Experiences from the First Implementation Round of Two Electronics Courses Utilizing Flipped Learning Method

K. Laine [1]
Tampere University
Tampere, Finland
0000-0002-7799-7203

E. Sipilä
Tampere University
Tampere, Finland
0000-0002-7437-8095

Conference Key Areas: *Engineering Skills, Teaching methods*
Keywords: *flipped learning, electronics*

ABSTRACT

During the past years we have witnessed various development trends in learning. More and more the learning has moved online thus making it independent of time and place, students' responsibility of their own learning has increased, methods that promote active learning have gained more interest as they result in better learning results, and the role of a teacher has shifted towards a facilitator of learning. Consequently, the flipped learning pedagogical approach has become more common in recent years as it is one way to answer these trends.

This concept paper introduces two studies of practice in which flipped learning approach was implemented for the first time in a bachelor level university course of

[1] *Corresponding Author*
K. Laine
katja.laine@tuni.fi

doi:10.5821/conference-9788412322262.1271

electronics at Tampere University (TU) during the academic year 2021 – 2022. The structure of the flipped courses consisted of online pre-class study materials and assignments, face-to-face learning events, various individual and group learning assignments and so-called prime time small group meetings with the teacher. Flexibility and versability of the learning experiences, both-way feedback possibilities as well as a combination of individual and collaborative face-to-face and online learning were emphasized in the course design.

According to the feedback many students felt that this flipped learning approach promoted learning and encouraged to study evenly throughout the entire course. Furthermore, the teachers' thoughts after the first implementation round are considered e.g., which parts and practices were successes, and which need further development. In addition, thoughts about teachers' workload and institute's support in utilizing flipped learning method are shared.

1 INTRODUCTION

In the flipped learning method (FLM) the students familiarize themselves with and learn the new course material first outside the face-to-face (F2F) learning events. Students can learn the new material at their own pace independent of time and place individually or in small informal groups. This is often referred as individual space meaning that students mainly work themselves and the work done is focused on the individual student’s efforts. In the F2F learning events, so called group space, students then learn with the entire class or in intentional small groups and the focus is on higher-level tasks and in active learning. [1] By creating such an autonomy-supportive learning environment in which the pre-class online materials meet students’ autonomy and competence needs and the interactive F2F learning events foster students’ competence and relatedness needs, active learning, self-regulation and engagement can be promoted, and students’ academic achievement may increase [2].

1.1 Designing Flipped Learning in Engineering Education

When designing flipped classroom, it is important to include there two components that can be seen in Figure 1: human interaction component (in-class activities) and computer-automated component (outside activities) [3]. Video lectures are a typical example of the outside activities and them being mainly teacher-centered they can be automated through computer technology. The in-class activities, on the other hand, should be designed based on student-centered learning theories, such as problem-based learning, active learning and collaborative learning to foster the success of the flipped classroom [3].

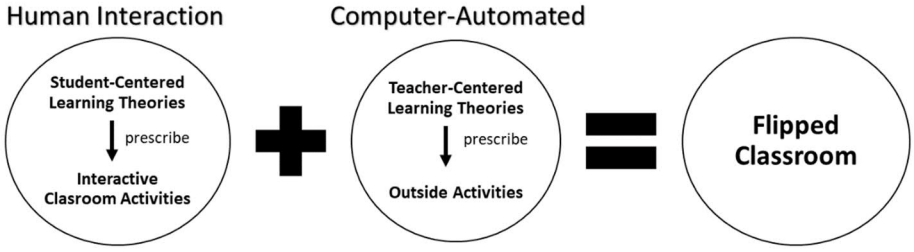

Fig. 1. Components of the Flipped Classroom [3]

It has been shown that the problem-based learning can offer students learning experiences in real world context and thus help them learn how to approach and solve challenging problems and improve students' ability to work in a team [4]. When designing flipped learning it's important to consider the collaborative learning as well as the collaborative environment of F2F learning events can strengthen students' critical thinking and problem-solving skills [5]. These higher order thinking skills, critical thinking, problem-solving skills and teamwork skills are core competencies that engineers need in the work life. The flipped learning setting of pre-class videos, in-class discussions and hands-on activities can furthermore contribute to a deeper synthesis of concepts and it enables more course content to be covered in addition of students learning more efficiently. Carefully designed flipped learning method has the potential to result in better learning outcomes, increase student engagement and enhance students' interest in engineering. [5]

2 FLIPPED LEARNING IN ELECTRONICS EDUCATION AT TU

Two electronics courses, Electronics and Circuit Theory and Product Design of Electronic Device, were designed and implemented using the FLM based on the above-mentioned components. Outside activities utilized the Moodle learning management system and the parts of the courses that required human interaction were designed to reflect student-centered learning theories. The target group of both these courses are bachelor students of the second and third years respectively, and both courses were implemented as seven-week implementations during the academic year 2021 – 2022. In addition to the technical core subjects, the target of these courses is to develop students' work life skills, such as documentation, presentation, critical thinking, argumentation, problem-solving and team work skills.

Both the courses had the same task and session types: pre-class materials and assignments, face-to-face learning events, and prime time meetings. Even though there were some differences between the course implementations, the basic idea in the design and implementation was similar.

With the online pre-class study materials that included short video lectures (duration 3,5 – 21 minutes) and online book materials the students learned the new topic and were able to work at their own pace independent of time and place. In both courses it was assumed that the students had studied the pre-class materials and completed the pre-class assignments before the F2F learning events. In this way the assignments to

be done at the F2F learning events could be designed so that they promote students' higher order thinking skills, such as design, compare, analyze, estimate and choose.

The prime time meetings were an important feedback channel both ways, from teacher to student and vice versa. The feedback discussion on the meetings was based on the students' answers regarding questions like, how did you accomplish the learning outcomes of the module, what was the most interesting topic this week, what did you learn / didn't learn this week, what was the most difficult topic this week. At these prime time meetings students were thus able to furthermore deepen their understanding on the topic, make their learning process apparent, understand what they need to learn more and adjust their learning process accordingly. Feedback from students also helps the teacher to visualize e.g., the weak points in students' learning and make possible adjustments accordingly.

In both courses the final course grade was determined based on course points students gathered during the course. The pre-class assignments, or the F2F learning events were not compulsory, but by completing the assignments and taking part in the F2F learning events students were able to gather course points.

2.1 Electronics and Circuit Theory

The Electronics and Circuit Theory course is the very first course in electronics for the students to whom this course is targeted to. The students have some basic knowledge of basic circuit theory already from previous courses, but mostly the topics in this course are totally new to the students. The FLM in this course was designed to follow a weekly schedule which is presented in Figure 2.

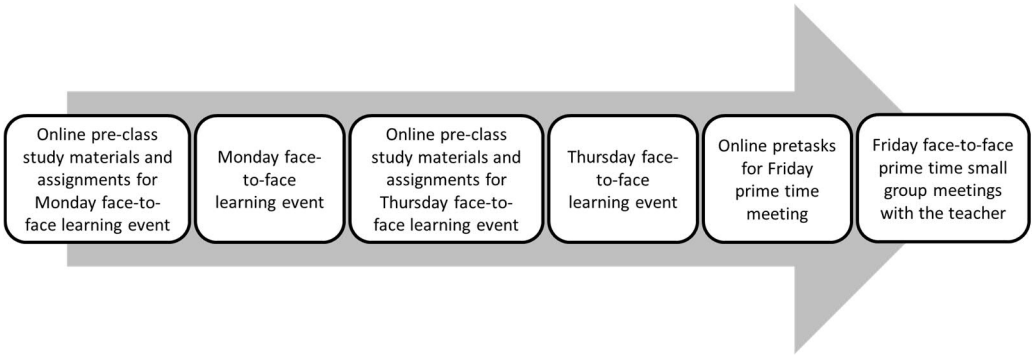

Fig. 2. Weekly schedule of Electronics and Circuit Theory

The assignments were Moodle tasks based on the pre-class study materials. Mostly the Moodle tasks needed teacher's checking, only some of them included automated checking. The future plan is to increase the amount of automatically checked assignments. The pre-assignments had a deadline, and the students had about two to three days to do them. The F2F sessions were for deepening the understanding of the issue at hand by doing various tasks, which mostly included paper and pen part, simulation part, and circuit prototyping part. The circuit prototyping in this case means that the student constructs circuits with through hole components on breadboards and measures and analyses them using a BYOD (bring you own device). Short mini

lectures (about 5 to 15 minutes) were included to F2F sessions occasionally, especially when the topic was more demanding for the students.

The prime time meetings were mainly for feedback from the week, and also for clarifying the issues that needed further clarification.

The students gathered course points from all the course parts: pre-assignments, F2F sessions, prime time meetings, and four miniexams. The miniexams were small exams containing calculations, simuations and prototyping. Only the miniexams were compulsory, but for each grade the students needed a certain amount of course points.

2.2 Product Design of Electronic Device

The core contents of the Product Design of Electronic Device course are the different hierarchical levels, production processes and design perspectives of an electronic product. For the FLM implementation the course contents were divided into five flipping modules each of which lasted one to two weeks depending on the extent of the module. Each module followed the same structure presented in Figure 3.

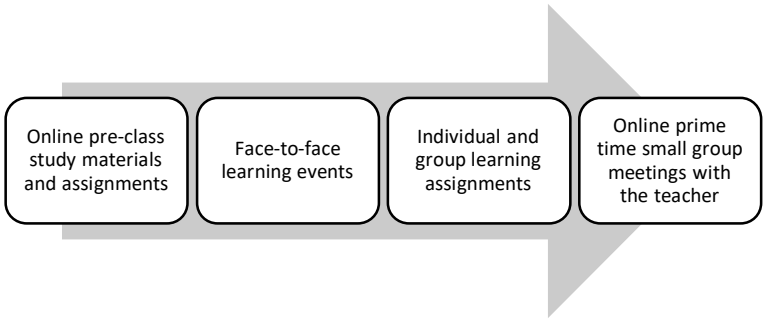

Fig. 3. Structure of one flipping module in the Product Design of Electronic Device course

The online pre-class assignments consisted of self-correcting multiple-choice tests that offered the students the possibility to test their learning and to make notes of questions or problems they may have.

The F2F learning events consisted of collaborative and active learning through various problem-solving and design exercises, calculations, presentations and group discussions in the classroom. In case of a difficult topic or questions from students the teacher explained the pre-class study material shortly anew. Students worked mainly in groups in order to enhance the collaborative aspect of learning as well.

The individual and group learning assignments were designed to deepen students' knowledge on the issue at hand, to promote collaborative learning and to increase students' work life skills. The individual assignments included a calculation exam in the Moodle and the group assignments included e.g., decibel meter construction work, a wiki assignment and a forum discussion assignment in the Moodle. The assignments were compulsory to complete the course and graded passed/failed or on a scale of 1 – 6 points.

The compulsory 30-minute prime time small group meetings after each flipping module were realized via Teams in groups of three students. In addition of the feedback

discussion students' knowledge on the topic were tested via small group problem solving tasks. Points were assigned from an active participation.

3 RESULTS

During the academic year 2021 – 2022 a total of 28 students completed the Product Design of Electronic device course approvingly. At the end of the course student feedback was gathered with a questionnaire consisting of open questions. Although about ten students were expected, only one student completed the Electronics and Circuit Theory course. It seems that many students have postponed this course to the next academic year. Thus, we cannot draw any conclusions about this course from the student perspective.

3.1 Final Grade of the Product Design of Electronic Device

For the final grade of the Product Design of Electronic Device course the student was able to gather points from the self-correcting multiple-choice tests, F2F learning events, learning assignments and prime time small group meetings. The final grade scale was 0 – 5 and for a grade one student had to gather 27 points out of 56 points. Grade three required 39 points. Grade five required 51 points and in order to gather this amount of points, the student had to take part in a voluntary electronic exam of the course topics. The final grade distribution can be seen in Figure 4.

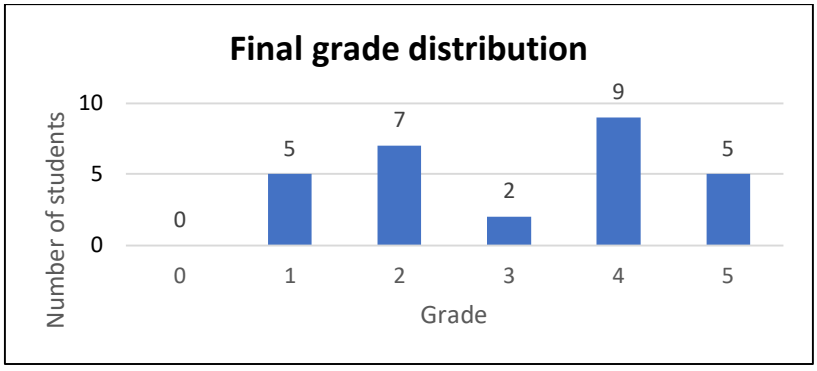

Fig. 4. Final grade distribution of the Product Design of Electronic Device course

As the Figure 4 shows many students (50%) performed very good (grade 4) or excellent (grade 5) at the course. This was expected as flipped learning often results in high student satisfaction and increased performance [5,6]. On the other hand, many students also received grade 1 (17,9%) or grade 2 (25%). There can be many reasons behind this, but these students might have lower self-regulation skills, as it has been shown that high self-regulation skills can be related to high learning achievement [7]. Overall, the grade distribution is consistent with other flipped courses [5].

3.2 Course Feedback of the Product Design of Electronic Device

The open questions in the feedback form asked students' experiences and opinions regarding the flipped classroom model, pre-study materials, learning assignments, F2F learning events, prime time group meetings and the grade formation. Many students believed the FLM promoted learning and made them learn throughout the

entire course. This is indicated in Table 1 in the freely translated quotations regarding the question “What are your thoughts about implementing the course by the flipped learning method? Did the implementation method work? Did it promote your learning?”

Table 1. Student feedback on the flipped learning method

“The implementation method worked well ja promoted learning compared to traditionally implemented courses.”
“One had to out of necessity familiarize with the subject and (the method) encouraged to learn through the entire course.”
“In my opinion studying with the short videos and applying the knowledge in the learning events was a functional arrangement. The course didn’t feel too heavy, but one studied regularly during it.”
“I felt I learned well, but I’m not sure whether it was because of the implementation method or because of well and interesting materials.”

The short lecture videos used as online pre-class study material received very positive feedback and many students felt that the F2F learning events deepened their learning, although some students experienced the pace of the events too slow (see Table 2).

Table 2. Student feedback on the pre-class videos and F2F learning events

Pre-class videos	Face-to-face learning events
“The videos were excellent, the most important things were summed up to suitable packages.”	*“The assignments in the learning events visualized and deepened the topics.”*
“The videos were good and it was nice that one was able to watch them several times.”	*“The assignments in the learning events made one consider the topic at hand, and as the assignments were often applied, they were meaningful.”*
“The videos were of suitable length and of suitable amount.”	*“In the discussion assignments one was able to work on the subject together.”*
“Study materials were useful. The videos summarized the main points and from the e-books one could read more detailed facts.”	*“The learning events specified the topics in the videos. Although, if one had watched the videos, the learning events proceeded slowly.”*

There were also some comments in the course feedback about the workload of the flipped learning method being too heavy.

4 EXPERIENCES AFTER THE FIRST IMPLEMENTATION ROUND

In this paper we have introduced our way of implementing FLM to two BSc level electronics courses. The purpose of is to shear our experiences and thoughts about FLM, and this way boost the implementation of FLM also in other higher education institutes.

The design and implementation of the FLM requires time and careful design. Making and editing video lectures is really time consuming and the in-class activities and facilitation need to be planned so that they enhance students’ higher order thinking

skills. Furthermore, the design and actual implementation of online self-correcting Moodle assignments were surprisingly time consuming. Teacher's workload is the highest during the first implementation year, but it is expected to be lower after that. Organisation's support for the teacher, such as time allocation, equipment acquisition, possibility to ask for help and peer support, are valuable assets and can greatly promote teacher's interest and success for the FLM implementation. In the structure of the flipped course flexibility, versatile learning experiences, feedback possibilities, individual and collaborative learning possibilities and learning of work life skills should also be considered. Skilled professional instructors are thus important in the FLM and the course content division between outside activities and interactive classroom activities need to be thoroughly planned [6].

The findings of the FLM studies of practise are encouraging for electronics teaching. The short video lectures accompanied with the self-correcting multiple choice tests worked very well as online pre-class study material offering students flexibility and possibility to work themselves mainly independent of time and place. The F2F learning events seem to have worked as well with the aim of learning actively together, deepen the learning and enhancing skills, like design, analyze and compare. Learning of the topic was further deepened with the versatile learning assignments that also offered students collaborative learning possibilities and taught work life skills. The prime time meetings wrapped up the topic and were an important feedback point. Some students felt that these prime time meetings were not useful and that there were too many of them, but from the teacher's point of view the meetings offered valuable information regarding students' learning and possible stumbling blocks. However, in future a prime time meeting after each module or every week it not absolutely necessary, fewer wrap-up and feedback points are adequate as the courses last only seven weeks.

When designing and implementing the FLM students' readiness and experience on working actively according to the method should also be taken into account. Students' readiness and self-regulation skills vary and this can result in disperse learning results as stated above. Course workload can also easily build up overloading or divide unevenly between the different modules or weeks. Careful design of the course workload and introduction to the teaching method are thus things to consider [6].

The findings of these studies are only preliminary since the FLM implementation of these courses were during the academic year 2021 – 2022 and the number of students attending the courses was 29. No absolute conclusions from the grade distribution or from the student feedback can thus be made, but these first implementations clearly showed that video lectures and self-correcting multiple choice tests as online pre-class study material can be automated them being mainly teacher centered. Carefully designed and facilitated student-centered F2F learning events and learning assignments are then needed to enhance students' higher level learning and work life skills not to forget important both-way feedback possibilities. In future the FLM structure of these courses will be continued and more experiences and feedback will be gathered in order to draw more conclusions on e.g., grades and students' self-regulation skills and to improve the courses accordingly.

REFERENCES

[1] Talbert, R. and Bergmann, J. (2017), Flipped Learning: A Guide for Higher Education Faculty, Stylus Publishing, Sterling, pp. 8-12

[2] Cho, H.J., Zhao, K., Lee, C.R., Runshe, D. and Krousgrill, C. (2021), Active Learning through Flipped Classroom in Mechanical Engineering: Improving Students' Perception of Learning and Performance, International Journal of STEM Education, 8, 46

[3] Bishop, J.L. and Verleger, M.A. (2013), The Flipped Classroom: A Survey of the Research, 120th ASEE Conference & Exposition, Atlanta, GA, pp. 1-18

[4] Clyne, A.M. and Billiar, K.L. (2016), Problem-Based Learning in Biomechanics: Advantages, Challenges, and Implementation Strategies, Journal of Biomechanical Engineering, Vol. 138, Issue 7

[5] Yelamarthi, K. and Drake, E. (2015), A Flipped First-Year Digital Circuits Course for Engineering and Technology Students, IEEE Transactions on Education, Vol. 58, No. 3, pp. 179-186

[6] Prevalla, B. and Uzunboylu, H. (2019), Flipped Learning in Engineering Education, TEM Journal, Vol. 8, Issue 2, pp. 656-661

[7] Hyppönen, L., Hirsto, L. and Sointu, E. (2019), Perspectives on University Students' Self-Regulated Learning, Task-Avoidance, Time Management and Achievement in a Flipped Classroom Context, International Journal of Learning, Teaching and Educational Research, Vol. 18, No. 13, pp. 87-106