Cite as: Tanner, M., & Scott, E. (2015). A flipped classroom approach to teaching systems analysis, design and implementation. *Journal of Information Technology Education: Research, 14,* 219-241. Retrieved from http://www.jite.org/documents/Vol14/JITEv14ResearchP219-241Tanner1840.pdf

A Flipped Classroom Approach to Teaching Systems Analysis, Design and Implementation

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Abstract

This paper describes a flipped classroom approach followed to teach systems analysis, design and implementation at university level. The techniques employed are described. These techniques were underpinned by a theory of coherent practice: a pedagogy that provides a framework for the design of highly structured interventions to guide students in their learning experiences. The paper also describes the students' perceived benefits and limitations of the approach. Overall, the flipped classroom approach had a positive impact on students' attitude to learning, level of understanding, ability to apply concepts and engagement. Limitations were mostly in line with a reluctance to take charge of their own learning (for some of them) and inability to engage in group discussions. A set of recommendations are proposed to address these gaps in line with what has been prescribed in literature.

Keywords: Flipped Classroom Approach, Inverted Classroom, Active Learning, Teaching & Learning, Problem-Solving

Introduction

A flipped classroom approach is one where students are expected to learn about theoretical concepts outside of the classroom setting and are given the opportunity to apply these concepts in class whilst getting assistance from the facilitator and other students (Water-Perez & Dong, 2012). This approach allows for more active and responsible learning on the part of the students who then obtain immediate feedback from the facilitator or lecturer during class activities (Lage & Platt, 2000). With the help of technology, a flipped classroom can provide a blended learning environment (Cornelius & Gordon, 2008) where students are given access to relevant and meaningful learning material given their different needs and capabilities (Davies, Dean, & Ball, 2013). A learning environment is labelled as *blended* when it specifically combines the use of asynchronous Internet technology with face-to-face learning (Garrison & Kanuka, 2004).

The flipped classroom approach, which creates a more learner-centred environment, is known to increase student engagement, encourage critical thinking and improve student attitudes (Moravec, Williams, Aguilar-Roca & O'Dowd, 2010). To date, the approach has been used in a variety of fields of studies including Biology, Engineering, Physics, Statistics, Mathematics and Computer Science (Talbert, 2014).

Editor: Lynn Jeffrey
Submission Date: March 24, 2015: Revised: May 22, 2015; Accepted: June 9, 2015

This paper describes the flipped classroom approach followed to teach systems analysis, design and implementation at university level. At the beginning of 2014, the teaching approach in two second year Information Systems courses focusing on systems analysis (SAC) and systems design and implementation (SDIC) were revisited to embrace the flipped classroom approach to teaching. This approach was underpinned by a theory of coherent practice. This theory is a pedagogy that provides a framework for the design of highly structured interventions to guide students in their learning experiences. The objectives were to increase the students' ability to reflect and propose innovative solutions to business problems while learning Unified Modelling Language (UML) as well as systems design and implementation concepts. It was anticipated that through this approach, students would be better equipped to critically investigate the effectiveness and elegance of a particular UML model and identify gaps in their knowledge early on. The aim was also to encourage class discussions and debates, which would further serve to exercise their critical thinking skills. In addition, students would have, not only a theoretical understanding of UML and design concepts, but also be able to apply these concepts early in their learning.

The paper specifically discusses the perceived benefits, impact on students' understanding and limitations of the approach from the perspective of the students. Recommendations are then proposed in order to enhance the current model.

Literature Review

The Flipped Classroom Approach

In its simplest form, a flipped classroom approach requires that instead of homework, students are required to study a specific element of the course material prior to the lecture or class (Alvarez 2011; Moravec et al. 2010). The lecture time is then dedicated to exercises, addressing specific problems that students experience on some topics or other activities that promote higher order thinking skills (Khan, 2012).

The approach requires that "direct instruction is blended with constructivist learning pedagogies so that individualized differentiated learning is facilitated" (Davies et al., 2013, p. 565). According to Talbert (2014), for a flipped classroom experience to be effective, it should include:

1. *Highly structured pre-class assignments* which are geared towards introducing the students with the new theoretical concepts
2. *Means of accountability* to ensure that students complete the required pre-class assignments and out-of-class work
3. *Well-designed sense-making activities* for the students to engage with during lecture time
4. *Open-Lines of communication* throughout the course so that students can interact freely with the instructor

The use of technology in a flipped classroom environment is beneficial as this provides students with wide access to rich resources and learning material (Woolf, 2010) in a medium that they deem applicable to their learning style. It can also assist the development of an awareness amongst students of the different conceptualisations of the discipline and to link this to the role of the IS actors as a potential IS practitioner (Byrne & Lotriet, 2007). From this approach it is evident that a comprehensive and coherent pedagogy should be implemented to address the limitations experienced in the IS curricula over the past years.

Teaching Pedagogy

The theory of coherent practice is a pedagogy that was initially developed to underpin the design of a learning environment in capstone or exit level courses to stimulate a new mindset amongst students, making them conscious of the complex reality of projects, the related social processes, and their emotional aspects. It "is a framework that prescribes how a set of carefully designed interventions can be constructed and implemented to empower IS majors. In this case empowerment implies the development of competence sustained by lifelong learning" (Scott, 2012, p. 223). In this pedagogy, theory is used to understand the learning process taking place within a student, which itself is a theory building process. Since the way in which students internalize knowledge is inextricably intertwined with the notion of using theory, this pedagogy is also effective to underpin the design of other courses, not only that of capstone courses.

In the flipped the classroom approach these theories can prescribe the design and implementation of the structured assignments (interventions) that will guide students through the three learning stages of *Knowing, Understanding* and *Applying*. These stages align with Cockburn's (2002) theory of the different stages of behaviour that explains how people transcend from the one stage to the next whilst learning and mastering new skills. Cockburn's theory forms part of the justificatory knowledge of the theory of coherent practice. Cockburn (2002) refers to the *following* stage as the stage where students gain knowledge through the extensive and detailed instructions of how to perform a task. In the *detaching* stage, student start to understand what they need to do and can therefore be encouraged to start applying their knowledge. This brings about the *fluency* stage where students can also apply their skills in different contexts, think out of the box and act more independently.

The next section describes the methodology for implementing this pedagogy.

Case Description

The two courses underpinned by the flipped classroom approach are described in this section. SAC and SDIC are two semester courses intended for students majoring in Information Systems for the BCom or BBusSci degrees, as well as in Information Systems and Computer Science for the BCom degree. In both courses, students are taught UML to visually represent user requirements and design models prior to system implementation. Each course is further described below.

SAC

In 2014, the class size for SAC was 164. This first semester course (13 weeks duration) was intended to provide students with an in-depth understanding of the front-end of the systems development life cycle. Students were taught the use of common tools of systems analysis. These tools and techniques include scoping, risk analysis, feasibility assessment, and techniques commonly used in object-oriented systems modeling including package, activity, use case, class, interaction, and state machine diagrams.

Students were required to complete the first stage of a systems development project, as part of the requirements for the course. This entailed the compilation of two documents: a Business Case (Project Work 1) and a User Requirements Specification (Project Work 2). Students worked in teams of two to complete their project assignments.

Students' final grades were derived from results of the Exercises (10%), Workshops (10%), Mid-Semester Test (15%), Project Work (15%) and Final Examination (50%). Students attended 30 class sessions of 45 minutes and were required to complete 13 exercises that were discussed in class.

In 2013, students attended 30 lectures. The students' final grades were derived from Workshops (7%), Exercises (3%), Mid-Semester Test (15%), Project Work (25%), and a Final Examination (50%).

SDIC

In 2014, the class size for SDIC was 83. This second semester course (6 weeks of lecture + 7 weeks of project work) followed on from the first semester SAC course and covered systems design and implementation. The course had a strong practical component where students were taught the use of common tools of systems design, coding, and implementation. They first learnt about these tools and techniques in isolation and were then required to apply them in combination to implement a small information system.

SAC is closely linked to SDIC and by implementing an information system based on the user requirements derived in SAC, students completed the whole systems development life cycle (SDLC) using the traditional waterfall approach. Students built and implemented the system in Visual C#.Net. In SDIC, there were only 6 weeks of lectures as students were given time to complete the coding for their projects during the second half of the semester.

Students' final grades were derived from results of the Exercises (5%), Workshops and Practicals (10%), Mid-Semester Test (15%), Project Work (20%) and Final Examination (50%). Students attended 17 class sessions of 45 minutes and were required to complete 6 exercises, which were discussed in class.

In 2013, students attended 17 lectures. The students' final grades were derived from Workshops (10%), Exercises (3%), Mid-Semester Test (12%), Project Work (25%), Final Examination (50%).

The Flipped Classroom Approach

The principles behind the flipped classroom approach followed for these two courses resonated with the implementation principles of the theory of coherent practice (Scott, 2012, p. 224) and also incorporated three of the Bloom's taxonomy's cognitive tasks: Applying, Analysing, and Evaluating (Bloom, 1956). Traditionally, students would be required to remember and understand (Bloom, 1956) during lecture time. However, in this model Remembering and Understanding happen prior to the lecture where students are required to go through the theoretical content on their own.

The flipped classroom approach employed in 2014 for SAC and SDIC is outlined in Figure 1. This figure also shows the techniques employed, and the tasks to be completed by the lecturers, students and tutors were regrouped into three learning stages: *Knowing, Understanding* and *Applying*. Each stage is further described below, with particular attention to the tasks completed by all the role players.

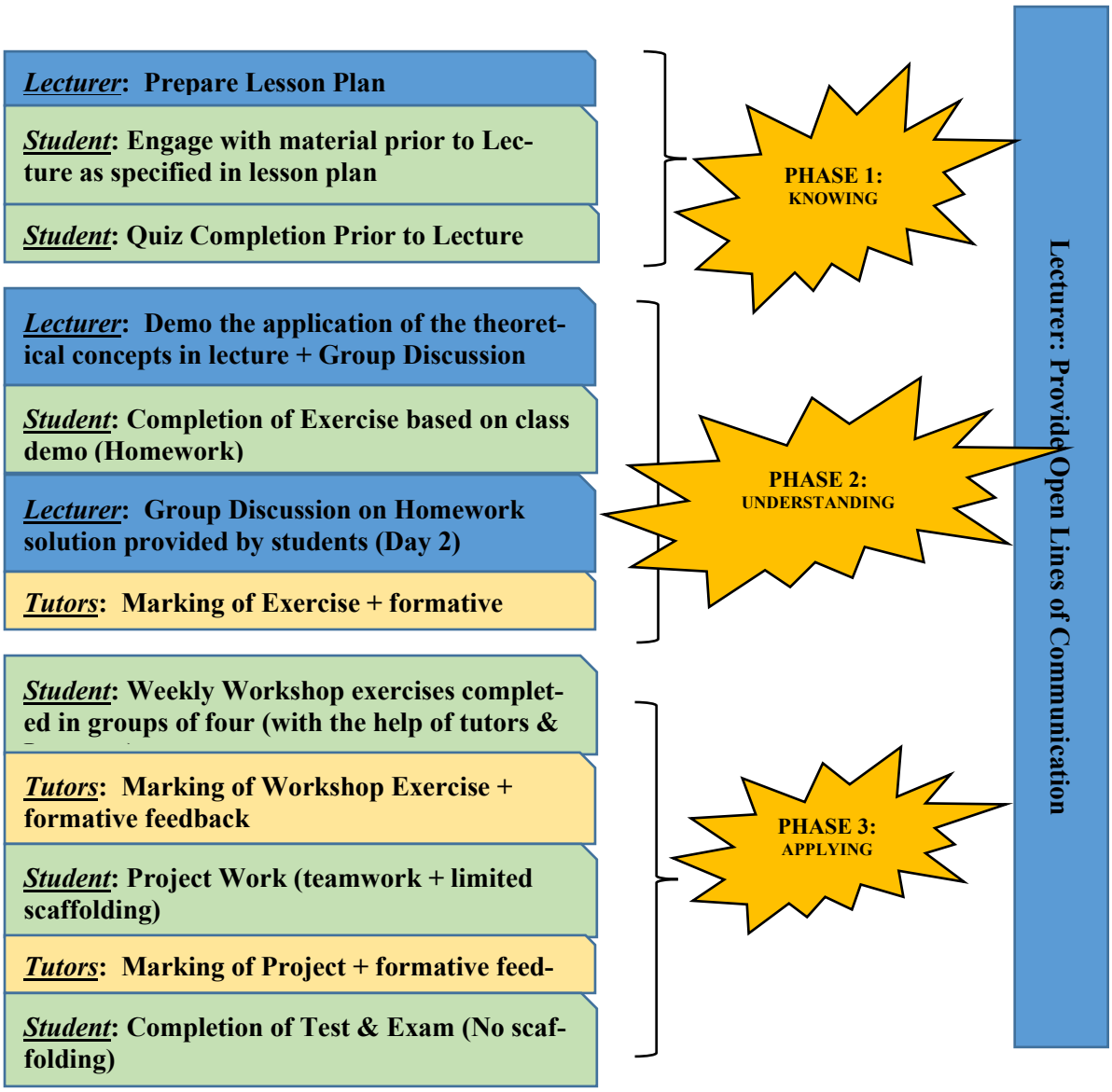

Figure 1: Flipped classroom model for SAC and SDIC

PHASE 1: Knowing

Phase 1, the *Knowing* phase, was initiated by the development of a lesson plan by the lecturer for the students. The lesson plan was essential to the success of the flipped classroom approach. It acted as a roadmap and provided a detailed overview of the tasks to be completed by the students on a daily basis, as well as the deliverables (quiz, exercises & workshops) that they were expected to complete (with deadlines) prior to each lecture. This provided the necessary structure around the pre-class assignments. Such structure was required in order for the students to feel guided as they took responsibility for their learning. An overview of the lesson plan for SAC and SDIC is provided in Tables 1 and 2 respectively.

Table 1: SAC lesson plan overview

Lesson Plan	Duration	Topic Covered	No of Quizzes	No of Exercises	No of Workshops
Lesson Plan 1	Weeks 1 & 2	- Problems in IS Development & Introduction to Modern Methodologies - Introduction to Modelling	3	2	2
Lesson Plan 2	Weeks 3 & 4	- Developing a Business Case - Fact Finding Techniques	5	2	2
Lesson Plan 3	Weeks 5 & 6	- Use Cases - Use Case Narratives	4	3	1
Lesson Plan 4	Weeks 7 & 8	- Class Diagrams	3	3	1
Lesson Plan 5	Weeks 9 - 13	- Sequence Diagrams - State Machine Diagrams - Revision Exercises	3	4	2

Each lesson plan was composed of 3 parts: (1) a general overview of the topics to be covered in the following weeks (2) a description of the learning objectives for each topic (3) a detailed description of the tasks to be completed by the students prior to a specific lecture. These tasks could include reading of slides, research articles and chapters in books, as well as watching Lynda.com videos and YouTube videos. We thus provided a combination of recommended textbooks, videos, research papers, and URLs, which constituted a blended learning environment in line with Alvarez (2011), Berrett (2011), Dziuban (2004), Fulton (2012), and Khan (2012).

Table 2: SDIC lesson plan overview

Lesson Plan	Duration	Topic Covered	No of Quizzes	No of Exercises	No of Workshops
Lesson Plan 1	Weeks 1 - 3	- Design Considerations - Software Architecture - Design Class Diagram - Design Sequence Diagram	4	5	1
Lesson Plan 2	Weeks 4 - 6	- Introduction to User Interface Design - Security & Control - Report Design - Testing	5	3	3

The date by which the corresponding quiz was to be completed as well as whether an exercise would be associated with a particular topic were also specified. An example is shown in Figure 2.

Week 3 – Lecture 7 – 3rd March 2014

Business Case: Finding a common vision for the project

- How to write a business case for innovation (YouTube video)
  - This video gives you an overview of the purpose of a business case. It also proposes some topics which you could cover in your business case document, depending on the nature of your project.
- The following section of the Business Case Primer pdf
  - Introduction
  - Phase 1: Assess Needs
  - Phase 2: Define the business opportunity
- Chapter 6 in Bennett book (Section 6.1) (Requirements Capture)
- Lecture 7 – Initiation Stage
- *Quiz to be completed by 2nd of March 2014 – 11pm*
- *Exercise to be completed*

Figure 2: Extract of lesson plan for weeks 3 & 4 (SAC)

Using the Lesson Plan as a road map, students were then required to engage with the course material in preparation for the lecture exercises and group discussions. They were also required to complete quizzes by the deadlines specified in the lesson plan. Each quiz consisted of simple questions derived from the prescribed course material and students were required to complete 80% of all quizzes in order to be allowed to participate in the final exam. The compulsory completion of 80% of the quizzes ensured that students engaged with the material and were ready for the lecture. However, the quizzes did not count towards their final grades.

PHASE 2: Understanding

Phase 2 related to *Understanding*. After completing the recommended material specified in the Lesson Plan and the quiz, it was anticipated that students would attend lectures with some basic understanding of the theoretical concepts. However, they would not be given the opportunity to apply these concepts yet.

The first lecture on a specific topic was typically dedicated to a demonstration of how to apply the specific theoretical concept to solve a business problem from a simple case study. For example, after learning about the purpose and notation of a Use Case prior to the lecture, students were given a demo in class of how to design use cases using a simple case study. It was valuable to conduct the demo in front of the students as it (1) enabled the lecturer to identify and address gaps in the students' understanding and (2) enabled the students to ask rich questions while the demo was being conducted while simultaneously reflecting on their current level of understanding. Students' questions were more targeted and reflective as they had engaged with the material beforehand, resulting in very interactive sessions.

Students were then asked to complete a similar exercise as homework. The exercise was based on a different and slightly more complex case study. Having the students complete the exercise as homework was valuable as it challenged them into thinking deeper about the concept being taught. It also gave them the opportunity to further reflect on what had been demonstrated to them in the lecture and identify gaps in their understanding. They would then be able to ask more in-depth questions during the next lecture.

In the next lecture, the lecturer would randomly select one student's solution and discuss the correctness/validity of that solution with the class. For example, the Use Case diagram solution of one student would be drawn on the board and the lecturer would invite the students to discuss/debate the accuracy, elegance, and efficiency of that solution. Mistakes would be pointed out

and the lecturer would also draw the students' attention to common pitfalls to be avoided in relation to that particular model. Ultimately, that solution would be updated, corrected, and enhanced based on the class' inputs and the lecturer's comments. This particular approach is particularly suitable to the teaching of modeling concepts as each analyst or designer could potentially conceptualize different models for the same business problem. Some models might be more accurate or more elegant than others, hence room for rich discussions during the session. The approach also allowed for interactive and collaborative problem solving and inquiry-based learning.

Traditional flipped classroom approaches typically require that exercises be completed in class in the presence of the lecturer. However, given the nature of the exercises to be completed for SAC and SDIC (modelling exercises require reflection and can be time consuming), the limited timeframe of 45 minutes per lecture, and the large number of students, it was decided that exercises would be completed at home. As a result, the entire lecture could be dedicated to discussions and debates.

All exercise submissions were collected at the end of the lecture and marked by tutors. Each student received extensive formative feedback for them to be better prepared for the workshops, project, test, and exam.

PHASE 3: Applying

As previously mentioned, students were required to complete a systems development project for both courses. This project was based on a case study designed specifically in collaboration with an industry partner to include real business problems and challenges in relation to an Order Management System. In order to complete this project, students were required to participate in regular 2 hour workshops (8 workshops for SAC and 4 workshops for SDIC). During the workshops, they worked in teams while engaging in problem solving and modeling tasks required for the completion of the project. The tasks were aligned with the concepts and exercises discussed in class.

Students were required to apply the skills and knowledge acquired in class to solve the complex business problems specified in the case. They would discuss ideas and concepts in teams of four with less scaffolding from the lecturer and the tutors. Lecturers and tutors were present during the workshops but students were encouraged to work more independently and ask for guidance only when really necessary.

All workshop exercises were marked by tutors, and students were again given extensive formative feedback. Students were then expected to enhance their solutions in light of this feedback and compile a Business Case and URS (SAC) as well as a Systems Specification Document and a software solution (SDIC). The work projects would thus be completed with limited scaffolding in order to encourage the students to think independently and detach. Ultimately, the mid-semester test and exam also required the students to apply their knowledge.

A summary of the techniques employed in the adapted flipped classroom approach followed for SAC and SDIC is provided in Table 3. The table also shows how these techniques align with Talbet (2014) proposed flipped classroom elements.

Table 3: Summary of flipped classroom techniques for SAC and SDIC

Proposed Flipped Classroom Element (Talbet, 2014)	Techniques employed in SAC & SDIC
Highly Structured pre-class assignments	- Readings (slides, research articles, Lynda.com videos, YouTube videos)
Means of accountability	- Quiz Completion (at least 80% of all quizzes to be completed) - Exercises given as homework count towards final mark
Well-designed sense making activities	- Group Discussion / Debates on relevance and accuracy of models
Open-Lines of Communication	- Open communications with students (face-to-face meetings during and after lecture hours, chats, emails)

Technology & Open Lines of Communication

Various forms of technology were used to support the flipped classroom approach. Firstly, all teaching resources were posted on a Learning Management System (LMS). The LMS was used to post announcements related to the course, to upload reading materials and links to the videos, to set up the quizzes and keep students informed of their grades throughout the semester.

In line with Talbet (2014), it was important to maintain open lines of communication and this was achieved through a combination of face-to-face and technology-based communication. In particular, the lecturers were available to the students during lecture time but also after lectures. Given that not all students were inclined to ask questions during lecture, the lecturers were available in between lectures and encouraged students to come for one-on-one meetings. The students and the lecturers also made extensive use of the chat system available through the LMS to discuss issues related to the course materials. Students regularly asked for clarifications and posted comments for the rest of the class on the chatroom, which further served to create a vibrant learning community throughout the semester. Students also emailed questions, to which lecturers responded on the same day.

Methodology

An overview of the assessment of the perceived benefits of this approach from the students' perspective is described below.

An interpretive study was conducted in order to evaluate the perceived benefits and limitations of the flipped classroom approach. As described below, qualitative data was collected and analyzed. Qualitative data was obtained to inductively assess the perceived benefits and limitations of the approach from the students' point of view. The research questions being addressed can be summarized as follows:

- What are the perceived benefits of the flipped classroom approach from a student perspective?
- What are the perceived limitations of the flipped classroom approach from a student perspective?

Sample

The sample consisted of the second year students who completed the SAC and SDIC courses. All respondents were taught using the flipped classroom approach and participated in the various exercises, workshops, test and exam. The sampling process was thus purposive (Teddlie & Yu, 2007). Through purposive sampling, the researchers could focus on the characteristics of the population of interest as a means of answering the research question. For example, the sample was selected as it was a cohort of students for which the flipped classroom approach was being used to teach systems analysis and design.

Research Instrument & Data Collection

In order to assess the perceived benefits and limitations of the approach, an open-ended questionnaire was devised and posted on the LMS at the end of the first and second semester. This questionnaire, which usually forms part of the annual course evaluation, was adapted to obtain data to answer the research questions. The questions were formulated around the techniques employed throughout the semesters. Students then completed the questionnaire anonymously via the LMS. For each course, students were given two weeks to complete the questionnaire. An incentive bonus mark of 1% was allocated to all participants. For SAC and SDIC, a response rate of 93% and 77% were achieved respectively. An overview of the open-ended questions specified in the questionnaire and how they relate to the research questions are presented in Table 4.

Table 4: **Questionnaire open-ended questions**

Research Questions	**Open-Ended Questions**
- What are the perceived benefits of the flipped classroom approach from a student perspective?	- What were the benefits of completing the quizzes? - What were the benefits of doing the exercises? - What were the benefits of participating in the workshops? - How prepared were you for the workshops, project, test and exam after having completed the exercises and participated in class discussions? - What were the benefits of going through the videos and readings prior to the lecture? - What were the most positive aspect of the course and the flipped classroom approach? - To what extent did the class exercises/homework/workshops contribute to your understanding and ability to apply the concepts? - To what extent did the class exercises contribute to your ability to understand and apply the concepts?

Research Questions	Open-Ended Questions
- What are the perceived limitations of the flipped classroom approach from a student perspective?	- What were the limitations of the quizzes? - What were the limitations of the exercises? - What were the limitations of the workshops? - What were the limitations of the class discussions? - What were the limitations of going through the videos and the reading materials prior to the lecture? - What were the most negative aspect of the course and the flipped classroom approach (with suggestions for improvement)
- What is the impact of the flipped classroom approach on students' performance?	- *Addressed through students' performance comparison in 2013 and 2014*

Data Analysis

The qualitative data was analyzed using thematic analysis (Braun & Clarke, 2006) and the steps followed are shown in Table 5.

Table 5: Phases of thematic analysis (Adapted from Braun & Clarke, 2006)

Phase	Description of Phase
Familiarize yourself with your data	Download data from LMS and read over data.
Generating initial codes	Generate initial codes whilst reading through the data.
Searching for themes	Combine codes into potential themes.
Reviewing themes	Compare themes against each other (level 1) and the entire data set (level 2).
Defining and naming themes	Name themes so as to create a story effect.
Producing the report	Produce a succinct and interest report of results, which are related back to research questions

The themes were derived from a series of open-ended questions that were designed and focused around the research questions. The purpose of the analysis was to summarize the raw data into codes and identify how these codes related to each other. The inductive process also assisted in linking the findings of this research to the literature that already existed on the subject. The quantitative data was analyzed descriptively.

Findings

This section describes the findings derived from the data analysis. The perceived benefits and limitations of the flipped classroom approach are first described followed by the impact that the approach has had on the class performance in 2014. The sample demographics are first described in relation to the students' academic year of study and gender for each case. These have been summarised in Figures 3 to 10.

Sample Demographics

As can be seen in Figures 3 and 4, distribution of students in their first, second and third academic year of study did not fluctuate much. Most students taking the course were in their second academic year of study (71% in 2013 and 69% in 2014) and a small percentage of students were in their third academic year of study (9% in 2013 and 10% in 2014). The remaining students were in their first academic year of study (20% in 2013 and 21% in 2014). As can be seen in Figures 5 and 6, most of the students in the 2013 (73%) and 2014 (77%) SAC class were male. The class was only composed of 27% females in 2013 and 23% females in 2014.

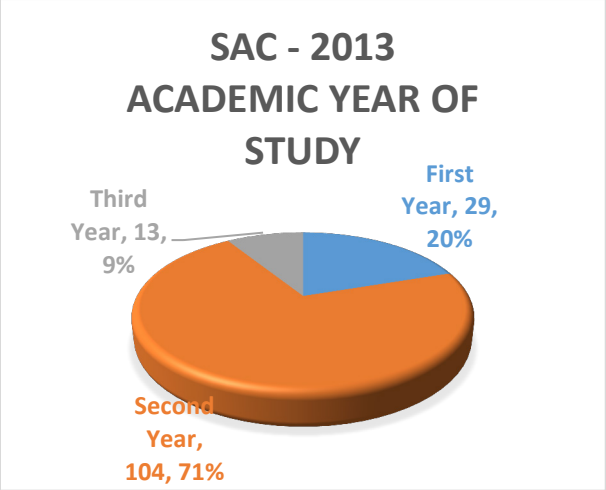

Figure 3: SAC Academic Year of Study - 2013

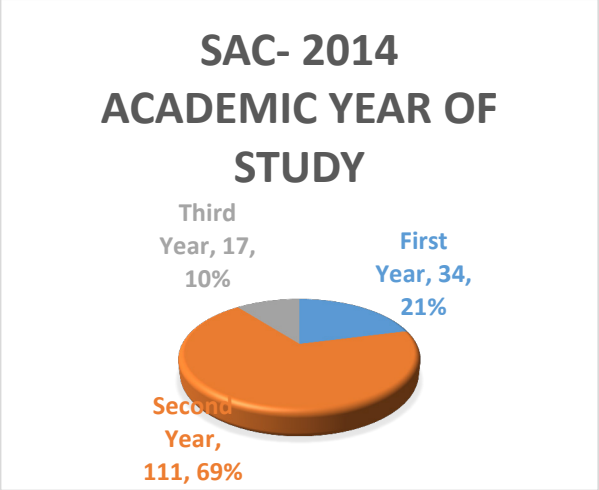

Figure 4: SAC Academic Year of Study - 2014

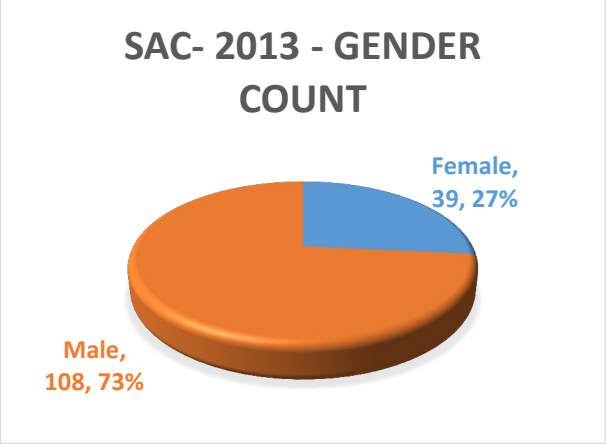

Figure 5: SAC Gender Count - 2013

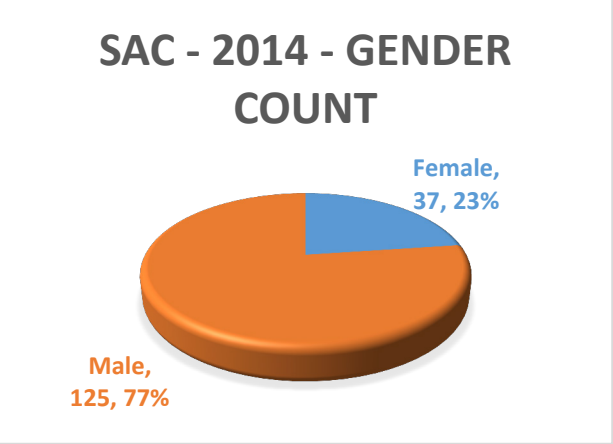

Figure 6: SAC - Gender Count - 2014

As can be seen in Figures 7 and 8, the distribution of students in their first second and third academic year of study did not fluctuate between 2013 and 2014. In both years, 2% of the students were in their third academic year of study, 23% were in their first year of study, and 75% were in their second academic year of study. Figures 9 and 10 also show that the gender ratio did not fluctuate much from 2013 to 2014. Similarly to the SAC course, most of the students were male (69% in 2013 and 70% in 2014) and only a minority of the students were female (31% in 2013 and 30% in 2014).

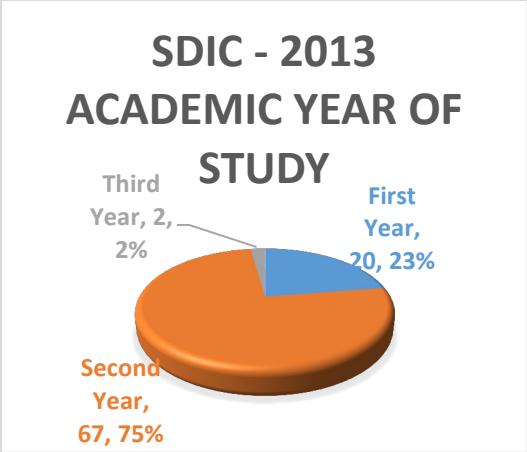

Figure 7: SDIC Academic Year of Study - 2013

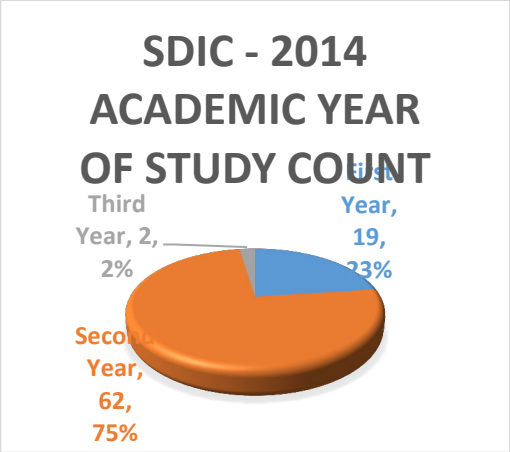

Figure 8: SDIC Academic of Study Count - 2014

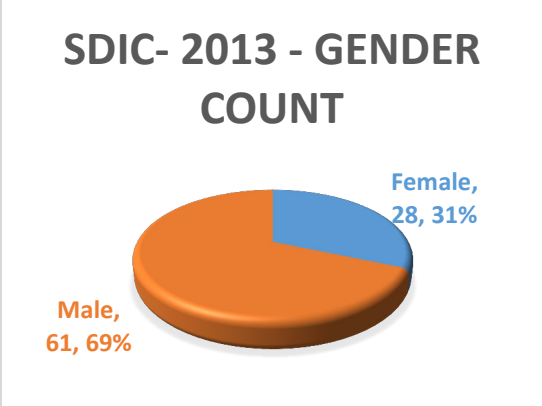

Figure 9: SDIC Gender Count - 2013

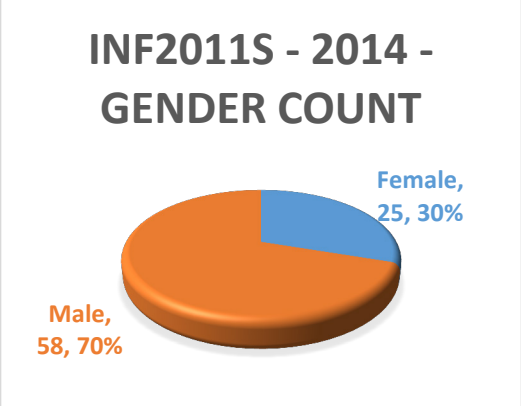

Figure 10: SDIC Gender Count - 2014

Perceived Benefits of Flipped Classroom Approach

Ten benefits specific to particular activities in the flipped classroom approach were identified (see Figure 11) and these were merged to form six general benefits (see Figure 12). These are discussed below. Quotes from students are identified by IDs in square brackets. Responses from both SAC and SDIC questionnaires have been discussed in combination. These relate to perceived benefits of the quizzes, exercises, class discussions, workshops, videos, and the approach overall.

Benefits of quizzes

Most students felt that the quizzes enabled them to keep up-to-date with the course content they were forced to regularly engage in pre-course readings.

Quizzes are a good way to force pre-reading, they helped a lot [SAC - R18]

It was also perceived that the quizzes motivated them to read the course material before the lecture. This extrinsic form of motivation stemmed from the requirement of students to complete 80% of the quizzes to be allowed to participate in the final exam.

> *Having a quiz before the lecture motivates to read material beforehand [SDIC – R45]*

Benefits of exercises

Students also felt that the exercises enabled them to keep up to date with the course content through constant practice. They perceived that the exercises boosted and solidified their understanding of the theoretical concepts, especially relative to UML modelling. Through their mistakes and eventually addressing these mistakes, students felt that they better understood how to apply the concepts to solve business problems. The exercises also allowed for practical applications of the theoretical concepts early on which was perceived as a benefit by the students.

> *Applying the concepts during the homework and getting them wrong, along with sorting them out, gave me good practice with the concepts and applications [SAC - R54]*
>
> *My ability to understand the application of concepts – like how they are shown on a diagram and what they mean in real world examples - was helped by the exercises [SDIC - R46]*
>
> *Exercises provide insight into how these concepts are used in the real world. Yes, real world problems are done – Engagement with real world problems [SDIC – R48]*

Students felt more engaged through the class exercises. They engaged with the material more regularly, resulting in a feeling of being up-to-date with the course content. They also felt in charge of their own learning which further enhanced their understanding.

> *Exercises are useful because they push us to do some work when we go home [SAC – R63]*
>
> *Puts the student in the driving seat and allows them to take charge of their own learning as the course progresses, which helps with understanding [SDIC – R4]*

Another perceived benefit derived from the exercises relate to their ability to engage in reflective learning. Students learnt from the mistakes that were pointed out to them during the class discussion and the formative feedback. Some of them even felt that most of the learning occurred during these exercises. Learning by doing was valued and being able to try out the exercises themselves enhanced their learning experience.

> *I can see how the exercises have helped me further develop [SAC – R14]*
>
> *[Exercises] Make you think about the work! Very good! [SAC – R59]*
>
> *I enjoy the fact we go over it in class because then we are able to learn from our mistakes [SDIC– R6]*
>
> *Yes, again actually doing the activity makes it much easier to understand them and apply them to other cases [SDIC – R34]*

Students felt that through the exercises, they were able to identify gaps in their understanding and ultimately clarify these issues early on. Most of them felt that the use of exercises was well suited to the teaching of modelling, that the questions were not too long and did not take up much of their time in the evening.

> *They help clarify the issues that I have when the slides aren't exactly that helpful. Especially when they are explained in class, so I can see what was wrong in my thinking [SAC – R101]*

Helps you to understand how much you know or rather how much you should know so very useful [SDIC – R18]

I think that exercises are a great idea; they really work well for this specific course. I also think that they are a good length (not too long that they take up too much of our home-working time). [SDIC – R63]

Benefits of class discussions

Most students perceived that the class discussions were beneficial. These exercises primarily enabled them to understand the concepts better after having gone through the class exercises on their own. They felt that the exercises, in combination with the discussions, were perceived to be more effective than traditional lectures and better contributed to learning.

Yes, class discussions, when we had them, we way more effective than lectures in general regarding contribution to understanding [SAC – R12]

I like doing a class exercise and discussing in class - yes, it contributes to my greater understanding [SDIC – R67]

The interactive nature of the class discussions enabled most students to better remember things. They were also able to clarify ambiguities and fuzzy concept.

Class exercises were especially useful since they were all thoroughly explained and discussed before every hand in. At first I thought this was a bit of a fail, since we could effectively correct our work as you hand it in, but now I think it's rather genius, since that's when I learned the most [SAC - R99]

Sometimes concepts were fuzzy, but discussions showed me how I went wrong, or how far off I was [SDIC – R42]

Another important perceived benefit of the class discussion was that after participating in the class discussions, most student felt better prepared for the workshops, projects, tests and exams.

It's good practice and preparation for the workshops, which ultimately help with the projects and exams. I like the structure a lot [SDIC – R26]

Benefits of workshops

One of the main benefits of the workshops from the perspective of the students was the group work. Most of them felt that that whilst participating in these workshops, they acquired practical skills as well as insights on how to work in teams.

The workshops also gave them the opportunity to further practice the skills acquired through the exercises and discussions but for a more complex business problem. They thus further learnt by doing.

I have really enjoyed this course thus far as the workshops employ practical skill and emphasise group work and group skills [SAC – R51]

Benefits of videos

The videos were perceived to be beneficial to most students and helped them improve their understanding of the concepts even though it was noted that depended on the individual's learning style. For example, some students felt that the readings were more useful and efficient than the videos, and favoured those.

Those who derived benefits from videos mentioned that after having watched them they felt more engaged in the class discussions. After watching the videos, some were also able to identify gaps in their understanding and formulate questions immediately (these were addressed during the lecture).

> *Yes, makes videos much easier to follow attentively in the lectures, especially when we go straight into applying the concepts in lectures [SDIC – R58]*
>
> *More than anything, I never did prior work in any of my courses, but now I do, and my marks are much better, and I understand topics discussed in class much better [SIC – R24]*

Overall benefits of the flipped classroom approach

Most students perceived that overall, the flipped classroom approach followed during the courses improved their understanding and ability to apply the theoretical concepts, identified in six general benefits. They felt that it was quite focused on problem solving and integrated real world examples in the case studies. They reported that there was a good balance between theory and practice.

> *It just makes more sense how Computer science is applied in business-oriented situations and to solve social issues as well [SAC – R24]*

Other advantages of the approach related to the open lines of communication that were maintained throughout the courses. They felt that the lecturers were approachable and willing to answer questions quickly. They also benefited from constant feedback through marked class exercises. Most students also mentioned that the approach prioritized learning and was adapted to suit the students' need whenever required.

> *Constant feedback through marked class exercises [SAC – R55]*
>
> *The lecturers are very approachable and replied to emails quickly which is great [SDIC – R2]*

Students also felt that they were given clear instructions early, which gave them a sense of direction.

> *It is a well-run course that seems to have a clear direction and I feel aware of where the course is going [SAC – R12]*
> *Appreciate how the lecturers really tried to understand our questions and give us thorough, easy-to-follow answers [SDIC – R57]*

A summary of the perceived activity-specific benefits of the interventions is provided in Figure 11. Figure 12 illustrates the perceived general benefits of the approach overall.

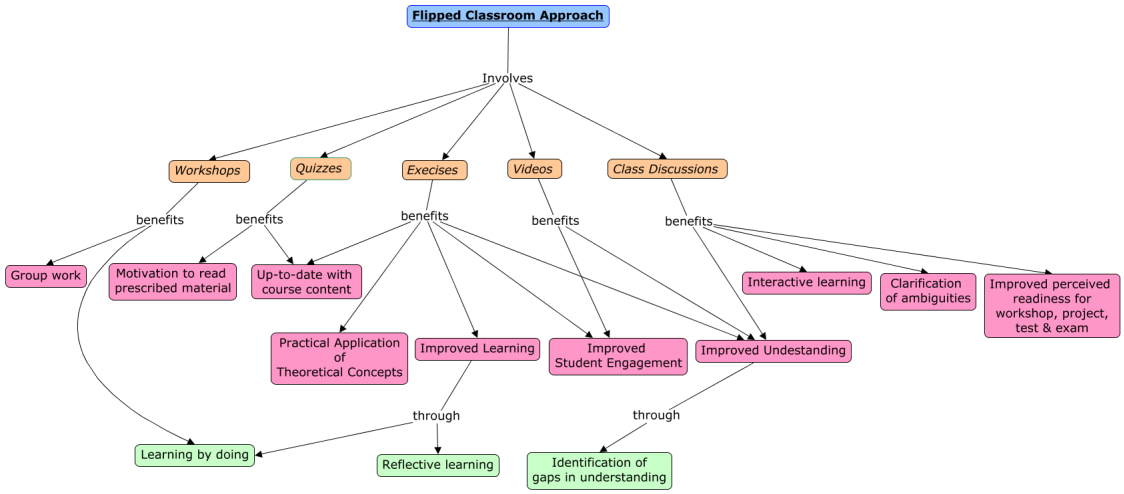

Figure 11: Perceived activity-specific benefits of adapted flipped classroom approach interventions

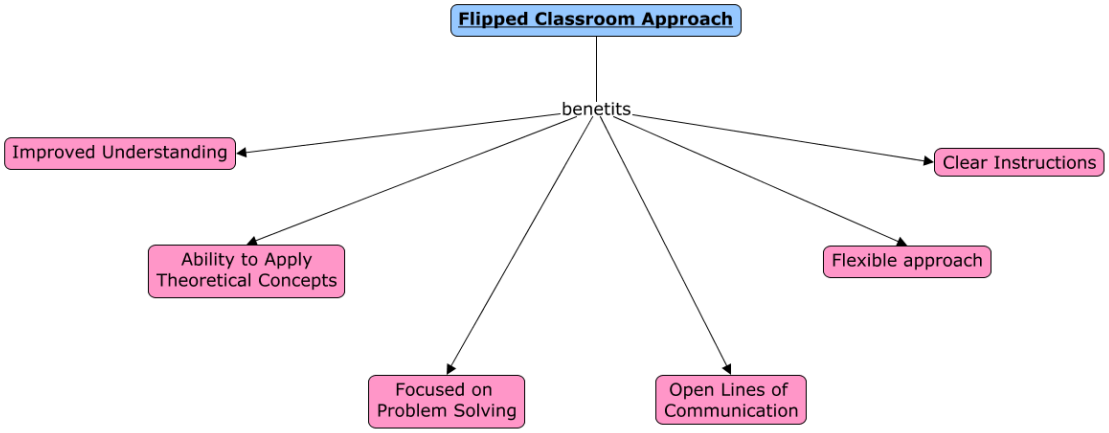

Figure 12: Perceived general benefits of the flipped classroom approach

Perceived Limitations of the Flipped Classroom Approach

Students perceived the activities to have nine specific limitations (see Figure 13) that could be summarised as two general limitations (see Figure 14). The perceived limitations of techniques employed during the flipped classroom approach are discussed below. Responses from both SAC and SDIC questionnaires have been discussed in combination. These relate to perceived limitations of the quizzes, exercises, class discussions, workshops and the approach overall.

Limitations of the quizzes

The perceived limitations of the quizzes, as reported by students, included: no marks were allocated for them, their timing in the sense that the quizzes were not available soon enough and the limited internet access of some students. Some students felt that they only completed the quizzes in order to be granted permission to complete the exam. These students did not worry about the correctness of their answers, as no marks were associated to the quizzes.

Some felt that all quizzes associated to a particular topic should have been accessible *in one go* to enable students to complete them all at once as opposed to forgetting to do so.

A minority of students had no internet connection at home and were not able to complete them after normal work hours.

> *Quizzes should count for the final mark, hence people would put more effort in [SAC – R60]*
>
> *Having to do a quiz every day/night before the next days' lecture can lead to forgetting to do the quiz. Keeping the same system but post all the quizzes for the week beforehand allowing people to do all quizzes for the week in one go if they fell like it [SDIC – R60]*
>
> *Quizzes, not all of us have access to the internet when the quizzes are uploaded and then are missed involuntarily [SDIC – R11]*

Limitations of the exercises

A few students felt that the exercises were not useful because they were being done too frequently and were thus time consuming. Another concern related to the complexity of these exercises. Some students felt that they were too simple in comparison to the workshop questions, while others felt that they were too complex.

> *Often homework much more complex than the demos done/discussed during lectures before and therefore can be quite challenging (uncertainty of how to approach some situations in homework) [SAC – R95]*
>
> *It may be more useful to make exercises a bit more challenging (i.e. more like the workshops) to prepare us properly [SDIC – R62]*

Limitations of the workshops

The perceived limitations of the workshops according to the students pertained to the team size, the complexity of the workshop exercises and the duration of the workshops. Some students felt that by working in teams of four, they were not able to truly assess their level of understanding and simply concurred with the majority.

Some students were unable to detach and apply their knowledge to solve more complex problems than the ones specified in the exercises, especially in programming workshops. They thus reported that they did not feel prepared for these workshops where they were "thrown into the deep end".

Some students also felt that a two-hour workshop was too short and that they were unable to complete the exercises on time.

> *Not as prepared as could have been as the level of the workshop was much higher than that of the class exercises [SDIC – R62]*
>
> *Size of the groups cripples one's ability to truly know if one is understanding and learning rather than just agreeing with team member's methods [SAC – R45]*

Limitations of the class discussions

A minority of students felt that the class discussions were hard to follow. By nature, modelling can be done in many different ways and the class discussions were often centred on exploring the various modelling options and assessing their validity. This seemed to confuse some students who then disengaged from the discussion

Sometimes the class exercises just confused me more because of everyone's differing opinions and ideas. It's difficult to get a concrete answer in subjective exercises like these [SAC – R21]

Overall limitations of the flipped classroom approach

According to some students, the general limitations of the approach related to not always being able to understand the prescribed readings, thus making the class exercises more difficult, and workload was seen as an issue by some because they felt that they did not have the time to complete exercises at home and engage with the prescribed material beforehand.

The work often is not clear enough beforehand, making class exercises difficult [SAC – R81]

They are ideal but reality is most students don't really have time for daily homework [SDIC – R10]

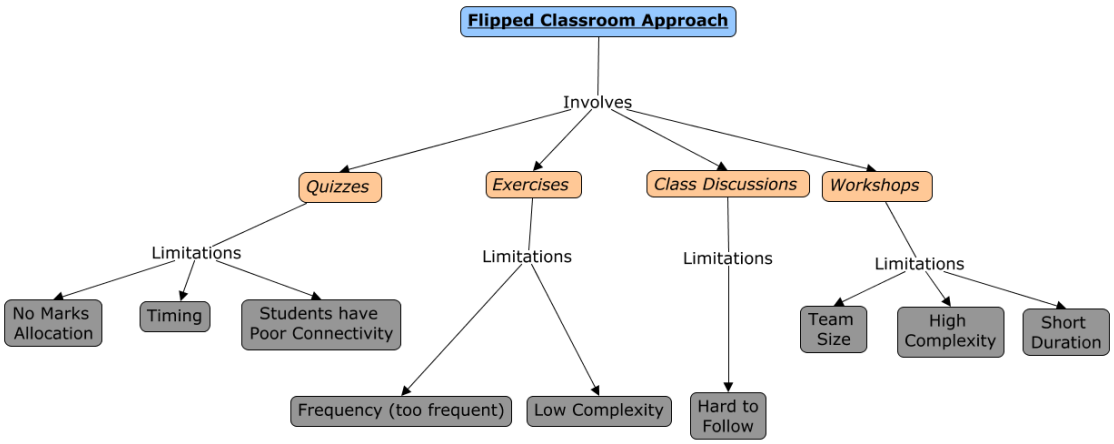

Figure 13: Perceived limitations of adapted flipped classroom approach interventions

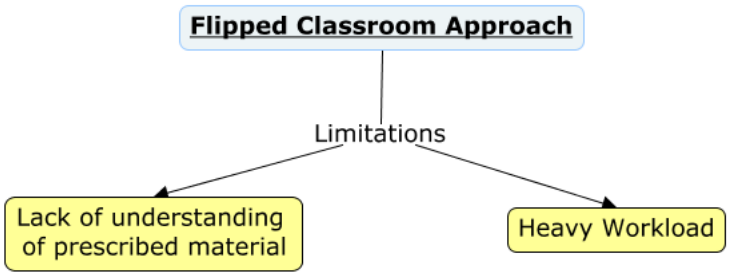

Figure 14: Perceived limitations of overall adapted flipped classroom approach

Discussion & Recommendations

From the analysis of the qualitative data, it has been found that students perceived several benefits from this approach as described in the previous section. However, limitations were also highlighted and in this section, mitigating strategies are proposed in line with the literature.

Improving the Quizzes

Students reported that quizzes enabled them to engage and keep up to date with the material. This was reflected in practice where they demonstrated a deeper understanding of the concepts during the workshops, project, test and exam as the grades were higher than in 2013. Similar to this study, others have found that online quizzes are useful in encouraging students to engage in preparatory readings which further result in improved student performance (Dobson, 2008; Johnson & Kiviniemi, 2009). However, in light of the limitations highlighted (no allocation of marks, timing, and limited connectivity of students) the following recommendations are made:

(1) Quizzes account for a meaningful per cent of the final marks and the level of question complexity be carefully considered to suit all levels of student.

(2) Quizzes be posted and made available as soon as the lesson plan is uploaded on the LMS. Ensuring that quizzes are available well in advance would enable students with limited connectivity to complete them on campus at their convenience

Improving the management of the quizzes as specified above could also allow for Just-In-Time Teaching (Novak & Patterson, 1998). For example, quizzes could be due 2-3 days before the lecture, allowing the lecturers to review the students' answers and identify common misconceptions. These misconceptions would then be addressed during the lecture.

Improving the Exercises and workshops

Students associated several benefits of the exercises and workshops. They felt that these exercises and workshops kept them up to date with the course content, improved their understanding, engagement, and ability to apply the concepts, promoted reflective learning and learning by doing, and highlighted gaps in their understanding. In line with Davies et al. (2013), this suggests that students were transformed from passive listeners to active learners. However, some limitations were noted around the frequency and complexity of the exercises. Limitations of the workshops related to the team sizes, the complexity of the questions (especially when related to programming) and duration.

Students perceive many of the programming workshops as being complex and the pace of building on the workshop entities in the series, too fast. It seems that there is a global perception that programming is notoriously difficult to learn and to teach. In the words of Jenkins (2002, p. 53), "If students struggle to learn something, it follows that this thing is for some reason difficult to learn." It would seem that in order to teach more effectively, it is essential for educators to have an understanding of what it is about programming that makes learning it so troublesome for many students worldwide. The theory of coherent practice highlights the importance of frequently engaging in these exercises and gradually building complexity from exercises to workshops. The justificatory theory states that students need to transition from being a novice, where detailed information is received to that of an advance beginner where the relevant context of the material is understood (Dreyfus & Dreyfus, 1986). This transcendence can continue until a student reaches the expert stage, although many students do not reach this level.

Improving the Class Discussions

In line with Toto and Nguyen (2009), students reported that they enjoyed lectures focusing on problem-solving and hands-on activities, which were useful to improve their understanding of concepts. The class discussions thus provided remedial assistance to students who misunderstood some concepts and needed clarifications (Davies et al., 2013), increased students engagement and satisfaction with learning experiences (Hugues, 2012).

In spite of these advantages, some students felt that these class discussions were hard to follow and thus tended to disengage during these activities. In line with Boyle and Nicol (2003), an electronic classroom communication system could be used to promote active discussions in large classrooms. The use of this technology promotes participation, allows the lecturer to quickly assess the overall class level of understanding, and allows students to evaluate how their personal responses relate to the rest of the class during the discussions.

Improving the Overall Approach

The students perceived the overall approach to be beneficial but some students appeared uncomfortable with the need to take responsibility for their learning and complained about the heavy workload. Other studies on the flipped classroom approach also report on this phenomena (Strayer, 2007). Mason, Shuman, and Cook (2013) further noted that it is essential for students to accept personal responsibility for their learning as this is instrumental to personal development. In line with Fredrickson, Reed, and Clifford (2005), this might be alleviated by adapting the lesson plan to clearly articulate the learning objectives expected from the students. Learning objectives could be split between *Basic* and *Advanced* so that students are aware of what they need to know before the lecture and what they should know after having engaged with all the material in class exercises and workshops. The advanced learning objectives could also guide class discussion and help with exam preparation.

Conclusion

This paper provided a detailed description of the flipped classroom approach used for two second year Information Systems courses at a South African University. The various techniques employed were described and their relevance was assessed based on the students' perceived benefits and limitations of the approach.

Overall, the proposed flipped classroom approach appeared to have a positive influence on students' attitude to learning. They reported that through this approach, they obtained a deeper understanding of the theoretical concepts and were better able to apply these concepts. They enjoyed the interactive nature of the approach and felt up to date with the course content and more engaged throughout the semester. They also identified gaps in their understanding early and were better able to address these gaps.

Some limitations were also noted which were mostly related to a reluctance to take charge of their own learning (for some of them) and an inability to engage in group discussions. A set of recommendations have been proposed to address these gaps in line with what has been prescribed in literature.

The flipped classroom approach proposed in this paper could be used in other Information Systems or Computer Science courses at tertiary education level, if these courses required students to apply their knowledge and critically evaluate the relevance, effectiveness and usability of their models and designs. Bergmann and Sams (2012) as well as Davies (2011) recommended that more research be conducted to evaluate the benefits and challenges experienced from the various forms of flipped classroom approaches and this study addresses this. In conclusion, it is hoped that this approach would be useful to other academics involved in the teaching of systems analysis and design using UML in tertiary education institutions.

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Biography

Dr Maureen Tanner has been teaching systems analysis and design at the Department of Information Systems of the University of Cape Town since 2009. Her research interests lie in Agile software development related issues (for both collocated and distributed teams), UML, software engineering and social aspects of social engineering, global software development, virtual teams, and team collaboration.

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