The mediators of the effect of meaningful classroom digital technology integration on students' subject-specific learning outcomes in basic education

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Abstract

Despite the prominence of classroom digital technology integration (CDTI) in contemporary education, controversy remains on its effects on learning. Hence, previous research suggests concentrating not on the essentially transient effect of CDTI but rather on what mediates its effect on teaching-learning processes. The PhD study introduced in this paper aims to identify mediators of the effect of meaningful CDTI on students' subject-specific learning outcomes in basic education. For that, data were collected from 93 basic education teachers, 984 students, and their parents through interviews, in-class observations, tests, surveys, and questionnaires on CDTI practices, students' subject-specific and general competencies, and students' background information such as personality, mental capacity, school satisfaction, and relationship with teachers. Collected data are processed through clustering with cross-tabulation to identify teacher CDTI profiles, latent profile analysis to identify student subject-specific achievement profiles, and nested multi-group SEM analysis to detect possible mediators of CDTI's effect on student learning outcomes. The results help understand what mediates the effect of meaningful CDTI on students' subject-specific outcomes, which contributes to giving recommendations on how to personalise the teaching-learning processes. Stakeholders such as teachers, students, and developers benefit from this knowledge to plan, design, implement, evaluate, and reflect on meaningful CDTI.

Keywords 1

classroom digital technology integration, technology-mediated learning, basic education

1. Introduction

The use of digital technology in the teaching-learning processes is a salient feature of modern education, rendered more prominent by the COVID-19 pandemic. The pandemic embodied a disruption in diverse sections, including education. Many researchers in the field are hence spurred by sense-making of the changes derived from this disruption. As one example, the pandemic provided a chance for educational innovations that had been initiated but not completely implemented before, mainly regarding the use of digital technology [1].

For several years, the potential learning benefits of digital technology have been explored, leading to digital technology integration in education being encouraged by education policies [see, e.g., 2]. Making use of the learning affordances expects a meaningful use of digital technology, resulting in technology-enhanced teaching and learning. For example, the latter has been deconstructed as improvements in practicality, understanding and engagement [3].

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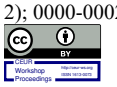

However, the term technology-enhanced learning includes an inherent bias [4, 5], an issue further so, as there is a noteworthy dispute between the researchers regarding the effectiveness of digital technology integration [see, e.g., 6, 7]. Regarding the main agents in determining the outcome, approaches to the field tend to be mainly divided into two, technology-led or pedagogy-led. The former invites compelling, rethinking and reevaluating pedagogical practices to incorporate technology's affordances [see, e.g., 8, 9, 10]. Opposing is the pedagogy-led approach, where pedagogical stances determine the technology integration [see, e.g., 11, 12, 13]; thus, pedagogy is seen as the main agent in determining the outcomes of the technology integration practices [14].

Recent research posits taking a step further from the technology-pedagogy dichotomy towards a consideration of entangled pedagogy [see 14], recognising that pedagogy and technology work in tandem not only with each other, but in interaction with the context and the different relations within these contexts on micro, meso, and macro levels, e.g., considering teachers, students, and the environment, such as the institution [4, 14]. Thus, the use of digital technology in education is regarded as "[…] complex, situated, and social in their constitution, their form, and their purpose, and as ungeneralisable in their effects as the choice of paintbrush is to the production of great art" [15], acknowledging that this recognition implies that the integration of technology into the teaching-learning processes may have different effects depending, for example, on the student [5].

Consequently, previous research suggests shifting focus from measuring the effects of digital technology integration on the teaching-learning processes, which are essentially transient, and concentrating rather on what mediates the effect of the technology integrations on these processes [5], considering and evaluating the relations of different elements [16]. Nevertheless, research alike is still scarce, possibly due to the complexity of the research design and process emanating from the numerous interacting and intertwined variables.

The PhD study described in this paper undertakes to gain insight into what affects the effect of technology-mediated learning on subject-specific learning outcomes aiming to identify some mediators of the effect of classroom digital technology integration. More specifically, we focus on i) understanding the practices of classroom digital technology integration in terms of how and why technology is integrated, ii) how these practices impact technology-mediated learning in basic education, and iii) what role do teacher, student and context-specific characteristics, such as attitudes, general competencies and personality, subject and institutional support, play in mediating the effect of classroom digital technology integration on subject-specific learning outcomes.

The context of the study is Estonia, where considering the effect of digital technology integration on learning outcomes and what affects the effect might be meaningful. The latter is due to two reasons; first, education in Estonia is considered one of the top-performing [17] and second, the use of digital technologies for learning and teaching is fairly widespread [18]. The latter is not only expected from the teachers [19], but teachers are also relatively well-prepared for it [20].

The following research questions thus guide the study:

RQ1: What are the teachers' classroom digital technology integration practices in Estonian basic education schools?

RQ2: What are the students' subject-specific learning outcomes in technology-mediated learning in Estonian basic education?

RQ3: What are the associations between classroom digital technology integration and subject-specific learning outcomes in Estonian basic education?

RQ4: What mediates the associations between classroom digital technology integration and subject-specific learning outcomes in Estonian basic education?

The aim of the described PhD study research is a contribution toward considering not only how technology affords learning and how to utilise these affordances to support pedagogical underpinnings but how to personalise education through evaluating the interactions of the technology, pedagogy, and the context.

2. Methodology

The PhD study described in this paper is a part of a larger research project, Digiefekt, running from May 2020 to April 2023. The

Human Research Ethics Committee of the University of Tartu, Estonia, approved the DigiEfekt project's research activities in December 2020 and again in September 2021 for a follow-up application that further developed the main study's plan in the light of the pilot studies' findings. The research project underwent two piloting studies to develop validated and reliable data collection instruments. The first piloting took place in April-May 2021, and the second piloting was in September-October 2021. The main study's data collection started in November 2021 and was completed in May 2022. The collected data will be analysed between June 2022 and March 2023. The main results of the project will be obtained by April 2023.

2.1. Sample

Purposeful sampling was used in the research project. We recruited schools with different profiles, considering different combinations of the following: i) academic achievement, ii) digital competence and iii) school satisfaction. More specifically, schools' performance was regarded in terms of students' achievement on academic tests. Digital competence was self-assessed by the teachers and the students. School satisfaction was reported in a survey conducted among teachers, students, and parents.

As participants, we selected Estonian, mathematics, and natural science teachers and their students from the end grades of each basic education level in Estonia, i.e., third (9–10 y/o), sixth grade (12–13 y/o), and ninth (15–16 y/o) grades. The participation of the schools, teachers and students was voluntary. The end sample consisted of 93 teachers and 984 students from 14 different schools across Estonia. Included were urban, suburban, and rural schools.

2.2. Data Collection and Analysis

To support the reader in following the research flow, the methodology will be described by the three sub-studies, which will make up the discussed PhD study. The first sub-study aims to identify teachers' classroom digital technology integration practices in their use and reasoning. To that end, data were collected by in-class observations to get an overview of how teachers integrate technology into the classroom. Further, interviews were conducted with the teachers to get an insight into the reasoning behind the specific use of digital technology. Following a content analysis of the collected data, a non-latent cluster analysis was conducted to identify profiles of teachers in terms of their digital technology integration practices. Moreover, data on teachers' background and demographics, e.g., age, years of service, self-efficacy, agency, and attitudes towards digital technology integration, were collected via questionnaires and will be used as control variables in cross-tabulations to support describing and explaining the identified clusters considering the relationships between the variables. Further, member checking will be conducted to validate the identified profiles.

For the second sub-study to identify students' profiles regarding subject-specific learning outcomes while also considering categorical latent variables, the following data were collected: students' results in digital competence and subject-specific competence tests, i.e., Estonian, mathematical and natural science competence, measured twice in the frame of one year, and students agency, learning anxiety and learning competence, measured once with self-report questionnaires in the frame of each subject, validated by in-class observations, as well as a test on students' mental capacity. These data will be analysed with latent profile analysis. Identified profiles will be further described and explained in the light of additional control data collected from and on students, such as students' socioemotional skills, personality and school satisfaction, analysed in cross-tabulations to explore relationships between the profiles and the control variables.

The third sub-study aims to discover associations between the profiles of teachers (profiling according to the classroom digital technology integration, identified in the first sub-study) and students (profiling according to the subject-specific learning outcomes, identified in the second sub-study) while considering the aforementioned background variables describing learners and teachers as well as a students' self-reported relationship with the teachers, and a nested multi-group SEM analysis will be conducted.

3. First Results

The data from the in-class observations on 167 lessons shows that digital technology is integrated into 82% of the lessons. These lessons included 269 different learning activities with the use of digital technology. In 59% of these activities, the technology was used only by the teachers. The activities used digital technology mainly as a substitute for a non-technological alternative, without making use of any functional improvement afforded by the technology (61% of the 269 activities). On approximately one-third of the occasions, technology was used for augmentation, relying on its affordances to provide functional improvements to the learning activities (34% of the activities). The rest of the 5% of the detected activities with digital technology integration made use of its affordances to revise and redesign the teaching-learning process (2% of the activities) or to adopt new teaching-learning practices, such as hybrid learning (3% of the activities) [see more 18].

Digital technology was integrated mainly to improve the practicality of the teaching and learning processes (42% of the activities), and the focus was more on facilitating teaching than learning. Besides, teachers adopted CDTI more commonly for its affordances to increase engagement (30% of the activities) than its affordance to facilitate deeper understanding (26% of the activities). In addition, teachers chose CDTI because they consider it more sustainable than non-technological alternatives (2% of the activities) [see more 21].

Regarding the teachers' classroom digital technology integration practices in terms of both the use and its purpose, we identified four profiles: introducers, facilitators, motivators, and deepeners. Introducers, facilitators, and motivators use technology mostly, although with different regularities, as a substitute, but the purposes for the substitution differ among these profiles.

More specifically, introducers integrate digital technology seldom to the classroom, and when doing so, there is no specific aspect of enhancement in mind. Facilitators stand out from the other profiles due to their main pedagogical reasonings for digital technology integration lying in its practicality and affordances to improve understanding, i.e., facilitating the teaching-learning processes for more in-depth learning. Conversely, Motivators focus mainly on digital technology's affordances to engage and motivate students.

The fourth identified profile, deepener, integrates technology both as a direct substitute and for the augmentation of the learning activities. Deepeners' aim in digital technology integrations is to facilitate understanding and augment learning gain. What lies behind these profiles, e.g., what would contribute to the sense-making and thus predict the occurrence of the specific profiles, is, however, still in the process of analysing.

4. Discussion and Conclusion

The PhD study described seeks to generate a holistic understanding of technology-mediated learning, i.e., what mediates the effect of technology integration on students learning, by adopting a relatively diverse and vast sample. Considered are the interactions between teachers' CDTI practices and students' subject-specific learning outcomes while scrutinising numerous student, teacher, and context-specific characteristics, acknowledging the agency of the stakeholders and environment in determining the effectiveness of the CDTI [5, 14, 15].

Although the results of this PhD study are still being processed, it emerged that in regard to teachers' classroom digital technology practices, student-centred objectives predominated over teacher-centred objectives, suggesting a focus on students in the pedagogical stances. These findings align with prior research showing a relationship between teachers' use of technology and the co-constructivist teaching approach, where learning is based on a conversation between teachers and students or peers [22].

Indeed, in the context where this study has been conducted, students are increasingly considered in the dialogue of creating educational experiences under the predominant paradigm of contemporary learning. In this paradigm, students are placed at the centre of learning design and instruction to scaffold their agency, as in the quickly changing, unpredictable environment, there is a need for autonomous, self-regulated learners [23]. Hence, lending to the aspirational digital technology integration, which is guided by the

context and the combined purposes of the stakeholders [14].

The PhD study contributes to understanding how stakeholders and context interact in technology-mediated learning, which is necessary for planning, implementing, and reflecting on meaningful CDTI practices and supporting the personalisation of education. This study is done in the context of one country, having thus the predominant learning paradigm acting as a constant variable. Hence, similar research in diverse contexts would be desirable since the practised learning paradigm can be considered as one of the essential mediating factors to evaluate the effect of the CDTI.

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6. References

[1] Y. Zhao, J. Watterston, The changes we need: Education post COVID-19, Journal of Educational Change 22(1) (2021) 3–12.

[2] F. Gabriel, R. Marrone, Y. van Sebille, V. Kovanovic, M. de Laat, Digital education strategies around the world: practices and policies, Irish Educational Studies 41(1) (2022) 85–106. doi: 10.1007/s10833-021-09417-3

[3] A. Kirkwood, L. Price, Technology-enhanced learning and teaching in higher education: what is 'enhanced' and how do we know? A critical literature review, Learning, Media and Technology 39(1) (2014) 6–36. doi: 10.1080/17439884.2013.770404

[4] S. Bayne, What's the matter with 'technology-enhanced learning'?, Learning, Media and Technology 40(1) (2015) 5–20. doi: 10.1080/17439884.2014.915851

[5] M. Bower, Technology-mediated learning theory, British Journal of Educational Technology 50 (3) (2019) 1035–1048. doi: 10.1111/bjet.12771

[6] L. Daniela, D. Kalniņa, R. Strods, An overview on effectiveness of technology enhanced learning (TEL), International Journal of Knowledge Society Research 8(1) (2017) 79–91. doi: 10.4018/IJKSR.2017010105

[7] J. W. M. Lai, M. Bower, Evaluation of technology use in education: Findings from a critical analysis of systematic literature reviews, Journal of Computer Assisted Learning 36(3) (2020) 241–259. doi: 10.1111/jcal.12412

[8] M. Webb, M. Cox, A review of pedagogy related to information and communications technology, Technology, Pedagogy and Education 13(3) (2004) 235–286. doi: 10.1080/14759390400200183

[9] P. C. Beukman, A pedagogical framework for the adoption of Technology Enhanced Active Learning (TEAL) with the consideration of learning spaces in a Higher Education context, Ph.D. thesis, University of Portsmouth, Portsmouth, 2021.

[10] D. A. Cohen, Contextual issues of technology integration in teacher practice, Ph.D. thesis, RMIT University, Melbourne, 2020.

[11] J. Tondeur, J. Van Braak, P. A. Ertmer, A. Ottenbreit-Leftwich, Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence, Educational technology research and development 65(3) (2017) 555–575. doi: 10.1007/s11423-016-9481-2

[12] D. Baneres, D. Whitelock, E. Ras, A. Karadeniz, A. E. Guerrero-Roldán, M. E. Rodríguez, Technology enhanced learning or learning driven by technology, International Journal of Educational Technology in Higher Education 16(5) (2019) 26–40.

[13] F. Aubrey-Smith, An exploration of the relationship between teachers' pedagogical stance and the use of ICT in their classroom practice, Ph.D. thesis, Open University, Milton Keynes, 2021.

[14] T. Fawns, An entangled pedagogy: Looking beyond the pedagogy—

technology dichotomy, Postdigital Science and Education (2022) 1–18. doi: 10.1007/s42438-022-00302-7
[15] J. Dron, Educational technology: What it is and how it works, AI & Society 37(1) (2022) 155–166. doi: 10.1007/s00146-021-01195-z
[16] P. Goodyear, L. Carvalho, The analysis of complex learning environments, in: H. Beetham, R. Sharpe (Eds.), Rethinking Pedagogy for a Digital Age, 3rd, Routledge, 2019, pp. 49–65.
[17] OECD, PISA 2018 results (volume V): Effective policies, successful schools, OECD Publishing, 2020.
[18] M. Pedaste, Ä. Leijen, K. Kallas, D. K. Raave, How to increase the potential of digital learning in achieving both cognitive and non-cognitive learning outcomes?, CO:RE Short Report Series on Key Topics, Hamburg (2022). doi: 10.21241/ssoar.79415
[19] M. Pedaste, Ä. Leijen, K. Poom-Valickis, E. Eisenschmidt, Teacher professional standards to support teacher quality in Estonia, European Journal of Education 54(3) (2019) 389–399. doi: 10.1111/ejed.12346
[20] M. L. Schmitz, C. Antonietti, A. Cattaneo, P. Gonon, D. Petko, When barriers are not an issue: Tracing the relationship between hindering factors and technology use in secondary schools across Europe, Computers & Education 179 (2022). doi: 10.1016/j.compedu.2021.104411
[21] D. K. Raave, E. Roldan Roa, M. Pedaste, K. Saks, Classroom digital technology integration – A double-edged sword? Engaging and practical yet harmful, in: International Conference on Innovative Technologies and Learning, Springer, Cham, 2022, pp. 241–251. doi: 10.1007/978-3-031-15273-3_27
[22] W. Admiraal, M. Louws, D. Lockhorst, T. Paas, M. Buynsters, A. Cviko, C. Jannsen, M. de Jonge, S. Nouwens, L. Post, F. van der Ven, L. Kester, Teachers in school-based technology innovations: A typology of their beliefs on teaching and technology, Computers & Education 114 (2017) 57–68. doi: 10.1016/j.compedu.2017.06.013
[23] C. Sum, I. Chan, H. Wong, Ready to learn in an uncertain future: Ways to support student engagement, Accounting Research Journal 34(2) (2021) 169–183. doi: 10.1108/ARJ-08-2020-0220