Flipping the classroom in engineering mathematics: why does not flipped classroom work for everyone?

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This paper explores students' experiences with a flipped classroom lecture format in a first-year engineering mathematics course with 118 students. While most students were satisfied with the flipped classroom and expressed appreciation for the flexibility, freedom and independence induced by the teaching method, other students expressed frustrations. Based on two surveys with both open-ended and closed-ended questions, the present study explores possible reasons why flipped classroom can be a source of frustration. Some students expressed having difficulty adjusting their study habits to the flipped classroom approach as well as having difficulty finding the motivation to watch the required learning videos before lectures. While some students viewed the group-work associated with the lecture format as a positive aspect of their learning, other students expressed irritation because of group members not meeting prepared for the group assignments. The results are discussed in light of self-determination theory and self-regulated learning theory.

Keywords: *Flipped classroom, student experiences, self-regulated learning, self-determination theory*

Introduction

The flipped classroom is a popular teaching method that entails students watching pre-recorded videos of the course material out of class in order to focus on student-centric activities such as group assignments and problem-solving in class. Studies on flipped classroom have shown promising results such as increased student performance (e.g. Foldnes, 2016; Nouri, 2016, Wasserman et al., 2017), increased self-confidence (Batiyeh and Naja, 2017), and perceived higher competence with the course material (Ha et al., 2019) as well as promoting creative thinking (Al-Zahrani, 2015; Batiyeh and Naja, 2017). By focusing the in-class time on students working with peers, the flipped classroom adheres to a socio-cultural learning style (Steen-Utheim and Foldnes, 2018; Bishop and Verleger, 2013), which theorises that learning is best fulfilled in a social context through interaction with others.

Abeysekera and Dawson (2015) went further to explain the possible benefits of flipped classroom by using cognitive load theory and self-determination theory, the latter being a theory of human motivation and development. Students in previous studies have expressed appreciation for the ability to pause and rewind the pre-recorded videos (Triantafyllou, Timcenko and Kofoed, 2015; Ahn and Bir, 2018) as well as the general time flexibility (Fisher, LaFerriere and Rixon, 2019) and freedom (Fisher et al., 2017) flipped classroom offers. Abeysekera and Dawson (2015) argues that the ability for self-pacing when watching videos might have a positive effect due to reducing cognitive load, i.e. the amount of strain posed on the working memory. This was the results of a study by Karaca and Ocak (2017), where the researchers found that flipped classroom could reduce cognitive load compared to traditional lectures. The reduced cognitive load might increase learning potential with flipped classroom, and Abeysekera and Dawson (2015) argues that flipped classroom, as a result, might also increase student motivation due to an increased feeling of competence with the course material.

Self-determination theory (SDT) describes the need for competence as one of three fundamental psychological needs that influences human development and psychological wellbeing, the others being the need for autonomy and relatedness (Deci and Ryan, 2008). The flipped classroom offers a great deal of choice and freedom for students to tailor the learning environment to their liking, i.e. giving them greater autonomy than being confined to passive listening in a lecture hall (Abeysekera and Dawson, 2015). Flipped classroom is also argued to increase students sense of belonging and relatedness to others (Abeysekera and Dawson, 2015), which can be indicated by some studies that have shown that flipped classroom can increase students' willingness to work with peers (Strayer, 2012; Batiyeh and Naja, 2017) as well as inducing a feeling of commitment and shared responsibility to fellow group members (Steen-Utheim and Fondles, 2018).

According to SDT, fulfilling the needs for competence, autonomy and relatedness can increase *intrinsic motivation* for a task or activity, i.e. a willingness to perform the task because the activity itself is perceived as interesting and satisfying (Deci and Ryan, 2008). SDT also describes another form of motivation, *extrinsic motivation* which entails doing an activity not because it is satisfying or interesting, but rather to receive rewards or avoid punishment (Deci and Ryan, 2008). A student working hard on a subject to receive good grades, or as a result of social pressure to avoid being perceived as a failure, would be an example of behaviour guided by an extrinsic motivation. At first glance, intrinsic motivation seems like the obvious better form of motivation, and intrinsic motivation has been shown to produce better results than extrinsic motivation (Lin, McKeachie and Kim, 2003). However, extrinsic motivation also has

its place, for instance, to perform activities and tasks that while necessary, are not perceived as interesting or satisfactory. Furthermore, according to SDT, a sense of autonomy can still be fulfilled while extrinsic motivated if the students accept the importance and value of performing a task, and makes it their own, even when they have no choice in whether to do the task or not and where the task is not necessarily satisfactory in itself (Deci and Ryan, 2008).

SDT describes various forms of external motivation that are differentiated by the relative amount of autonomy and how students internalize the behaviour into their sense of self, ranging from *external regulation* (acting as a result of external demands), followed by *introjected* internalization (avoiding guilt or shame, or to increase a feeling of pride), *identified* internalization (activity is seen as important and having value) and *integrated* internalization (the activity has been aligned with students feeling of self) (Deci and Ryan, 2008). In a flipped classroom, students are often 'forced' to work independently and with peers by the nature of the lecture format, and not because they chose to do. However, Abeysekera and Dawson (2015) argued that the autonomy offered by flipped classroom, both in the choices on how they work with the homework and by being an active participant in the in-class-time, can increase students' ownership of their learning although they might be extrinsically motivated, and as a result increased the amount of internalization as described by SDT.

Based on the theoretical frameworks and positive results from previous studies, flipped classroom might seem like the 'silver bullet' of pedagogical teaching methods. However, studies have also shown mixed results with the lecture format such as lowering student motivation (Yough et al., 2017) and students preferring traditional lectures over flipped classroom (Novak, Kensington-Miller and Evans, 2017). A common challenge with flipped classroom is the lack of pre-lecture preparation by the students (see Shibukawa and Taguchi, 2019; Novak, Kensington-Miller and Evans, 2017; Jovanović et al., 2017; Fisher, LaFerriere and Rixon, 2019; Chen, 2016), which is a crucial part of success in the flipped classroom format.

The motivation for this study was at first to investigate how students who are used to a traditional lecture format in engineering mathematics experience a flipped classroom, as the unfamiliarity with the flipped classroom format can be a challenge for some students (Fisher et al., 2017; Chen, 2016). Studies have shown that students often need several weeks before being able to adjust their study habits to the flipped classroom (Yilmaz and Baydas, 2017; Mason, Shuman and Cook, 2013). Knowledge of how such students perceive the flipped classroom could therefore be valuable to find optimal ways of implementing the lecture format and reduce challenges for students not used to the lecture format. However, during the flipped

classroom implementation in this study, which will be described in detail in the next section, some students started openly displaying strong frustration with the lecture format. This shifted the focus of the study resulting in the following research question:

Why do some students have a strong negative experience with the flipped classroom approach?

There have been previous studies on flipped classroom where students expressed frustrations with the format, although the students usually became more positive as they became more used to the flipped classroom (Mason, Shuman and Cook, 2013; Chen, 2016). Some students can feel overwhelmed by the amount of pre-lecture work that is required (Shibukawa and Taguchi, 2019) and struggle to keep up with the homework (Strayer, 2012). In addition, Triantafyllou, Timcenko and Kofoed (2015) argued that not all students can handle the offered autonomy that flipped classroom offers, which goes against self-determination theory that describes autonomy as a fundamental psychological need. Thus, there is a need for a deeper understanding of students' negative experiences with flipped classroom in order to find ways to implement a flipped classroom such that more students receive the benefits to learning and motivation shown in other studies and to avoid pitfalls.

A flipped classroom requires students to change their study habits often drastically from the traditional lecture-style and increases the importance of being able to self-regulate their learning since a flipped classroom relies more on independent work. Zimmerman (2002) describes three phases that are a part of being a self-regulated learner, the *forethought* phase, *performance* phase and the *self-reflection* phase. In the forethought phase, students must set their goal and plan how and when they are going to work. This is especially important in flipped classroom since the students must figure for themselves out when they should watch the content. In the performance phase, students in a flipped classroom must have the self-control to do the necessary work, as well as self-observe how well their strategy is working. The self-reflection phase is where the students must evaluate how their strategy and performance worked and if there are necessary adjustments needed (Zimmerman, 2002). Students must be aware of their strengths and limitations which demands a high level of metacognition (Zimmerman, 2002), i.e. their awareness of their thinking, to make correct evaluations and adjustments.

Studies on flipped classroom have shown that students feel they become more independent (Zainuddin and Perera, 2019) and that the method teaches the students to become more responsible for their learning (Novak, Kensington-Miller and Evans, 2017; Batiyeh and

Naja, 2017). However, although students in a flipped classroom can recognize the importance of regulating their learning (Comber and Brady-Van den Bos, 2018), some students have shown resistance to change their study habits from the traditional lectures style (Boevé et al., 2017) even when they receive poor results (Jovanovic et al., 2017).

In the next section, the flipped classroom implementation in this study will be described. This is followed by a presentation of both positive and negative experiences expressed by the students on two anonymous surveys, with particular attention put on the challenges and negative experiences. These experiences are then discussed in light of self-determination theory and self-regulated learning theory with the aim of increasing the knowledge of students' negative experiences with flipped classroom.

Method

Background

The course 'Mathematics 2' is mandatory for all engineering students at Sør-Trøndelag University College in Norway (now a part of the Norwegian University of Science and Technology) and is taught during their second semester of the first year. A flipped classroom approach was implemented on the second half of the course for a class consisting of 118 students from three different fields: chemical engineering, material technology and logistics studies. Before flipping the classroom, the students would attend three 2x45 minutes traditional theory lectures each week (on Mondays, Tuesdays, and Thursdays). The students also had the opportunity to attend a guided session once a week where they could ask a senior student for help on written assignments, and a certain number of written assignments needed to be approved to be eligible for the exam. Both the traditional and flipped part of the course was taught by the author of this paper.

In the flipped classroom, the traditional one-way-style classroom lectures were substituted with student group activities and individual problem-solving sessions. Attending these sessions replaced the previous written assignments and counted towards the number of approved assignments needed for the exam. In order to be able to assist each student group during the group activities, the class were divided in half where each half was assigned to either Mondays or Tuesdays for group activities. In each half, the students were divided into smaller groups of 4-6 students who worked together during the group assignments. Students worked in a room designed for group activities called the 'learning laboratory' where each group had

access to their own Smartboard. In addition, a classroom was booked for Mondays and Tuesdays for students to use for self-study while the other groups attended group activities.

The in-class time on Thursdays was used for individual problem-solving exercises for all students in the lecture hall where the traditional lectures were held. The students were given problems during the first session (45 min.) which were to be solved without collaboration with fellow students. In the break between sessions, the students would use a student response system (SRS) to vote on which problems they found most difficult. In the second session (45 min.), the lecturer would explain the solution to each problem, were most time were given to problems students voted to be most difficult. After a few weeks into the flipped classroom, however, the individual problem-exercises were slightly changed to where the students were given one problem at the time and used the SRS to vote when they finished the problem (or gave up). The lecturer would then go through the solution of the problem on a Smartboard before the students were given the next problem to solve. Reasons for this change will be discussed later in this paper.

A total of 104 videos were made to cover all the subjects that would have been taught in the lectures. The videos were organized into 'lessons', where a typical lesson consisted of 4-6 videos with each video varying in length between 3 and 35 minutes (average video length was 13 minutes). There was a total of 20 lessons, usually bundled in groups of three that needed to be finished before the in-class activities. The total video length of each bundle would vary, but the average running time was about three hours. The in-class activities and out-of-class activities would work in parallel, i.e. students would work with the lessons for next week's assignments at home while having in-class activities based on last week's lessons (see figure 1). The students would usually have one week to finish the required lessons, with some exceptions where the students had two weeks (mostly due to various holidays). The flipped classroom lasted for the last 85 days of the course, the last problem-solving exercise being on day 73 and the exam being on day 85.

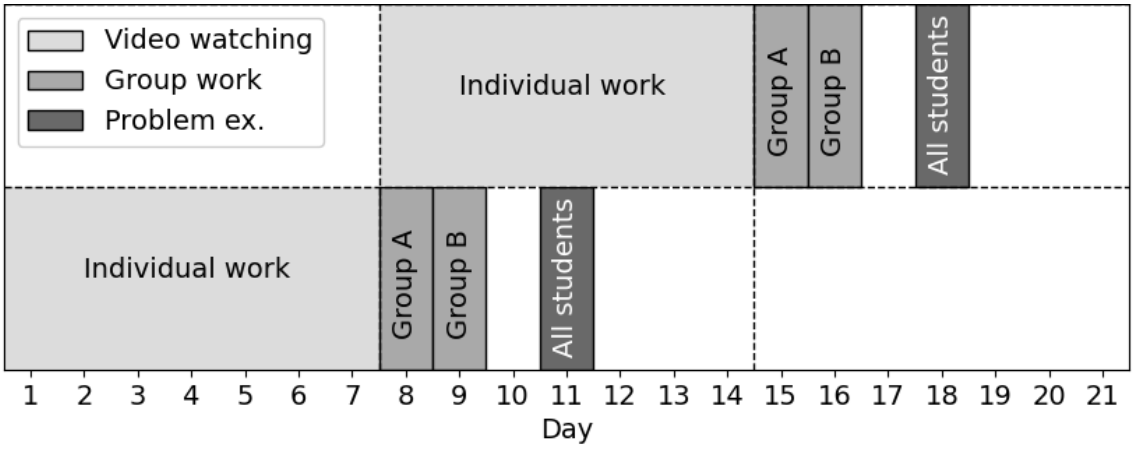

Figure 1. Example of the parallel nature of the flipped classroom implementation. Students would work with the video content out-of-class while having in-class activities the same week based on last week's video content.

Survey

The students were subjected to two anonymous surveys, one given at the middle of the flipped classroom-weeks and one given at the end of the semester. Both surveys contained a mix of open-ended and closed questions. The open-ended answers were subjected to a coding scheme reminiscent of the initial line-by-line coding scheme used in grounded theory where each line or sentence is given a code based on its content (Charmaz, 2003). Based on the codes and students' answer on the closed-ended question, a small summary was written for each student on both surveys were the open-ended answers were put in context to what the student answered on the rest of the survey. A small program was written to summarize all codes from open-ended questions to easier see recurring themes. All survey quotes presented in this paper have been translated from the students' native language, Norwegian. In addition to the surveys, video statistics from YouTube (where the videos were stored) were collected. However, students' viewing behaviours during the flipped classroom will be reported in another paper (Author, 2020).

Results

The learning videos

The majority of students were satisfied with the flipped classroom at the end of the semester. While 69% of the students who answered the second survey (n = 87) were either satisfied or very satisfied, 20% of the students were either dissatisfied or very dissatisfied (see figure 2). This was a statistically significant increase from the first survey given in the middle of the

flipped classroom weeks where 45% were satisfied (n = 64) and 33% dissatisfied (p = 0.015 with Mann Whitney-U-test, effect size = 0.22 (Cliff's delta)). On the last survey, the students were asked if they felt that they were given enough information on how to study effectively as a flipped classroom student. While 72% of the students felt that they were given enough information to either a large or very large degree, 23% of the students answered the more neutral "to neither large nor small degree". Only 5% of the students felt that they were not given enough information.

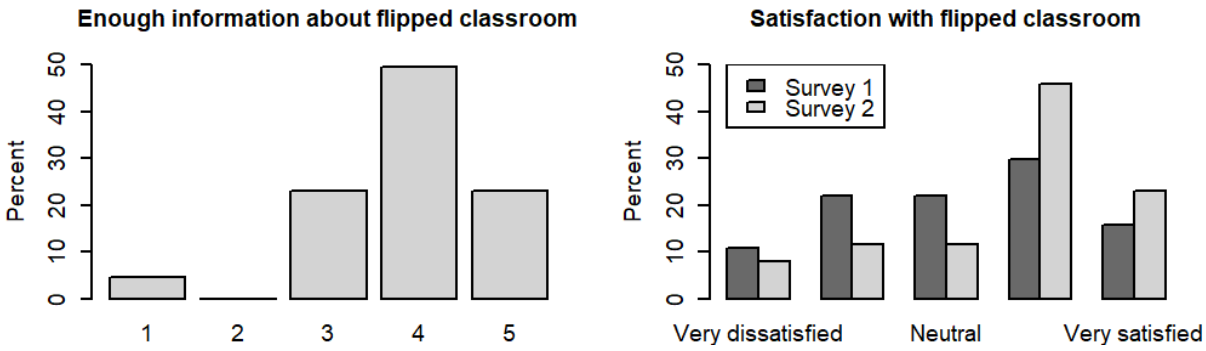

Figure 2. Comparison of student satisfaction with the flipped classroom from the first and second survey, as well as how well they felt they received enough information to study effectively with flipped classroom (5 = "very large degree", 1 = "very little degree").

Most positive comments on the flipped classroom focused on the freedom given by the videos, both regarding the time control given by having the theory in video format, but also in form of the freedom to choose when and where to watch the videos. As one student put it:

> You can take it at your own pace and study in a self-chosen environment. There are no social distractions. You do it when it suits you, i.e. if you are tired and unable to do it, you don't do it. More freedom for us students.

While 53% of the students who answered the second survey felt that it was easier to concentrate on the mathematical theory when it was presented in a video, 33% of the students felt that is was easier during the traditional lectures (see figure 3). Some students found the freedom of flipped classroom to be a hindrance since it is easier to be distracted when watching on a computer at home. As three students put it:

> When you must watch it on the computer there is a lot of things that can distract you, while in a lecture you are there to be lectured, and then it is easier not to go off track.

During the traditional lectures, you are "forced" to pay attention because you only have this 'one' change to really get the theory, while with the videos you are more relaxed because you know you can watch it multiple times.

It is easy to skip examples and less "important" things when you sit at home alone. It is much better to the "forced" to listen during a lecture. It is easier to skip a small 5-minute video compared to leaving a lecture.

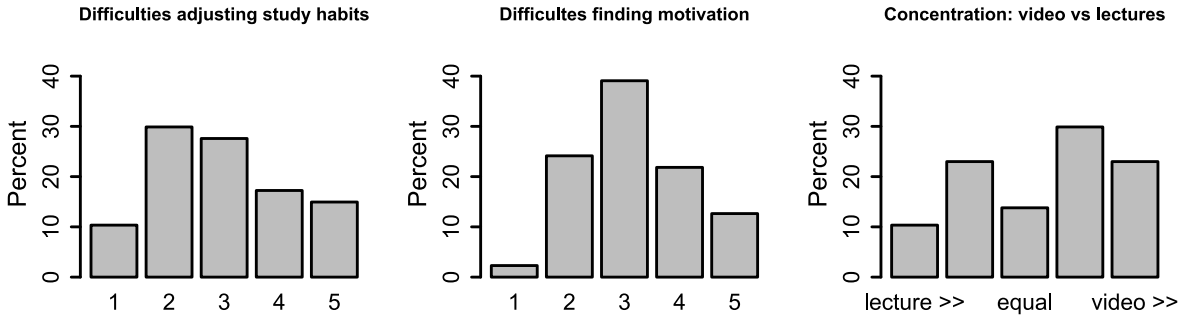

Figure 3. Questions from the last survey. Far left: "How difficult did you find it adjusting your study habits to the flipped classroom method?" Middle question: "How difficult did you find it finding motivation to work in the theory by yourself?" Alternatives on both questions: 5: "Very difficult", 4: "Difficult", 3: "A little difficult", 2: "Not particular difficult", 1: "Very easy". Right question: "How easy/difficult was it to concentrate on the theory when it was presented in lectures vs. a video?". Left alternatives: "easier/much easier with lectures". Right alternatives: "easier/much easier with videos".

One student also explained how being around other students could help with increasing the discipline of working with theory:

It is much easier to be disciplined to meet to the lectures when there are people around you that notice if you are around or not, compared to when you sit down and work with the videos on your own.

Figure 3 also shows to what degree the students found it hard to adjust their study habits to the flipped classroom as well as how difficult they found it finding the motivation to work with the subjects on their own. The distributions of the answers are relatively wide, meaning that there are many students that found it hard to adjust their study habits as well as finding the motivation to work by themselves as well as a large portion of students that did not. There were negative correlations between these questions and how satisfied the students were with the flipped classroom (Spearman's rho = -0.67 and -0.65 for "difficulty adjusting study habits" and "difficulty finding motivation" respectively). There was also a similar correlation were students who found it easier to concentrate on the theory with videos tended to be more satisfied with

the flipped classroom overall (Spearman's rho = 0.67). Some students also stated that they would have received the flipped classroom better if they were not as used to the traditional lectures, for example:

> The flipped classroom probably works better if you are used to it. I still do not quite know how to approach the lessons because I'm too used to the traditional lectures.

> Ever since primary school, I have been used to going to school and hearing a teacher talk. I think I am dissatisfied mostly because this is something I am not used to and because I have not chosen an online course, which I felt this was.

In addition to flipped classroom being an unusual lecture format for students used to the traditional lectures, it also is more demanding on students' discipline and ability to self-regulate their learning. The students must set up their own lecture plan, find a place and time to work with the theory and have the discipline to follow their plan. As some students put it:

> For anyone who is disciplined enough to watch the videos, flipped classroom is obviously better than traditional.

> I feel that the format is good, but it demands the students to be structured, something I know I must improve on myself.

> The importance of working independently and preparing well is greater with such a lecture style. Without independent work you get very little out of flipped classroom, much less than if you meet unprepared to a traditional lecture. But if you are good at working independently, meeting prepared and have a group that works well, then I think there is great learning potential in this type of teaching style.

One student elaborated further and explained how he/she saw how the flipped classroom made a greater distinction between students with good and bad study habits:

> In this lecture format I see a greater difference between those who work regularly and well with the subject matter and those who do not. It is much easier to fall off when everything is done at home, which requires some self-discipline. It is easier to go to a lecture than to sit down to complete the lessons at home. I see that those who previously showed up in the lectures, but did not work so much on their own, now neither watch anything particularly on the lessons or are working on their own (and then it is no wonder you don't manage to follow along).

The video statistics from YouTube showed high spikes in the number of views on the days before the group activities, indicating that there were several students that waited until the last

day before watching the learning videos. This was also reflected in some student answers, for example:

> I find it difficult to set up a "schedule" to be able to watch all the videos in time. I often end up watching everything on Sunday and Monday in order to finish before the group exercise on Tuesday. It will then be very much to do in a short time.

> The videos are long, and you feel that "you just want to be done", so I end up watching all videos in one day and get sick and tired!

The students were asked to state to what degree different sources were important for their learning of the subjects such as the videos, group work, fellow students and so on (see figure 4). Most students found the videos to be important for their learning, as well as studying old exams. The textbook, on the other hand, were for most students rated as the least important source for their learning. One student specified how some students might view the textbook:

> For people who may not be as motivated every time they have to work on math problems, the overly thick math book can often feel like a big black hole that sucks all motivation out of you already at the first page.

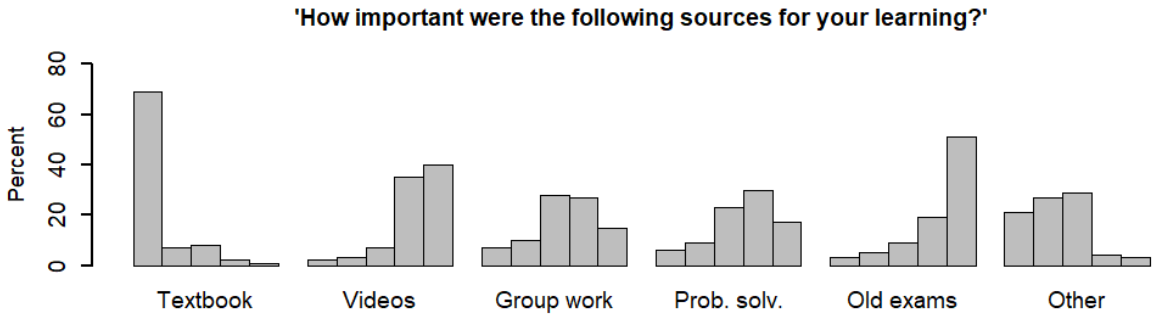

Figure 4. Student rating on how important different sources were for their learning. Alternatives ranging from "very important" (far right) to "very unimportant" (far left).

A common complaint from the students on the flipped classroom method was that it took a long time to watch all the videos in time for the group activities. There were also other complaints from some students that there was no possibility to ask questions during a video, and that the videos had too much focus on theory and not enough on problem-solving techniques, as well as the examples given in the videos, differed too much from the problems given in the group and problem-solving activities.

The group and problem-solving activities

Although the group and problem-solving activities were rated as less important for the students' learning compared to the videos, they were still valued for many students an important part of their learning. Some students described the benefits of working together with other students, as well as how the activities functioned as a motivator to work hard with the theory beforehand:

> I am very happy that we do tasks together as a group. It is easy to weed out mistakes and uncertainties with discussion and explanation on the smartboard. The problem-solving exercises are hugely beneficial, whether you get it or not. The time you have at school are used much better in this way and you work more regularly. It was very easy to fall behind before this type of lecture format.

> The lecture format works very well. The group and problem-solving exercises force us to watch the videos so we don't end up falling behind.

However, not all students found the problem-solving exercises as a positive aspect of their learning. As two students put it:

> Mathematics is a subject that needs to mature before getting the grip on it, and then it is very depressing for every problem-exercise and feel that you are not prepared when you have actually worked well through the lessons and group exercises and you see that you do not get it.

> I admit that on every problem-solving exercise I have "cheated" by using the notebook to see if I find something similar. I do this so that I actually learn something. I am totally chanceless without these, and I am rarely able to solve anything even if I look at the notes. If I look around, I see that almost no one can do more than write the problem text.

According to some students, there were also challenges with the group activities, especially when some group members did not come prepared. According to some students, this would result in less optimal group work in addition to be a source of frustrations for other group members. As some students put it:

> The group exercises work fine, but not optimally. The problem is that not everyone in the group is well prepared, that is, has not seen the videos beforehand, and then it can be a bit difficult to work effectively as a group.

> I experiences several group exercises where I had to use my time explaining people what they should have seen in the video lessons beforehand. I will gladly help fellow students, but I have no interest explaining things from scratch because they didn't bother doing their homework.

> The group works poorly as people come unprepared and there is a lot of sitting around the table where we are not able to get anything done. This is both because people can't contribute because they are not prepared, and because there is little help to get if no one understands the problem.

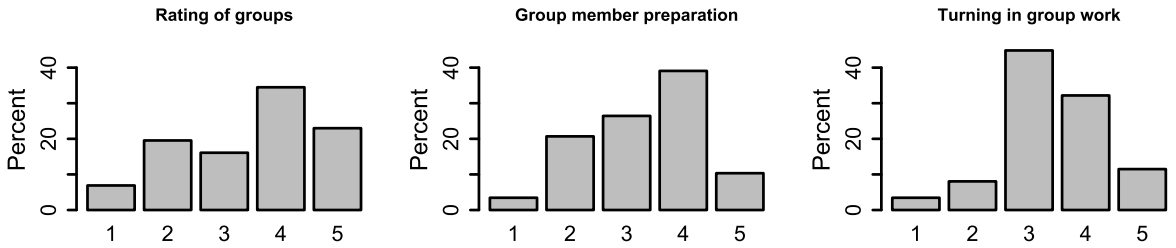

Figure 5. Left: "On the group sessions, I felt that my group functioned:". Alternatives from "very well" (5) to "very poorly". Middle: "To what degree did the group members come prepared?" Alternatives from "very high degree" (5) to "very little degree" (1). Right: "If you were required to turn in your work at the end of the group session, and that this had to be approved, how would this affect the group work?". Alternatives from "Much better" (5) to "much worse" (1).

The students were asked to rate how well they felt their group functioned, as well as to what degree they felt the group members came prepared. The results can be seen in figure 5. Students who felt that the group members came prepared tended to rate their group better (rho = 0.67). In addition, there were a negative correlation between group ratings and how important the groups were towards learning the mathematical subjects (rho = -0.49). Some students argued that they felt the group activities would have worked better if all groups were required to turn in their work for approval. As two students put it:

> No turning in group work makes the group demotivated since no one sees any point in making an effort.

> The group assignments become a little unserious since we solve the problems just for 'fun' without being checked or something (which we were used to from last year).

On the last survey, we asked the student how they felt this would have affected the group work (see figure 5). While 44 % felt that the group would have worked either "better" or "much better", 45 % of the students who answered the last survey felt that it would have made no difference. The most common complaint of the group activities, however, was the lack of a student assistant. Several students felt that it took too long to get assistance if they were stuck on a problem during the group work. This could result in time being wasted as the group could result in sitting idle while waiting for assistance.

Discussion

The students in this study were polarized on the difficulty of working with the flipped classroom format, as can be seen in figure 3, although the majority of students ended up being satisfied at the end of the semester. While many students appreciated the freedom and flexibility offered by flipped classroom other students saw it as a hindrance. Some students expressed that it was easier to be distracted when watching videos on their computer at home, which is aligned with results from other studies (e.g. Fisher et al., 2017; Fisher, LaFerriere and Rixon, 2019). While Abeysekera and Dawson (2015) argued that flipped classroom can lower cognitive load required to learn the course material, which is consistent with the study by Karaca and Ocak (2017), Jovanovic et al. (2017) argued that flipped classroom can have the potential of higher cognitive load as students both have to learn the course material as well as adjust and evaluate their study habits to a different lecture format. In addition, the students in this study did not value the textbook as a good tool for learning the material (which can also be seen in other studies on STEM education such as Seaton et al. (2014) and Podolefsky and Finkelstein (2006)). If the students struggled to understand the theory when being presented in the videos, they would either had to go elsewhere for other resources or be stuck with no viable resource for learning the course material out of class.

Although Abeysekera and Dawson (2015) used self-determination theory to explain the possible benefits of a flipped classroom, it could also be a valuable tool to help explaining negative experiences with a flipped classroom and why the lecture format could be a source for frustration. For instance, if students end up with no viable resource for learning the course material, as explained above, it could have a negative effect on their sense of competence, which could lower motivation according to self-determination theory. It is interesting to see how one student viewed the lack of the social aspects of attending lectures as a benefit to his/her concentration, while another needed the social pressure from peers to motivate him/herself. This goes to show that it can be challenging making flipped classroom accessible for all kinds of student types. Being dependent on social pressure is aligned with being externally motivation as they do the work to avoid being perceived as a failure. If students lack the intrinsic motivation to work with the course material, or at least being externally motivation with a sense of identified or integrated internalization, they might struggle to find the discipline to do the necessary work required from a flipped classroom. While some students might have an identified internalization with attending lectures, seeing the value they have for receiving good grades, there is also the possibility of an introjected internalization where attending

lectures are associated with being a good student, and consequently attending lectures to increase the sense of self-esteem and self-worth as a student. In the study by Yough et al. (2017) student motivation were found to be lower with flipped classroom compared to traditional lectures and students did not perceive flipped classroom as increasing their learning, although students in the flipped classroom displayed higher learning outcome (Yough et al., 2017). The researchers argued that a possible reason might be that the traditional lecture format was more in line with students' pre-perception of what it means to study in higher education, even though their study showed a higher learning outcome with flipped classroom. This is also aligned with the study by Wasserman et al. (2017) where the students evaluated in-class time with flipped classroom as less effective compared to the traditional lecture, although students performed better in the flipped classroom.

In this study, there are indications that some students inhabited poor study habits in the flipped classroom (by waiting until the last days to watch the learning videos and/or meeting unprepared to group activities). Poor study habits from a flipped classroom can come from either being unable to adjust to the new format or from having poor study habits in general. The result of poor study habits might not be as apparent in a traditional lecture as there are no immediate consequences for not paying attention or taking good notes. Students acting out of an introjected internalization might still leave the lecture with a positive feeling as the student did his/her 'duty' as a student, i.e. attending the lectures. The result of poor study habits might not become apparent until receiving grades from tests and exams. However, if the students do not possess the necessary metacognition skills to accurately self-evaluate, the student might write the poor results off as not being very good at mathematics and not because of poor study habits (Zimmerman, 2002). The experience might be very different in the flipped classroom since the poor study habits will become very apparent as he/she will not be able to do the problems given at the problem-solving activities (as one student also commented in the survey). It will also be more visible to other students as he/she will not be able to contribute to the group assignments and might also receive resentment from other group members for not coming prepared, as seen in some of the student quotes from the survey. This is also consistent with the study by in Fisher, LaFerriere and Rixon (2019). That students experience an increased visibility with flipped classroom, can also be seen in the study by Steen-Utheim and Foldnes (2018). As one of their students put it: 'In a lecture hall you can hide. You cannot hide in a flipped classroom'. In addition to thwarting students' sense of competence, the negative reaction from the group could also have had a negative impact on the sense of relatedness with their peers.

The question then becomes how students deal with these negative experiences. Zimmerman (2002) describes two ways a student might react during a self-reflection phase; they can adapt or become defensive. If a student lacks the motivation to work on their own during the flipped classroom, this motivation could be further diminished if the student encounters such negative experiences and reacts defensively to the experiences instead of managing to adapt. This could possibly result in a vicious circle or negative feedback loop where the motivation to adapt diminishes further for each group assignment and problem-solving exercises the student attends.

Even if a student normally inhabits good study habits from the traditional lecture format, a negative feedback loop could still be a possibility if the student struggles to adapt to the flipped classroom lecture format and lack the tools needed to self-evaluate and self-regulate their learning in this new environment. The result could possibly be an even stronger negative reaction towards the flipped classroom since they were used to be able to study effectively with the traditional lecture format. In other words, they can see their sense of competence being thwarted by the flipped classroom lecture format, decreasing their intrinsic motivation as a result. The frustration expressed by the students in the study by Mason, Shuman and Cook (2013) came particularly from students that typically performed well in engineering classes (Mason, Shuman and Cook, 2013).

Although this negative feedback-loop could be a possible explanation for frustration with flipped classroom, there is not enough information in the data presented in this study to verify the viability of this hypothesis or determine if different student types are more likely than others of ending up in the cycle. This could be a focus for future studies. A possible explanation for the increase in satisfaction with the flipped classroom at the end of the semester could be that some students had an initial negative experience with the flipped classroom, but reacted with adaption and managed to adjust. Previous studies have shown that it can take three to four weeks into a course before the students get used to the flipped classroom (Mason, Shuman and Cook, 2013; Yilmaz and Baydas, 2017). While this might be because students are unfamiliar with flipped classroom and therefore do not know how to study effectively with the lecture format, the students in this study mostly agreed that they received enough information on effective study habits. Perhaps the reason it takes time before students start adapting their learning style, is rather that they need time to develop the necessary metacognitive skills, as was seen in the study by Yilmaz and Baydas (2017), which might also explain the initial

reluctance for some students to change their study habits in flipped classroom (Boevé et al., 2017).

Strayer (2012) argued that novice students might not be ready for a flipped classroom because they are not interested enough in the subjects matter in order to self-motivate, while others have argued that it might be easier to convince first-year students of flipped classroom as they have not been ingrained with several years of traditional lectures (Ha et al., 2019). In a study by Cho, Park and Lee (2019), however, the researchers found that older students perceived flipped classroom more positively than younger students, and the researchers argued that a possible reason might be older students are more likely to have higher self-regulating skills. In any case, is important to not underestimate the importance of focusing on developing students' skills in self-regulated learning and metacognition (Zimmerman, 2002). Perhaps one of the greatest weaknesses with how the flipped classroom was implemented in this study, is the lack of focus on self-regulation. Besides from an initial lecture on how to study effectively as a flipped classroom student, there were no other assignments related to self-evaluation or metacognition, such as using self-evaluation surveys.

There is also room for improvements in other areas such as limiting the size of student groups. The students complained that they often had to wait a long time before receiving help during the group work. This could have been another factor that could have decreased their sense of competence since it becomes more apparent that the group is unable to solve the problems. In a class of a total of 118 students, it might have been more fruitful to divide the class in three instead of two to have a more manageable group size, or alternative have student assistants present during group works in addition to the instructor. The possible thwarting of a sense of competence was also the reason why the format of the problem-solving exercises was changed mid-semester. If a student could not solve the problems, the student could potentially be sitting most of the first lecture hour doing nothing. By having one problem at a time, the aim was to increase the sense of competence since the student would be doing something 'useful' for their learning after a few minutes even if they didn't manage to complete the problem. Regretfully, there was no question on the surveys that specifically asked about the new format to the problem-exercises. This could be a focus for future studies to determine if begin given one problem at the time increases a sense of competence, compared to having all problems at once, for students struggling with the course material.

Limitations

Although surveys can be an efficient tool to collect data on a large population, for instance, a class with many students, they are not efficient for obtaining a deep understanding of persons' feelings or experiences (Charmaz, 2001). Having open-ended questions on the surveys opened a window into students' experiences that could not have been done with using close-ended questions alone, but they are still limiting as it can be difficult to obtain a deep understanding from a few written lines. To investigate the viability of a negative feedback loop with flipped classroom, future studies should, therefore, include student interviews, as interviews can be an important tool for obtaining a deep understanding of experiences, feelings and opinions (Johannessen, Tufte and Kristoffersen, 2004).

Conclusion

The study described in this paper has investigated engineering students' experiences with a flipped classroom in mathematics and explored why some students can be frustrated with the lecture format. Students' negative experiences were discussed in light of self-determination theory and self-regulated learning theory. While researchers have used self-determination theory to explain the benefits of flipped classroom, the results in this study also indicate that they could explain some of the challenges and frustrations experienced by some students. Not being able to adapt their study habits to the flipped classroom becomes very apparent and could possibly have a negative impact on students' sense of competence as well as a possible decrease in relatedness towards group members that respond negatively to their inability to contribute. In addition, this paper hypothesises that a negative feedback loop could arise where students' ability to self-motivate decreases with the negative experiences with flipped classroom, which in turn makes it more difficult to find the motivation to adapt. However, additional studies are required to investigate this hypothesis. Although this article has mainly focused on students frustrated with the lecture format, most students ended up being positive towards the format at the end of the semester. In order to reduce frustration from students when implementing a flipped classroom, this paper argues for the importance of focusing on increasing students' skills in self-regulated learning.

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