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Out of Classroom Instruction in the Flipped Classroom: the Tough Task of Engaging the Students

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Abstract. This article presents experiences and student perceptions on the introduction of the flipped classroom model in two consecutive semesters at Media Technology department of Aalborg University, Copenhagen, Denmark. We introduced the flipped instruction model to a statistics course and a mathematics workshop. We collected data by two online survey studies, which show support for student perceptions that out-of-classroom instruction with online resources enhances learning, by providing visual and in depth explanations, and can engage the learner. However, students stated that they miss just-in-time explanations when learning with online resources and they questioned the quality and validity of some of them. Based on these findings and our own experience, we discuss requirements for resources and activities in flipped classrooms in order for the student to engage and learn. Finally, we present a framework for experienced-based learning in flipped classrooms to promote student reflection.

Keywords: Flipped Classroom · Mathematics · Screencast Technology · Student Engagement · Student Learning

1 Introduction

One of the recent developments in teaching, which heavily relies on current technology and open resources, is the flipped (or inversed) classroom approach [3]. In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. The course content, which is provided for self-study, may be delivered in the form of screencasts and/or pre-class reading, exercises or quizzes, while class time is mainly used for group work activities. The hypothesis is that there could be deep and creative discussions when the teacher and students physically meet. This teaching and learning approach endeavors to make students owners of their learning trajectories [8].

Various researchers and instructional designers have sought to investigate the advances in flipped learning environments. Kay and Kletskin introduced problem-based video podcasts covering key areas in mathematics. The video podcasts were created

adfa, p. 1, 2011.

as self-study tools, and used by higher education students to acquire pre-calculus skills [11]. The results indicated that a majority of students used the video podcasts frequently, viewed them as easy to use, effective learning tools, rated them as useful or very useful, and reported significant knowledge gains in pre-calculus concepts.

Love et al. compared a classroom using the traditional lecture format with a flipped classroom during an applied linear algebra course [17]. Students in the flipped classroom environment had a significant increase between the sequential exams compared to the students in the traditional lecture section, but they performed similarly in the final exam. Moreover, the flipped classroom students were very positive about their experience in the course, and particularly appreciated the student collaboration and instructional video components.

Bates and Galloway conducted a practice-based case study of curriculum redesign in a large-enrolment introductory physics course [2]. The course followed a flipped classroom approach, where lectures were transformed to guided discussion sessions, with focus on peer instruction techniques and discussion facilitated by extensive use of clicker questions. Their results suggest student engagement with pre-class reading and quiz tasks, positive student perceptions of this different instructional format and evidence for high quality learning.

Enfield applied a flipped classroom model of instruction in two classes of a course focusing on web design [7]. Student reports suggested that the approach provided students with an engaging learning experience and was effective in helping students learn the content. They also found that students increased self-efficacy in their ability to learn independently.

While the aforementioned approaches report on benefits of the flipped classroom, there are also critics to this approach [12], [18], [19]. Concerns include among others: criticism about the accessibility to online instructional resources, the growing move towards no homework, increased time requirements without improved pedagogy, teachers concerns that their role will be diminished, lack of accountability for students to complete the out-of-class instruction, poor quality video production, and inability to monitor comprehension and provide just-in-time information when needed.

Our research efforts focus on improving mathematics education in “creative” engineering studies by use of technology [26]. In this context and taking into consideration the reported strengths and weaknesses, we introduced the flipped instructional model during two consecutive semesters for a statistics course and a mathematical workshop at Media Technology department. In both semesters, we collected data on student perceptions on their experience with this new instructional model through survey studies. In this article, we discuss the results and we extract requirements for resources and activities in flipped classrooms that promote student learning and engagement.

This article is organized as follows: the next section discusses the theoretical framework, which we employed for designing the flipped classroom and the related out-of-classroom and classroom activities, the third section reports on the methods we used to design our studies, the fourth presents data from two survey studies on student perception on the flipped classroom and our own experiences, while the fifth section discusses these findings and proposes a framework on experience-based learning that can be used to improve student reflection and engagement in flipped classrooms. We conclude this article with some suggestions for future work.

2 Problem-based Learning and the Flipped Classroom

In the literature, there have been used various theoretical frameworks to justify the flipped classroom and support the design of in- and out-of-class activities. Such theoretical frameworks typically argue for the benefits of student-centered and collaborative learning (e.g. active learning, problem-based learning, peer-assisted learning) [4].

Throughout our research, we are inspired and guided by the Problem-Based Learning (PBL) pedagogy, which is applied at Aalborg University since its establishment in 1974 [1]. PBL is a student-centered instructional approach, in which learning begins with a problem to be solved. Students need to acquire new knowledge in order to solve the problem and therefore they learn both problem-solving skills and domain knowledge. The goals of PBL are to help the students "…develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation." [10].

At Aalborg University, PBL is also combined with group work [14]. While working in groups, students try to resolve the problem by defining what they need to know and how they will acquire this knowledge. This procedure fosters the development of communication, collaboration, and self-directed learning skills. Moreover, group work in PBL may enable students to experience a simulated real world working and professional environment, which involves process and communication problems and even conflicts, which all need to be resolved to achieve the desired outcome.

Additionally, PBL represents a paradigm shift from the traditional one way instructional methods. In PBL, the teacher is not an instructor but rather a tutor, who guides, supports, and facilitates the learning process. The tutor has to encourage the students and increasing their understanding during the problem-solving process. Therefore, the PBL teacher facilitates and challenges the learning process rather than strictly transmitting domain knowledge.

Therefore, the flipped classroom that employs computer-based individual instruction outside the classroom and devotes classroom time to group activities with the teacher as facilitator is well justified by the aforementioned principles of PBL. The goal of a flipped classroom is to let the student study individually at her own pace while providing the appropriate support material for out-of-classroom instruction and then come into class, where groups of students engage in group activities facilitated by the teacher. Since our previous research has shown that mathematics courses at Media Technology follow mostly the one way transmission model (lectures as presentation of information) [24], we decided to introduce the flipped classroom approach in mathematics related courses for Media Technology students for aligning them with the PBL pedagogy. In the following sections, we present two studies on the introduction of the flipped classroom at our department with a focus on out-of-classroom instruction.

3 Methodology

We introduced the flipped instructional model during two consecutive semesters at the Media Technology department, Aalborg University Copenhagen. In the first semester, we introduced a flipped classroom approach for a statistics course [25], while in the second semester we used this approach for teaching mathematics related to computer graphics rendering [23]. To facilitate this instructional approach, we provided students with online resources for out of classroom instruction. In the first semester, we created our own screencasts, which were combined with selected sections of the www.mathisfun.com webpage, readings from the www.betterexplained.com webpage, and scanned lecture notes from their past mathematics course covering the relevant subjects. In-class assignments were provided along with each lesson. In the second semester, we substitute our screencasts with selected Khan Academy screencasts and related practice problems, because our experience was that creating quality screencasts is time consuming and hard, since students criticized our won screencasts. Students were required to choose at least one of the proposed resources for studying before lectures. We estimated that going through any of the provided resources would not take more than one hour and a half to complete.

In both semesters, the learning process generally followed the same sequence. Prior to class, students were expected to watch the related video lessons and read the external web resources. In the second semester, students were also provided with some practice problems, which were related to the material they had just studied. In both cases, students were provided with a reading guide in order for students to not get lost in the provided information. During class, a question round took place, in order to clarify aspects that students found challenging. Then, students were provided in-class assignments to reflect on, discuss, and practice what they had learned. The classroom activity was mainly not teacher led; instead, students in groups worked on the assignments while the instructor provided individual guidance as needed. The in-class activities were structured so as to provide students with a variation of the tasks they completed when watching the video, providing opportunity for both practice and transfer of learning to new situations. Additionally, some activities were teacher led demonstrations. Since students were expected to already know some content from previous mathematics courses, the teacher was calling on individuals to explain what to do to complete the task.

During both semesters, we conducted a survey study in order to further investigate student acceptance and experiences in the flipped model, and student perceptions and preferences on screencasts. These online surveys used a Likert scale in order to collect student responses. Items in the survey were measured using 5-point rating scales, with the range of answers from “strongly disagree” to “strongly agree.” Moreover, there were items, which gave students the opportunity to provide further information in an open-ended manner.

4 Combining Experiences and Results from Two Survey Studies

In the first semester, we collected answers from 104 fourth-semester students, while in the second semester 46 fifth-semester and master students responded to the survey (N_1=104, N_2=46). The results of these two survey studies and their analysis are described in [25] and [23]. In the following, we present results from both studies (quantitative and qualitative data). For better presenting the results, we have analyzed the responses and extracted the main topics raised by the questionnaire statements and students' comments.

4.1 Impact on learning and understanding

The majority of students who were exposed to out-of-classroom instruction reported that using screencasts and other online resources contributed to improved learning and understanding. In their responses, students mentioned the following characteristics of such resources as improving their learning and understanding. Firstly, online resources can be seen or read multiple times and they give the learner the opportunity to only focus on specific parts of it. This feature allows for recapitulation of challenging parts of the reading curriculum and focusing on what the individual student perceive as important. Regarding adapted instruction, another important feature of online resources is that they provide different means and approaches for explaining the same thing. For that reason, students reported that such resources also contribute to understanding the course material, since they can find alternative explanation in case they are not satisfied with ones provided in the material chosen by the teacher to cover course-related topics. Students also mentioned that screencasts increase understanding because they provide step-by-step explanations and an overview of the process of solving a specific problem. When Khan Academy material was used, students favored also the fact that they are provided with hierarchically organized mathematical knowledge and the connection between topics in mathematics.

Nevertheless, there were students, who criticized the effect of screencasts and online resources in better understanding. Some of them argued that watching a screencast or reading a solved mathematics example does not necessarily lead to improved learning, if learners are not forced to practice themselves. Some others reported that out-of-classroom instruction can be difficult to follow for weak students with gaps in their mathematical knowledge or who don't understand the terminology used. Finally, a student expressed even a more general concern regarding online resources. He feared that getting used to find solutions and explanations on the internet, the learner becomes lazy – as he mentioned: "…*on a philosophic point of view, we could end up as "google-heads" where the things we look up on the net are not really remembered at all, since our brain might fall into a sleep in which it's accustomed to be given the answer instead of remembering it*…".

4.2 Self-reported engagement

In the survey studies, students were asked if different resources help them to engage during out-of-classroom instruction. Students gave screencasts a better engagement mark compared to text-based online resources. They also favored the fact that they can follow out-of-classroom instruction at their own convenience and they can control the pace instruction. Furthermore, they mentioned that they felt engaged in the classroom, because they could on their own try things out before the lecture and then ask more relevant and specific questions to the teacher. However, few students said that it was boring and tiresome to watch screencasts.

4.3 Information overload and filtering

Although we provided the students with a detailed reading guide and we selected only relevant sections from the online resources we proposed to them, there were still students who complained about the time they had to spend on out-of-classroom instruction. Others criticized the screencasts for being too long and others said that they feel overwhelmed by the plethora of information on the internet, when they are searching for alternatives explanations. Finally, many students challenged the validity of the available information on the internet. They argued that not all sources can be trusted and that in some cases information is misleading. A student summarized both problems of information overload and validity as follows: "*It may take a long time to find the right resources for you and you cannot be 100% sure they are actually correct*."

4.4 Out-of-classroom and classroom instruction

Regarding out-of-classroom instruction, students appreciated the fact that they could be introduced to lecture material and practice with it before going to the class, because according to their comments they were able to ask more in-depth and meaningful questions. They also mentioned that it felt as they had more time for the course compared to traditional lectures. In general, we got positive feedback for the new instruction model and students mentioned that they liked the combination of out-of-classroom and classroom instruction.

What students missed in out-of-classroom instruction was mostly the ability for just-in-time explanations. Students said that it would be nice to be able to get answers to questions raised while studying alone. Moreover, the students mentioned that in-classroom explanations are paramount and they underlined the importance of interaction with the teacher. Finally, there were students who said that they were not sure how they feel about the flipped classroom, since it was the first time they experienced this instruction model.

5 Discussion

Our results so far indicate that online resources were seen by students as valuable and useful as an aid to learning. We also believe that out-of-classroom instruction can contribute to improved understanding, since it has been found that working with mathematics by themselves is perceived by students the most important learning [22]. Screencasts, visualizations and other online resources are also powerful media and provide different ways to engage with mathematical thinking. Nevertheless, it is imperative that teachers make sure that students practice while going through all this material, otherwise they cannot be sure that authentic learning takes place [21]. Providing practice tests and quizzes can help in making the students study and come to class prepared. Moreover, out-of-classroom and classroom (typically group) activities should be carefully chosen and always being part of a pedagogical framework, which justifies this kind of activities. Otherwise, teachers cannot be sure that such activities will result in meaningful mathematical work and student learning. If these preconditions are met, then the lecture time can be devoted to in-depth discussions and the teacher will be able to offer personalized and meaningful feedback. Otherwise, the lecture time has to be spent for presenting the information the students should have studied before classroom, and this eliminates the added value of a flipped classroom.

A flipped classroom may also contribute to more engaged students. Our results show some evidence for that, since students reported that working with online resources increased their engagement. We also experienced that in-group and in-class discussions during lectures unfolded more smoothly, students participated more actively and asked not only more but also more advanced questions compared to our previous classes. The group classroom activities were another engagement factor, especially for weaker or more introvert students.

However, the decision of which tools should support the out-of-classroom learning is a crucial one not only in terms of learning but also for engaging the student. Based on our experience, we propose that the time devoted to out-of-classroom activities is estimated and kept in mind, when choosing the material given to students or when producing resources (e.g. screencasts). A guided reading curriculum will also help students structure their out-of-classroom studying and not get lost in the provided information. Moreover, providing all the necessary information is important in order to avoid students spending their time looking for it on the web. Finally, as far as online resources in general are concerned, we recommend that students are taught how to determine the validity and affordances of such resources.

In their responses, students reported that they lacked the ability for clarifying challenging parts during out-of-classroom instruction. In order to deal with such problems, researchers have introduced the holistic flipped classroom, where teachers support students both in- and out-of- classroom [5]. Nevertheless, such approaches increase the burden of the teacher, who has already a tight schedule in a flipped classroom (production or selection of online resources, planning of activities and actual lectures). Moreover, we believe that letting the student think about the challenging parts is not per se a disadvantage, because it provides time for students to reflect before coming to the classroom, where the teacher can help. Of course, clear instructions about how and when answers and clarifications will be given are required, in order to avoid student frustration. Practice tests can also help the students check their comprehension, while studying by their own.

All in all, we received positive feedback for the new flipped instruction model. Students were in favor of the blending character of this model, in accordance with results of other studies (e.g. [16]), although there were some students who underlined the importance of the teacher's role and of in-classroom explanations. This may be attributed to the fact that this was their first experience in a flipped classroom, where the teacher's role is different compared to the traditional lectures, where he uses most of the classroom time. In the literature, there have been reported similar comments from students who think that the teacher's role is reduced in flipped classrooms [9], but we believe that they can be attributed to the transition phase from a traditional to a flipped setting. In such transitional phases, students will need time to get used to their teacher's new role.

By applying the flipped classroom, we have also noted that it has another important potential, which has not been emphasized in the literature. The flipped learning model can be used to support a continuous cycle of student reflection over practice and experimentation [15]. We use the term reflection, as used in the Cowan model (**Fig. 1**) [6]. Cowan combines the analytical reflection from Kolb's experienced-based learning cycle "experience-reflect-generalize-test" [13], with Schön's evaluative reflection for creating this model of reflection loops [20]. Schön's reflection-for-action is the reflection that takes place prior to actions, while his reflection-in-action and the actual action take place at the same time. Kolb's reflection-on-action is more systematic than reflection-in-action and a means to get from experience to conceptualization. We propose that provided that the out-of-classroom and classroom activities are designed properly and the reflection process is facilitated by the teacher, the flipped instruction model with its out-of-classroom, in-classroom and after-classroom phases can be used to involve students in reflection loops and to progress experienced-based learning. However, we still have to apply this framework for data collection in order to prove our assumption.

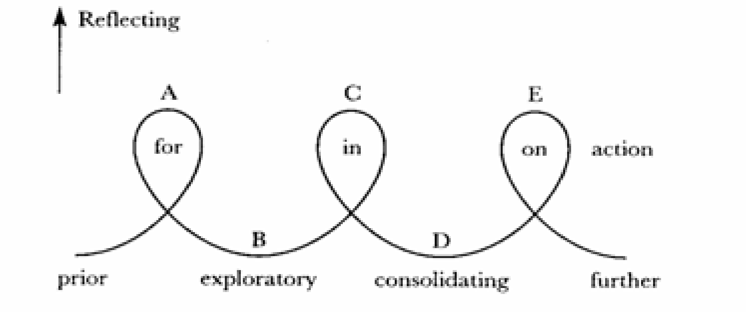

Fig. 1. Cowan's model with reflection loops (taken from [6])

6 Conclusions

In this article, we presented results from two survey studies conducted in two consecutive semesters at the Media Technology department of Aalborg University Copenhagen. Taking inspiration from the PBL pedagogy, we applied the flipped instruction model in a statistics course and then at a mathematics workshop. The studies addressed student perceptions on the flipped classroom approach, they had just experienced. We discussed the results of these studies in four dimensions: self-reported impact on student learning and engagement, information overload and filtering and out-of-classroom and classroom instruction. This discussion revealed some of the advantages and disadvantages of the flipped classroom according to students and according to our own experience. Based on these findings, we proposed design requirements for out-of-classroom instruction. We believe that the flipped classroom can increase student engagement and motivation, encourage deeper though and provide confidence for weaker students, provided the aforementioned design requirements are taken into consideration. Our results suggest also that the resources and activities in such classrooms may determine if the student will engage and learn. Therefore, we presented a framework for student reflection that can be used for designing resources and activities at flipped classroom to promote experienced-based learning. Although the results revealed that students perceive out-of-classroom instruction as contributing to their learning and understanding, it is difficult to draw firm conclusions in terms of improvements to student learning as at this stage it has not been possible to measure this quantitatively. In the future, we aim at applying the presented framework in order to collect data on student reflection in the flipped classroom, and at conducting a quantitative study, in order to compare student attainment in traditional and flipped settings.

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