and low-quality social regulation. In the lab study, small groups of adults worked on a poetry analysis task on a tabletop computer. The videos of their discussions were coded for social regulation processes and quality and the computer's log files were studied for interaction patterns that frequently occurred alongside particular codes from the video. A set of interaction patterns were found to indicate quality of *content monitoring* – a social regulation process characterized by effort to evaluate and further the group's understanding of task content (Rogat & Linnenbrink-Garcia, 2011).

The field studies were conducted in classrooms with high school students in two different subject areas – science inquiry and informatics. In the field studies, the patterns identified in the lab study were tested and refined in a different context and the technical challenge of distinguishing between individual users at a tabletop was addressed, enabling real time detection of the interaction patterns associated with social regulation processes.

The next phase of this work is to design and evaluate interface adaptations that will be triggered when the tabletop detects interaction patterns associated with low-quality content monitoring. The designs will be evaluated in a secondary classroom with students working on a science inquiry curriculum for a number of weeks. As with the preliminary work, groups' sessions at the tabletop will be video recorded and coded for social regulation processes. There will also be a qualitative measure of the students' experiences and perceptions of the system.

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Supporting Wiki-Based Knowledge Exchange Processes

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Abstract: Complex knowledge exchange processes in collaborative knowledge building settings within Wikis can be either supported by providing guidance in form of cognitive group awareness information or by explicitly guiding learners with collaboration scripts. My Ph.D. project comprises a series of three experimental studies to determine which kind of support is most beneficial for varying types of learners working with Wikis. For this research different fields of CSCL are integrated and both quantitative and qualitative methods are applied to provide comprehensive analyses in order to provide opportunities for other related research. Presenting and discussing aspects of my research and first results could be beneficial for my future research.

Keywords: wiki, cognitive group awareness, guidance, knowledge building

Background

Due to the structures of common Wikis (e.g. Wikipedia using MediaWiki), collaborative knowledge building within such environments especially focused on knowledge exchange via article talk pages as a basis for discussions can be a challenging task for participants. This Ph.D. project's overarching goals are (1) to quantitatively and qualitatively analyse knowledge exchange processes in Wikis used in educational contexts, (2) to analyse and support communication processes between authors and editors beneficially for learning, and (3) to develop and evaluate Wiki modifications for more effective and efficient collaboration and learning by structuring relevant aspects of collaborative knowledge building.

Knowledge building can be defined as the creation of knowledge as a social product (Scardamalia & Bereiter, 1994). A significant amount of research has been conducted on how knowledge building and in consequence learning processes can be backed by computer-supported collaborative learning (CSCL) environments like online discussion forums, blogs or Wikis. Collaborative knowledge building can lead to controversies and furthermore to socio-cognitive conflicts. Such conflicts arising from contradictory information do not have to be detrimental for learning (Mugny & Doise, 1978).

Supportive measures for dealing with conflicts that have proven to be effective for learners in CSCL in different contexts range from implementations of implicit guidance approaches, e.g. implementation of cognitive group awareness tools (Janssen & Bodemer, 2013), to more explicit instructional methods, e.g. instructional designs through collaboration scripts (Dillenbourg, 2002). Wikis differ fundamentally from "classic" online discussion forums that have been analysed more extensively because of its two layer distinction of article view and the corresponding discussions. However, little research has been conducted specifically on those Wiki article talks as a layer for knowledge exchange.

Therefore, it is of particular interest how participants in informal Wiki learning settings can be further supported with implicit and/or explicit guiding aids to benefit from socio-cognitive conflicts arising from controversies that are led by opposing evidences. In addition to that, my doctoral research covers the influences of specific cognitive and personality constructs that can be relevant for learning processes. These constructs are an individual's (1) need for cognitive closure and (2) epistemic curiosity that both are potential mediators for successful learning and should be considered for further implementations and design recommendations.

For this Ph.D. project a number of three experimental studies have been planned to analyse support mechanisms for different types of learners in CSCL settings. In the first study, an implicit structuring aid as cognitive group awareness tool was implemented to support learners to focus on relevant evidence-led controversies rather than onto non-contentual discussions (Heimbuch & Bodemer, 2014). In a second study, that has to be analysed in detail yet, I was particularly interested in the comparison of two different collaboration script approaches (Heimbuch, Uhde, & Bodemer, 2014).

Experimental scenario

All experimental studies implement varying degrees and types of learners support (implicit vs. explicit vs. combined guidance), focussed on informal learning via conflicting information provided on Wiki talk pages. Learning materials are differing in topics (e.g. mass extinction of dinosaurs, pirate personalities etc.). As an important common ground all studies comprise content-related controversies that are led by evidence, i.e. relevant research, rather than personal opinions.

For the first study, a single independent factor with three levels was randomly varied across the study. The three experimental groups reflect differing implicit structuring degrees of additionally implemented cognitive group awareness support on controversy information for a number of 24 Wiki talk page discussions. Study participants in the two supported conditions were primarily focussed on meaningful and relevant discussions in order to complete the task of editing a basic Wiki article by themselves. A total of 81 university students (58 females and 23 males), aged 18-30 ($M = 27.70$, $SD = 2.76$), were randomly assigned to the three experimental groups.

First study

In either of the guidance groups (*G2* / G*3*), students preferred to select and read the most relevant topics containing evidence-led conflicting discussions at first. In contrast, participants without additional guidance (*G1*) showed the tendency to follow a less focussed top-down reading strategy. This first look at most frequent closed sequential patterns indicates that guidance towards the potentially most relevant discussions of interest worked as intended in both guidance groups. These results are further supported by reviewing the students' topic clicking behaviours. A corresponding analysis of variance revealed that in *G1* significantly more topics on the article's talk page were selected, compared to both supported conditions *G2* / *G3* ($F(2,78) = 3.80$, $p = .027$, $\eta^2 = .09$), indicating a more focussed selection and reading behaviour by providing implicit guidance. Further analysis of variance on the learning success, measured by a multiple-choice knowledge test, could not reveal any overall differences between the three investigated groups, $F(2,78) = 0.03$, $p = .968$, $\eta^2 < .01$. More detailed analyses of the knowledge test scores between all groups revealed, considering different categories of discussion types as mediators in a parallel multiple single-step mediation, students receiving more implicit guidance ($G3 > G2$) and spending more time on reading unsolved controversies scored significantly higher in the multiple choice test.

Overall, these results indicate that structuring Wiki talk pages by implementing cognitive group awareness representations related to socio-cognitive conflicts produced promising results in terms of focussing readers' attention towards relevant. Furthermore, the results demonstrate that implicitly guiding readers towards relevant evidence-led discussions containing opposing points of view leads to measurably higher learning success.

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Learning Technologies for Vocational Education and Training

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Goals of the research

Integrating learning technologies into classroom for Vocational Education and Training (VET) is the general goal of my PhD research. Vocational education is of great importance to the labor market in Switzerland as two thirds of teenagers enter VET programs. VET provides them with solid foundations in a given occupation, forms the basis for lifelong learning, and opens up a wealth of job prospects. VET in Switzerland is based on the dual-track approach: one day of classroom instruction at a VET school combined with four days of apprenticeship at a host company. Apprentices develop professional competences and skills at their workplace, while classroom instruction covers general knowledge and theoretical principles needed to perform their occupational tasks. Even though this approach seems to be pedagogically powerful, different specifications and constraints of the two learning contexts introduce major concerns about integrating different forms of knowledge acquired in the two contexts (Schaap, Baartman, & de Bruijn, 2012), which can leads to gaps between practical skills and theoretical knowledge.

In my research, one goal is to bridge this gap between school and workplace learning contexts through computer technologies and digital spaces. Collaborative learning scenarios need to be developed, in which apprentices capture workplace experiences (e.g. by photos, videos, sketches, etc.), bring them to school and perform scaffolded reflective activities which build-up connections between workplace activities and theoretical knowledge.

Despite all the research on learning technologies in recent years, their implementation in authentic classrooms is still scarce (Roschelle, Rafanan, Estrella, Nussbaum, & Claro, 2010). Teachers fail in adapting many research-based learning technologies either because they often introduce too much complexity or require too much time, or are not flexible enough in the unpredictable world of the classroom. Moreover, pedagogical scenarios often consist of a continuum of activities occurring at different social levels (individual, group, and class) and are distributed over multiple artifacts. Enactment of such complex scripts can place a heavy load on teachers. Therefore, for a learning technology to be effective in classrooms it is necessary to support teachers with tools for real time management of multi-layered activities in the multi-constrained classroom context. This is referred to as classroom orchestration (Dillenbourg, 2013).

Another goal of my PhD research is to investigate orchestration requirements for integrating our proposed technologies in vocational classrooms and to provide teacher with appropriate tools empowering him/her to control the activity flow on the fly.

Background of the project

My PhD is part of DUAL-T project (http://dualt.epfl.ch), which explores learning activities relevant to the dual contexts of vocational education in Switzerland. TinkerLamp and TapaCarp are two examples of Dual-T previous research projects. TinkerLamp is an augmented reality tabletop system designed to teach logistics to apprentices by allowing them to build warehouses and evaluate them through running simulations (Zufferey, Jermann, Lucchi, & Dillenbourg, 2009). This system is successfully integrated and being used in several logistics classrooms in Switzerland.

TapaCarp is a tangible user interface (TUI) system for improving spatial visualization skills of carpentry apprentices (Cuendet, 2013). TapaCarp is a TUI tabletop system and the user interaction with it is through manipulating wooden blocks equipped with fiducial markers which the system can accurately detect and track. Cuendet has conducted several user studies in authentic settings showing that TapaCarp and the learning activities implemented on it can be useful for training spatial skills. However, in all these studies, the task flow was managed by one or several researchers, with no or marginal contribution of the teacher. To make our technologies widely available, it is necessary to study and provide support for teachers to implement VET technologies.

Methodology

My research is based on design-based research method that relies on iterative prototyping-testing cycles. Prototyping is done in collaboration with teachers and empirical studies are conducted in classrooms to check if there is a learning gain from the activity (pre-test, post-test assessment), to study collaboration patterns, and to understand how teachers orchestrate the classroom and what the orchestration difficulties are.

Current status

The DUAL-T development team has recently been developing an online platform that allows apprentices to upload, share, annotate and comment on digital material from their various learning places. Moreover, the platform enables teachers to create activities, monitor students' submissions, evaluate their work or send them feedbacks. Shared resources on the platform can also serve as supplementary teaching materials for the teacher.

This online platform provides an infrastructure for developing links between workplace and theoretical schools experiences. However, learning scenarios for each profession should be designed in collaboration with field's experts. In my research, I am focusing on the carpentry profession for which I designed several learning activities that include capturing workplace experiences, linking them with theoretical knowledge and performing individual or collaborative activities in class, directly on workplace experiences or on a simplified models.

Currently I am conducting meetings with carpentry teachers in order to validate and refine the scenarios. Observing several carpentry classes in VET schools to acquire a better image of the classroom settings, teaching practice and orchestration requirements are also the work in progress.

Preliminary results of pilot work

Extending TapaCarp activities and bringing them into carpentry classes is one of the goals of my research. However, the high hardware and maintenance costs of TapaCarp is one issue preventing it to be widely used at schools. eTapaCarp is a web-based version of TapaCarp and if the user experience with it shows to be satisfying, it can be a low-cost replacement for TapaCarp. In addition the web-based version could be integrated into the online platform just described. To compare user performance in these two versions of the system, I conducted a user study. In this study, I took advantage of eye-tracking data to get a more detailed insight on user interaction with the systems. According to the results, there was no significant difference in performance accuracy and speed between the two versions. This encourages further developments and usability tests on the online version.

Open issues

There are several questions I would like to discuss at the workshop, such as:

- How can the workplace experience being captured and exploited in school?
- What criteria's should be considered in designing learning scenarios?
- What criteria should be consider for evaluating the effectiveness of learning scenarios?
- How can we increase apprentices' motivation for using the online learning platform?
- How can we automatically evaluate apprentices' participation on the online learning platform (e.g. auto-evaluate resources being shared, discussions, etc.)?
- What kind of feedback should be provided to teachers to increase their awareness of the class and support decision making?
- What kind of feedback should be provided to the students about their performance?

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Potentials of Text Mining based Technologies for Improving Cognitive Group Awareness

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Abstract: CSCL can be supported by Cognitive Group Awareness Tools, since they visualize learners' different knowledge and thereby stimulate them to independently initiate and structure discussions. Furthermore, text mining allows for capturing knowledge in a (semi-) automated manner from written text. Although not yet established in educational context, it appears to be very efficient to equip a Cognitive Group Awareness Tool with text mining methods. My Ph.D. project aims to design and evaluate such a tool: the Grouping and Representation Tool (GRT). Results of the first study indicate that the GRT not only increases knowledge acquisition, but also students' exchange of concepts while discussing.

Keywords: cognitive group awareness, graphical representation, text mining

Background of the project

Teachers face challenging requirements for supporting their students in collaborative learning. They need to know what criteria to use to form groups or how to structure learning activities. Additionally, they often have to gather context information on which the aforementioned decisions can be based on. Cognitive Group Awareness Tools implicitly structure collaborative learning and motivate students at the same time. They do not only stimulate learners to initiate and independently structure discussions (e.g., Bromme, Hesse, & Spada, 2005), but also trigger elaboration processes, providing that discussants' knowledge is different from each other's (Bodemer & Buder, 2006). However, there still is the disadvantage that context information (e.g., about learners' knowledge) needs to be provided by the students or teachers. Text mining methods can capture such knowledge information from written text in largely automated manner and thus remove the disadvantage of subjectivity. Furthermore, they increase teachers' efficiency in forming groups and preparing graphical representations with awareness information, since they deliver values on which heterogeneous group formation and visualizations can be based on. Consequently, my Ph.D. project is motivated by the idea to combine the advantages of Cognitive Group Awareness Tools with the potentials of text mining.

The first study was conducted to examine an overall effect of the GRT. Research suggested that discussions increase the exchange of concepts between learners (Hatano & Inagaki, 1997), whereby the exchange of knowledge further improves learning outcomes (Nickerson, 1999), especially if students' knowledge is heterogeneous (Williams & Tolmie, 2000). Furthermore, providing feedback on differences in knowledge usually guides learning partners to discuss unshared knowledge (Schittekatte & Van Hiel, 1996) and motivates them to fill their knowledge gaps by discussing topics that only one discussant is familiar with (Sangin, Molinari, Nüssli, & Dillenbourg, 2011). Thus, I hypothesize that the use of the GRT that matches learners who have different knowledge in a domain and feeds back graphical representations to them (1) leads to better learning outcomes and (2) facilitates students to discuss unfamiliar topics with their partners resulting in higher topical similarities between them.

Methods

The GRT provides two main functions: the preparation of knowledge information that serves as basis for transforming qualitative data into quantitative data (function 1), and the application of group formation and visualization mechanisms (function 2). In function 1, text mining method Latent Dirichlet Allocation serves for capturing topics from a text corpus (function 1a) and a Vector Space Model expanded by Euclidian distance measure is used to determine the knowledge distance between all texts included in the corpus (function 1b). As a result of function 1a, the GRT returns concept clusters that are interpretable as topics and quantitative values on the extent of how intensively these topics are debated in each text. These topics and topic values serve as data basis for visualizing (function 2a) identified topics (listed as text) and each student's topic values (displayed as bars). The calculation of function 1b results in a text-text-matrix serving as data basis for group formation (function 2b). To group partners with the highest possible knowledge distance, this matrix is scanned for its highest value in an iterative process and the two learners who are authors of the respective texts will be matched to a dyad, resulting in a jointly graphical representation as you can see one in figure 1.

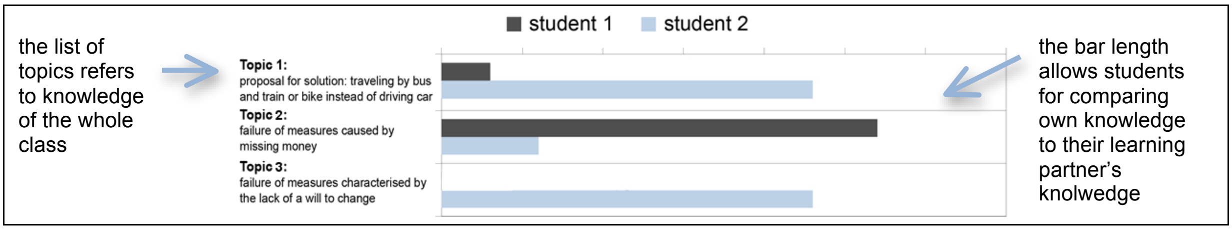

Figure 1. Example of graphical representation with explanations

The GRT's impact on learning outcomes was tested in a 2x2 mixed factorial design with group membership as between-subject factor (GRT vs. No-GRT) and time of measurement (T1 vs. T2) as within-subject factor. As dependent variables the sum of topic values per text and Euclidian distance were calculated. The sample consisted of 54 high school students, who were randomly assigned to two groups. They were given the assignment to reflect on *global warming* and had to individually write an essay on natural and man-made causes. Members of the control group were paired into 14 dyads by random. GRT-group members were matched by the tool due to knowledge differences and endowed with graphical representations. Subsequently they were instructed to discuss their essay with their learning partner. Finally, they could revise their text.

Results, current status and further issues

My first study shows the impact of the GRT on learning outcomes: Students added twice as many relevant concepts during an optional essay revision if they used the tool during their collaboration. Moreover, knowledge distance between learning partners has been further reduced in the experimental group suggesting a more intensive exchange of concepts between students compared to the control group. However, the experimental scenario involved the acceptance of some confounding and open issues that require further investigations:

1. In contrast to the original intention, knowledge distances between students were not significantly higher in the experimental than in the control group. An effect of group formation on learning failed to be confirmed. Nevertheless, there was a relation between Euclidian distance and sum of topic value.
2. The graphical representation allows two-dimensional comparisons: The topic lists represent a qualitative (it informs on topics that are relevant to the class), the bars a quantitative dimension (longer or shorter bars inform learners, if their learning partners know more or less than they).

Further research will experimentally investigate the potential of each dimension to clarify their impact on structuring processes (qualitative analyses) and learning results (quantitative analyses). It will also be investigated which knowledge distribution are best suited for supporting students to compare to others, taking the present confounding between group formation and feedback of graphical representations into account.

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Tangible Interfaces for Developing Statics Skills

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Abstract: The fundamentals of statics are a well-known part of the STEM curricula, but it is also crucial for many crafts, such as carpentry, metal works or construction workers, although the required mastery is supposed to be mostly qualitative. This presents a challenge for teachers to translate physics equations and abstract concepts to concrete workplace situations. The goal of this PhD thesis is to design a tangible educational environment for developing statics reasoning skills, targeted to vocational education and training (VET) of Swiss carpentry apprentices but also applicable to other crafts and educational stages.

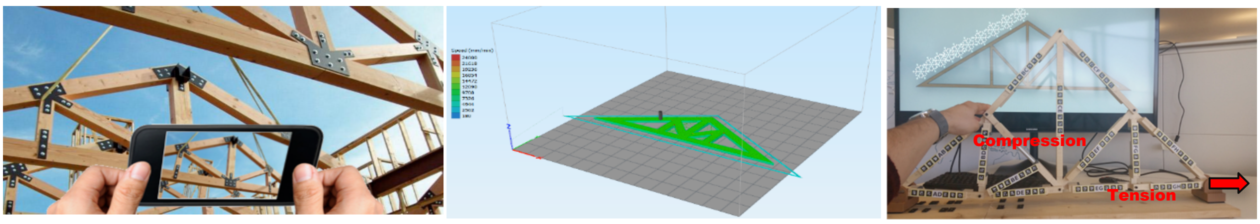
Keywords: tangible user interface, vocational learning and training, statics

Background of the project

In Switzerland and in several other European countries, the common approach to carpentry training is the dual track. The peculiarity of this approach lies in the synergy between the workplaces and vocational schools. Apprentices usually work four days at a company and acquire the practical know-how; during the remaining days, they learn theory and the general principles at a vocational school. Although it is claimed that the system matches the labor market requests for high professional training, some issues, referred as "skills gap" (Motta, Boldrini & Cattaneo, 2012), arise in bringing together these two learning contexts. Carpenters are not required to learn the mathematical frameworks of statics but they must have a qualitative understanding for two reasons: working safely and performing tasks involving small structural changes. However, apprentices rarely get to practice their statics skills while working. Tangible interfaces have been successfully applied in VET for bridging the skill gaps (Cuendet, Bumbacher & Dillenbourg, 2012, Zufferey, Jermann & Dillenbourg, 2008). These studies suggest that tangibles are effective to connect theoretical knowledge with practical examples, bringing into the classroom the physicality and concreteness that, indeed, is a fundamental feature of the craft. Moreover, a tangible interface should provide a wider interaction area compared to a graphical user interface (GUI), which supports scripting collaborative activities and classroom orchestration (Do-Lenh, Jermann, Legge, Zufferey & Dillenbourg, 2012).

Goals of the research

The current PhD plan consists of the development of a learning scenario composed of three stages of interaction.



(a) (b) (c)

Figure 1. Learning scenario: (a) Capture workplace experience, (b) Make the tangible interface, (c) Explore the tangible model through augmented reality

a. The apprentice collects real life examples of statics in the workplace in form of pictures. This will create an opportunity to frame the theory in the daily practice.
b. She/He builds (or partially 3D prints) the tangible interface. Currently, some vocational schools use off-the-shelf construction kits. However, interviews with vocational teachers revealed some issues related to the use of commercial kits: a) usually kits allow a discrete set of combinations and they take time to be assembled; b) these kits are made out of plastic or metal: materials that carpentry students recognize as "foreign" to their profession. Consequently, wooden structures can be built and augmented with parts printed using filaments that resemble wood.

c. Using augmented reality through PCs or tablets allow exploring the statics by running simulations of possible scenarios, such as snow or wind acting on a roof. The implementation aims to gamify the learning task and to stimulate the apprentice to discover possible scenarios that could happens on the construction sites.

Methodology

In the context of this project, Design-Based Research (DBR) seems an appropriate approach due to the complexity of statics and the carpentry field, which require the participation of teachers and apprentices. Unfortunately, given the short available time at school, interventions cannot be run often and they needs to be carefully scheduled. Therefore, gathering valuable data from such interventions is essential. In addition to the data coming from the manipulation of the interface and the results of semi-structured interviews, the eye-tracking methodology will be employed for studying the effect of different design choices on the students' experience. The application of gaze analysis is quite novel in tangible interaction studies, although it is promising, as found in our pilot study which it revealed some behavioral differences among the participants while using either tangible interface or a graphical one (Lucignano, Cuendet, Schwendimann, Shirvani Boroujeni, Dehler & Dillenbourg, 2014).

Current status

A prototype of a tangible interface and a preliminary experiment have been designed to assess the level of reasoning about statics of carpentry apprentices. The interface is designed to show expansion and compression when a force is applied to a structure (Figure 1.c). The experiment has a 2x2 between-subjects design, with one variable for expertise (novice or experts) and other for the interface (static or dynamic). The task consists of seven trials in which the participant identifies the kind of uniaxial stress the beams of a structure are subjected to while a force is applied. The primary goal of this experiment is to compare the reasoning strategies of apprentices compared to the strategies of experts, such as master carpenters or structural engineers. In particular, the comparison will focus on the analysis of the think-aloud data and mobile eye-tracking data in order to discover similarities or differences in the way of solving sets of statics problems.

The comparison between the interfaces aims at verifying the effectiveness of the physical model providing feedback as a learning tool: in the dynamic condition, after giving an answer for a trial, the participant can explore the model and its reaction to different forces; in the static condition, the model cannot be explored, it does not react to applied pressure and the participant receives only the verbal feedback from the experimenter. Our hypothesis is that tangible exploration leads to a learning effect and better problem solving strategies.

Open issues

The proposed plan describes a context-based learning approach that aims to teach statics by linking to real-life scenarios. One possible drawback of this approach could be that the students might not be able to transfer their statics reasoning skills from one example to another. Another issue concerns the evaluation of qualitative understanding of the students. Currently, teachers do not implement statics exercises to assess the performances of apprentices due to the involved mathematics. The question is whether or not a tangible interface can be used as assessment tool and how to validate this approach.

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Towards a Theoretical Model to Design and Evaluate Blended Learning Environments in Adult Education

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Abstract: The present project focuses on the (re)design of blended learning environments (BLEs). As an important part of this BLE, online computer-supported collaborative learning (CSCL) tasks will be designed and implemented. The aim of this project is to study (a) how to design learning activities in online collaborative communities, (b) how to scaffold the regulation of learning in online collaborative communities, and (c) how to measure effects of the interventions based on the first two questions.

Background and goals

Blended learning (BL) is a combination of face-to-face and online learning approaches (Graham, 2006; Watson, 2008) and is being used with increased frequency. It has the advantage of improved pedagogy and increased access and flexibility (Graham, 2006). As a result, BL is likely to emerge as the predominant teaching model of the future (Watson, 2008).

This evolution is especially relevant for adult education as adult learners can be considered as a heterogeneous group with specific needs and challenges (Brown, 2002). Many adult learners have several responsibilities, e.g. family, job, childcare, dealing with aging parents (Brown, 2002; Cercone, 2008), which may interfere with the learning process (Cercone, 2008).

In this research project, the target group are adult learners with a background in technical or vocational secondary education. This target group is challenging because they differ in several aspects from other adult learners. For instance, they (a) perform lower on average on problem-solving skills in technology-rich environments (Hämäläinen, Cincinnato, Malin, & De Wever, 2014), (b) are less motivated to participate in lifelong learning (Kyndt, Govaerts, Dochy, & Baert, 2011), (c) are struggling with self-initiating their learning process (Stine-Morrow & Parisi, 2010).

In order to respond to the (a) heterogeneous group adult learners and (b) characteristics of the target group, we want to design a flexible BLE that encourages CSCL. Online collaborative communities require a culture of inquiry and collaboration (Hoadley, 2002) and skills to regulate the learning process (Charles, Miller, Azevedo, Hadwin, & Lajoie, 2013). Whereas a lot of the participants of the specific target group focused on in this project perform poor on problem-solving skills, motivation to learn, and self-directedness, we want to stimulate a culture of inquiry and collaboration by paying attention to self-regulation (SRL), co-regulation (CoRL) and socially shared regulation of learning (SSRL) (Hadwin, Järvelä, & Miller, 2011; Panadero et al., 2013). For instance, to promote SSRL in groups, tools can be implemented that stimulate learners to plan together, monitor how the group is performing, etc. (Panadero et al., 2013).

Methodology

The present research project concerns an intervention study which includes design based research (Herrington, Mckenney, Reeves, & Oliver, 2007) with at least two redesign cycles. Theoretical courses will be redesigned and (online) CSCL is implemented into the courses. In view of high usability, the study is ecological in nature. Participants in this research project are adult learners enrolled in teacher education with a background in technical or vocational secondary education. The first redesign will take place during (maximum) one semester, starting in September 2015. To measure the outcomes of this first intervention, we will make use of pre- and posttests (e.g. knowledge tests, motivation). In addition, during the intervention, the learning environment will be observed and analysed using for instance classroom observations and log files. The final goal is to elaborate a model for BL suitable for adult education, with a focus on how to design and enhance online collaboration.

Current status

At the time of writing, two studies are conducted to map the current state of (a) blended learning models and (b) characteristics of the target group. The first study is an extensive literature review of existing design models for BL. These models provide a good insight into some valuable features of BLEs, where further research will rely on. The second study concerns in-depth interviews with lecturers (and questionnaires conducted by adult learners) to search for the needs of the target group. Based on these results, we want to elaborate a model for blended learning that encourages online collaboration.

Particular issues to discuss

A first particular issue that I would like to explore includes the design of learning activities in online collaborative communities. Secondly, additional to this design, I want to explore how we can scaffold the learners in order to stimulate the regulation of their learning (CoRL, SSRL), e.g. by scripting and visualization tools (Charles et al., 2013). Thirdly, I would like to 'think aloud' with consortium participants on several research methods to collect and analyse data to investigate the effects of the interventions, e.g. by learning analytics (Siemens & Gasevic, 2012; van Leeuwen, Janssen, Erkens, & Brekelmans, 2014).

Since I am exactly at the design/preparation phase of the first intervention, the input from the doctoral consortium could be essential at this particular moment to discuss my research design for this study and determine my future direction of the doctoral project.

I expect that a presentation focusing on (a) the features described in literature to design (online) CSCL environments and (b) the existing tools to stimulate regulation activities, will provide several interesting starting points for small group discussions, which can provide directions for future design.

Although the focus of the project mainly lies on the domain of instructional design (of CSCL environments), a discussion regarding its general design issues could also benefit other junior researchers within the broader field of CSCL.

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Supporting Engineering Students' Estimation Skill Using a Collaborative Digital Learning Environment

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Goals of the research

Professional engineers are routinely called upon to make estimates during the course of their work (Linder, 1999). However the current engineering curricula do not include instruction on estimation (Linder, 1999). The goal of my project is to design and evaluate a collaborative digital learning environment to improve students' estimation skill. The design of the learning environment will be based on two inputs, namely, the estimation practices of experts and students' natural approach towards ill-structured engineering problems (like estimation).

Background of the project

Consider this problem: "ABC Company has designed a toy laptop for kids which helps them spell and read and is touch sensitive. Estimate how long the laptop will run on 2 AA batteries." Professional engineers must regularly make estimates such as these wherein an unknown parameter must be determined. Often unclear to non-experts is, where to begin and what method to use to obtain a good estimate. Such estimation is used, a) to do sanity checks of results b) when there is uncertainty in the data or conceptual models c) to establish the feasibility of a design and d) to eliminate candidate design solutions (Dunn-Rankin, 2001). Researchers (Linder, 1999) found that engineering undergraduates provided poor estimates for even simple engineering quantities such as force and energy. Despite this known deficiency, there do not exist systematic teaching-learning tools or strategies for engineering estimation.

Estimation problems arise in other sciences as well. For example, researchers (Ogilvie, 2009) found that that learning to solve estimation problems leads to expert-like problem solving behaviors in Physics. Thus estimation is an important skill and should be explicitly taught to students in the STEM disciplines.

Research suggests that engineering problems are solved collaboratively and using digital technology (Johri & Olds, 2011). Engineers extensively use representations and digital technology facilitates the creation and exchange of representations at a large scale (Johri & Olds, 2011). Therefore in order to provide an authentic learning environment (LE) for engineering estimation, I propose a collaborative digital LE as part of my doctoral research.

Methodology

I am using design-based research (Cobb et al, 2003) to design and evaluate the collaborative digital LE. Studies of expert estimation practices and students' natural ill-structured problem solving behaviors will inform the choice of interactions and tasks (see Figure 1 below) in the LE.

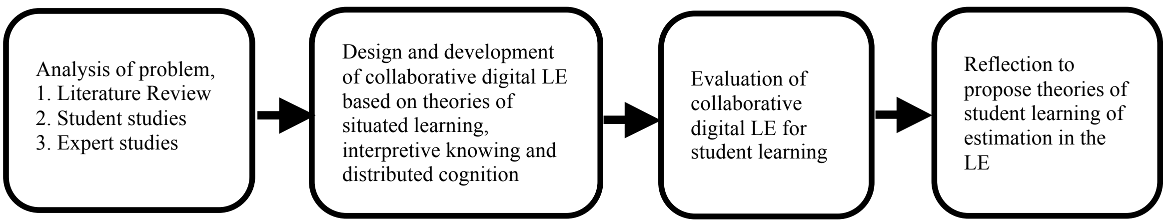

Figure 1. Stages of design based research

Understanding students' ill-structured problem solving practices

I performed a pilot classroom study with two groups of engineering students. One group got ill-structured problem solving instruction using a strategy based on productive failure (Kapur, 2008) while the other group learned with question prompts and peer interaction (Ge, 2003). After three interventions, I interviewed students to identify how they approach engineering problems, what heuristics they use and how they apply knowledge. The interviews were analyzed using content analysis and I identified several categories of student behaviors and heuristics.

We found that students in the productive failure group show a wider variety of behaviors and heuristics to construct the problem space, generate and defend solutions and evaluate and revise them. Further, these students reflect more on the role of various factors in their problem solving process. Importantly, we found that students are not aware of the importance of their own problem solving behaviors; hence we need to include features in the LE to improve student awareness and ensure that students explicitly practice them.

Understanding expert estimation practices

While there is research on students' practices of engineering estimation (Linder, 1999), there are no studies of how experts perform estimation. Therefore, I am studying expert engineers from different engineering disciplines as they solve estimation problems from inside and outside of their parent disciplines. This study will produce rich case studies of how experts solve estimation problems when they have domain knowledge and without it. These insights will be used to design the interactions in the LE such that that it supports the attainment of expertise. Moreover this analysis will identify and define the sub-skills included in the skill of engineering estimation. Then the tasks in the LE can be constructed to support the development of all these sub-skills.

Design a collaborative digital learning environment

The design of the LE will be based on the theories of situated learning (Johri & Olds, 2011), interpretive knowing (Bransford & Schwartz, 1999) and distributed cognition (Hollan et al, 2000). The LE will include authentic tasks so that learning is situated and tasks for the development of all sub-skills. The interactions will be based on expert actions and include the affordance to create problem representations. I will focus on student learning and develop a theoretical account of how engineering students develop estimation skill using the LE. I hope to argue that the opportunity to practice the sub-skills and create problem representations in the LE will promote integration of knowledge and skills required for solving estimation problems.

Issues to be discussed

The primary issue is to identify the skills and behaviors to be extracted during the analysis of the expert studies data. A preliminary list includes the domain dependent and independent parts of the experts' estimation strategies, heuristics used, actions that have productive consequences in estimation and the most useful steps in estimation. Also, how do we identify when an expert is using "intuition" or a "cognitive trigger" which causes everything to "come together", since experts often do not articulate this in their solutions.

The LE should enable students to do experts' productive actions. How should these actions translate to interactions which the students are impelled to do in the digital LE? How can we include experts' "intuition" in the LE? Researchers (Wu et al, 2011) designed a tangible interactive tabletop LE, based on studies of expert modeling practice, to support mathematical modeling. I would like to discuss how to translate insights from my expert studies on estimation to interactions on the LE that will develop estimation skill.

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Using Complimentary Strengths of Individual and Collaborative Learning Within An Intelligent Tutoring System

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Introduction

Classroom instruction often involves both collaborative and individual work. Both have been shown to be effective instructional methods, and there is not a consensus on which may be more effective (Lou, Abrami, & d'Apollonia, 2001). Collaborative and individual instructional methods appear to have complementary strengths, but it is not clear how they are complementary and how best to combine them. In creating instruction, it is important to consider the possibility that individual and collaborative activities may be better for acquiring different types of knowledge, such as conceptual and procedural knowledge (Mullins, Rummel, & Spada, 2011). Conceptual knowledge is the implicit and explicit understanding of the principles in a domain and how they are interrelated (Rittle-Johnson, Siegler, & Alibali, 2001). Procedural knowledge is the ability to be able to perform the steps and actions to solve a problem (Rittle-Johnson et al., 2001). Mullins, Rummel, and Spada (2011) found that with 9th graders doing algebra, students who worked collaboratively on conceptual tasks outperformed those who worked individually, whereas students who worked individually on procedural tasks outperformed those who worked collaboratively. This study was implemented with older students and the question still remains if the same results will generalize to elementary school students since younger students are at a different level of development that impacts their social skills and ability to verbalize their reasoning. In addition, it remains an open question how collaborative and individual instructional methods can best be combined.

Some prior research has indicated that Intelligent Tutoring Systems (ITSs) can be a practical way of addressing challenges of using collaboration in the classroom. An ITS can provide the cognitive support (i.e. step-by-step guidance and hint features) that is beneficial to student learning (VanLehn, 2006). Although most prior work on ITSs has focused on individual activities, there has been some work on combining ITSs with collaborative activities that has shown promise for supporting learning with high school students (Walker, Rummel, McLaren, & Koedinger, 2007). Walker et al. (2007) found that students working with an ITS redesigned to support collaboration (specifically, peer tutoring) had learning gains at least equivalent to those working individually. These prior studies show ITSs to be a promising technology to use to combine collaborative and individual activities.

Study aims and research questions

The goals of this research are of both theoretical and practical importance. The understanding of how collaborative and individual activities are complementary and how they can best be combined can have an impact on future theory. To develop this understanding, I have two research questions: (1) Do collaborative and individual activities have complementary strengths for conceptual and procedural knowledge and (2) is a combination of the two instructional methods better than either one alone and in what combination? The combination of the instructional methods will be determined from the results of the first research question. The research also is of practical importance in that it may impact ITSs and the way that they are developed. By increasing the awareness of what I need technology to support in individual and collaborative activities, I can ask future questions such as how to orchestrate the use of both methods.

Methodology

To answer the above research questions, I have run two pilot studies and one pull-out study, all which I have already completed. Additionally, I will conduct two distinct classroom experiments in several local elementary schools. The pull-out study and first classroom experiment are designed to answer the first research question while the second classroom experiment is designed to answer the latter. The participants in the studies are 4th and 5th grade students working on a fractions tutor. In the pull-out study, 4th and 5th grade students worked on equivalent fractions through an ITS in a 2x2 between subjects design. Each teacher paired the students participating in the study based on students who would work well together and had similar, but not equivalent, math abilities. The pairs were then assigned to either work collaboratively or individually and on either a procedurally-oriented or a conceptually-oriented problem set developed for the purpose of the experiment. When the students were collaborating, they sat at separate computers and talked through Skype (audio only). The students' knowledge is assessed both before and after the intervention in a pre/post-test design. In addition, I am collecting both tutor log data and audio transcripts (for the students collaborating) during the intervention.

The first classroom experiment has a similar set-up to the pull-out study except the students will be working with an ITS that has problem sets for a larger range of fraction topics and students who are working collaboratively will be seated next to each other. The classroom experiments will be integrated into part of the normal classroom instruction that spans multiple days and students will be assigned randomly by classroom to condition. For the second classroom experiment, there will be a 4x1 between subjects design where students will either be assigned to work individually, work collaboratively, or have a mix of the two methods playing to the strengths or against the strengths, where I hypothesize that students who use a mix of collaborative and individual activities according to the strengths will have greater learning gains compared to the other conditions.

For the pull-out study, I used repeated measure ANOVAs to investigate the between-subjects effects of instructional method. For the classroom experiments, I will use a multi-level model in order to investigate the between-subjects effects of instructional method and knowledge type (first question) or instructional combination (second question) on procedural and conceptual knowledge at the post-test, using data from the pre-test as a covariate and dyad differences at the second level. In addition, I am analyzing log data of students' interactions along with audio transcripts (and in the lab study, gaze data) to study the finer-grained interactions within the collaboration.

Current status and issues

I ran a pull-out study to begin to answer the first research question. In the study, I had 81 4th and 5th grade students. To test my hypothesis that on tutor activities targeting conceptual knowledge, students working collaboratively have higher learning gains than students working individually, I conducted two repeated-measures ANOVAs (conceptual and procedural test items, respectively). For the conceptual items there were pre/post learning gains, F (1, 39) = 4.23, p = .046, and on the procedural test items there were marginal learning gains, F (1, 39) = 4.00, p = .053. There was no interaction between the conditions. To evaluate my hypothesis that students working individually on tutor problems targeting procedural knowledge have higher learning gains than students working collaboratively, I again conducted two repeated-measures ANOVAs. There was no pre/post learning gains and no interaction between the collaborative and individual conditions. In this study, I found that students had equivalent learning gains in the collaborative and individual conditions showing that a collaborative ITS can effectively support learning with elementary school students. However, I did not find the expected difference between instructional methods for the different knowledge types, which may be due to the short instructional time and student's self-consciousness of working alone with a researcher. Future studies aim to address these limitations, which I am currently in the process of conducting in the classroom.

There are two main challenges in my research plan for which I think the CSCL community would be able to provide insights. The first is the challenge of bringing different data sources together. In my experiments, I am collecting log data, process data, and gaze data, which all need to be synchronized for analysis. The second challenge is in conducting studies in actual schools where the re-grouping of students is necessary due to absentees and audio recordings need to be collected in a classroom environment.

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How a Synchronized Display Technology for Mobile Devices Affords and Extends Small Group Face-to-Face Learning and Collaboration

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Abstract: My research focuses on face-to-face learning in small groups with Pinch (http://tinyurl.com/cbuuz9v) (Ohta & Tanaka, 2012). Pinch is an interface that synchronizes mobile devices when they are pinched together; "the multiple-screen layout can be changed dynamically and instantly even while applications are running in each device." (Ohta & Tanaka, 2012). My study explores how Pinch best fosters MCSCL and how students' contributions vary as a result of the different ways of using Pinch.

Keywords: mobile, small group, face-to-face, gesture

Goals of the research and background

My research focuses on mobile computer-supported collaborative learning (MCSCL) in small groups. Research in MCSCL investigates shared display groupware and interactive whiteboards to better support collaborative learning with tablets with success (Warwick et al., 2010, Yang & Lin, 2010). Promising new technologies such as tabletops are designed for co-located teamwork and afford multi-touch interactions. (Dillenbourg & Evans, 2011). In addition, collaborative mobile technologies have become increasingly ubiquitous with context proximity devices such as Smart-Its Friends (Holmquist et al., 2001). However, groupware research focuses on whole-class orchestration rather than in-depth small group activity, tabletop technologies are expensive and lack the flexibility of mobile devices, and research has yet to explore the educational potential of context proximity devices.

To address these issues, my research explores collaborative learning in classrooms using Pinch (http://tinyurl.com/cbuuz9v) (Ohta & Tanaka, 2012). Pinch is an interface that synchronizes mobile device screens when they are pinched together; "the multiple-screen layout can be changed dynamically and instantly even while applications are running in each device." (Ohta & Tanaka, 2012). By using Pinch students and teachers may work together agilely, in multiple permutations, as it affords both knowledge construction and distribution via gesture. For example,

1. Students may work in pairs on a single application displayed across their individual devices.
2. Students in a group of four may pinch their devices together to form a large square or row, like a flexible tabletop, to discuss and construct content. Group members may then disconnect their devices for further individual construction of the co-constructed content.
3. If space allows, several groups could join devices for public critique and reflection.
4. A teacher may pinch her device to groups or students in order to scaffold work and then disconnect to review and annotate it privately.

Given these affordances and ways of using Pinch, my research questions are:

- *What are the different ways in which the Pinch technology best fosters collaborative learning?*
- *How does orientation affect learning?*
- *How do students' contributions vary as a result of the different ways of using the Pinch technology?*

Methodology

Context

The setting will be a sixth grade classroom. The virtual component of the context includes the following technologies: 1) iPads, 2) Pinch, and 3) WeCollabrify, an open source drawing and mapping app.

At the end of a unit on energy transformation, students will construct a model of the relationship between energy and the processes plants enact to produce food, like photosynthesis. Each student will be given an iPad and instructions on using Pinch and WeCollabrify. Students will be grouped in fours; half the groups will work in pairs and the other half will work in quads for a contrasting case study design.

Participants
Sixth grade students will participate in the study. Participant groups will be heterogeneous per gender and science knowledge.

Data collection
I will use the following instruments to collect data: 1) biology content knowledge test, 2) video and audio recording, and 3) field notes.

Data analysis
I will transcribe all video and audio recordings and field notes and manage and code my data using the qualitative analysis software NVivo 10. My unit of analysis is tool-mediated action. I will analyze this action within pairs and groups in each case and across cases to look for patterns of coordination and communication. I expect to find that Pinch affords a unique kind of collaborative and cognitive flexibility.

I will analyze students' biology content knowledge as well as their science knowledge representational artifact construction process and quality by examining video data using a science knowledge evaluation rubric. I will also examine knowledge construction and group negotiation processes by conducting discourse analysis of audio and video recordings (Gee, 2014).

Because I am using qualitative methods I will use validation strategies of triangulation and inter-rater reliability of coding.

Current status
I have finished my prelims and am working on my proposal, which I plan to defend early fall. In addition, I am collaborating with Dr. Takashi Ohta, Associate Professor at Tokyo University of Technology, and writing a grant proposal in order to hire developers to integrate the Pinch code with WeCollabrify.

Particular issues/problems in my dissertation and CSCL research I would like to explore further in the discussion at the Workshop
I would like help in my theoretical grounding and aligning my research questions with my analysis.

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The Role of Student-Generated Visual Representations in Collective Inquiry

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Goals of the research

There is a growing recognition among science educators that an important curricular aim should be to foster students' skills in constructing and interpreting visual representations. If students are to become more than passive consumers of science, they need to have opportunities to invent, modify and discuss their own scientific representations (Danish & Enyedy, 2007). This idea aligns with a prevailing understanding held by science educators, that students should have opportunities to cultivate skills that are part of *authentic scientific practice*. Hence, an effective role for student-generated visual representations (e.g., diagrams, drawings, and photographs) would be one in which they are situated within a legitimate context or social practice (Greeno & Hall, 1997).

A close examination of science learning reveals that modes of student expression are primarily verbal and textual, and opportunities for students to express themselves visually are limited. Ainsworth Prain, & Tytler (2011) contend that when students do engage with visual representations, they are rarely encouraged to create *their own visual forms.* Students may be required to construct representations *of something*, rather than to produce representations *for something* (i.e., serving a concrete purpose, such as communicating to peers; Greeno & Hall, 1997).

The goal of my doctoral research is to investigate the role of student-generated visualizations within a context in which they play a meaningful role for advancing collective inquiry. Since visual representations can serve to externalize thought, they can allow students to jointly consider the same ideas and collectively revise them (Tversky, Morrison, & Betrancourt, 2002). My goal is to engage students in practices of artifact "reuse or remixing", that are situated within a knowledge community approach to learning and instruction (Slotta & Najafi, 2010). Just as students can build on and improve the ideas of peers through knowledge-building discourse and textual contributions (Scardamalia & Bereiter, 2006), my research seeks to understand how students can use, appropriate, integrate, and "remix" visual artifacts.

Background of the project

My work is situated within a program of research called Embedded Phenomena for Inquiry Communities, which brings together researchers, designers, and software developers from the University of Toronto and the University of Illinois at Chicago.

Methodology

My dissertation consists of two studies, the first informing the design of the second. I am pursuing a design-based research methodology where the materials and activities are a principal outcome of the work, situating the research (i.e., of students' use of student-generated visual representations) within a rich social context.

My research questions concerning the role of student-generated visual representations in collective inquiry for a middle school ecology curriculum are:

1. What types of visual representations do students generate in the course of their inquiry investigation?
2. At what stage(s) of the inquiry process do they create them and for what purpose(s)?

My analysis will focus on visual artifacts, but data sources also include computer log files, researcher observations of tool use, and face-to-face interactions, group interviews with students, semi-structured interviews with teachers, and questionnaires. Descriptive statistics will be applied to the computer log files and questionnaires. A qualitative approach will be used to develop a coding scheme to study the content of researcher observations, interviews, and the relationship of the visual artifacts to the text-based content of the notes, and the community-discourse surrounding them.

Current status and preliminary results

I am in the third year of my doctoral studies. I have completed my coursework and my comprehensive examination. I have collected data for one of two of my dissertation studies. I am currently designing the second study and will collect data for it in the fall of 2015. This doctoral consortium could provide helpful perspectives on the design of a learning sequence in which visual representations play a meaningful role.

In the first study, students employed motion-activated cameras (i.e., "camera traps") to collect photographs of wildlife in their school grounds. Students used camera trap photographs and developed their own visual representations (e.g., annotated maps) to express their ideas about animal populations and behavior (see Figure 1). Findings from the first study indicate that through carefully designed prompts and learning activity sequences, students can be supported in using visual representations (photographs and their own invented representations), as they work towards understanding animal behaviors. We extracted lessons from the cases where students were highly effective at using visual representations for community knowledge construction. We identified technology features (e.g., tools that allow for graphical annotation, text captions, and cropping)—to be considered in subsequent design iterations—that show promise for supporting the use of visual artifacts within a knowledge community context.

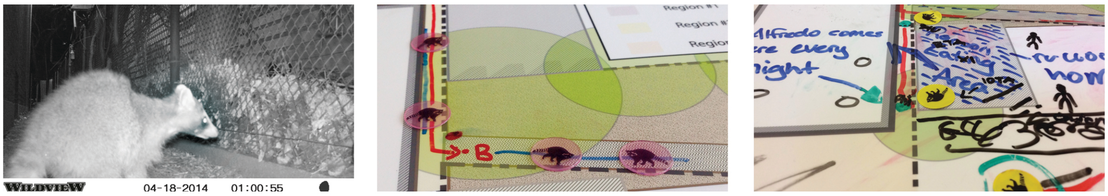

Figure 1. Examples of visual representations created by students. *Left:* Photograph example, taken by students with camera trap *Middle and right:* Annotated schoolyard map examples created by students

In the second study, two classes of Grade 5/6 students will be immersed in a classroom-sized biology simulation, known as WallCology (Moher, 2006). I will develop a learning design that emphasizes visual forms of knowledge, including drawings, photographs, and videos. Students will use a digital note-sharing tool called Common Knowledge (CK) to create, capture, and share their visual representations.

Particular issues that I would like to explore

The challenges of design-based research are well known. A significant challenge of design-based research is that it can be difficult to pinpoint what aspects of a design, or which combination of features, contributed to its success (O'Donnell, 2004). In this doctoral consortium I would like to explore how I can be strategic about data collection and map out a plan of analysis for the data for my final study.

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