FLIPPED LEARNING IN INTERACTION WITH PROBLEM-BASED LEARNING

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Abstract

In 2015, Aarhus University School of Engineering in Herning decided to offer an online bachelor's degree in Electronics Engineering in addition to the traditional on-campus education. In order to be able to teach both online and on-campus students, a blended learning strategy based on the 'flipped classroom' approach was implemented.

At a semester evaluation, students raised the question: "When do we have time to study?" The students' concern was that as they grow and develop as students, the problem with flipped classroom becomes greater; the flipped courses simply cause the students to disapprove the flipped learning method, as they feel they spend their time on matters that the lecturers consider important. In other words, the students do not feel they have enough time to study, which also includes the time *scheduled* for studying.

Building on a master's thesis conducted by the author at the Aalborg University in Denmark, this paper addresses the following problem formulation based on the above question:

Is there a contradiction between problem-based learning and flipped learning?

To be more specific, the master's thesis described the following questions:

- What does it mean to 'study'?
- What are the essential criteria for adult education?
- What are the characteristics of problem-based learning?
- What are the characteristics of the flipped learning method?
- What are the differences between problem-based learning and flipped learning?

A survey was conducted to investigate how much time the students in fact spend studying, working, etc., if they are satisfied with the time spent, and if they are satisfied with what they have achieved in the time spent.

The results from the master's thesis revealed the following findings: A student at a higher education institution is an adult who seeks new knowledge. When students in higher education are given a relevant problem to solve, it allows them, as adults, to take control and be responsible for own learning. To be able to learn in the best possible way, adults must be able to take control in solving relevant problems. Adult learners takes responsibility for their own learning. The flipped learning method can create opportunities for problem-based teaching. There is no contradiction between problem-based teaching and flipped learning if the students experience the freedom inherent in a flipped classroom approach as compared to a traditional didactic setting. Problem-based teaching does not have to be 100% problem-oriented; there are different levels of problem orientation and it is important to find the level of problem orientation that didactically fits the study programme, semester or course.

Keywords: Online Education, Flipped Learning, Blended Learning, Adult Teaching, Andragogics, Project Work, Problem-Oriented Teaching, Problem-Based Teaching.

1 INTRODUCTION

At the bachelor's degree programme in Electronic Engineering in Herning, Denmark, an extension of the teaching method flipped classroom, i.e. flipped learning, has been applied since 2015 [2]. In addition to reading the curriculum at home, the students respond to questions from the lecturer prior to a lesson. In class (follow-up lessons), the lecturer provides the students with feedback on their answers to make sure that any misunderstandings are clarified. This is recorded so that the students can watch the teaching online synchronously or asynchronously. Having reviewed the responses, the lecturer can activate the students in different ways, e.g. by means of tutorials, exercises or small projects. Activation takes place in the learning space, after which a follow-up on the students' work is made. The structure of the teaching is described in Figure 1.

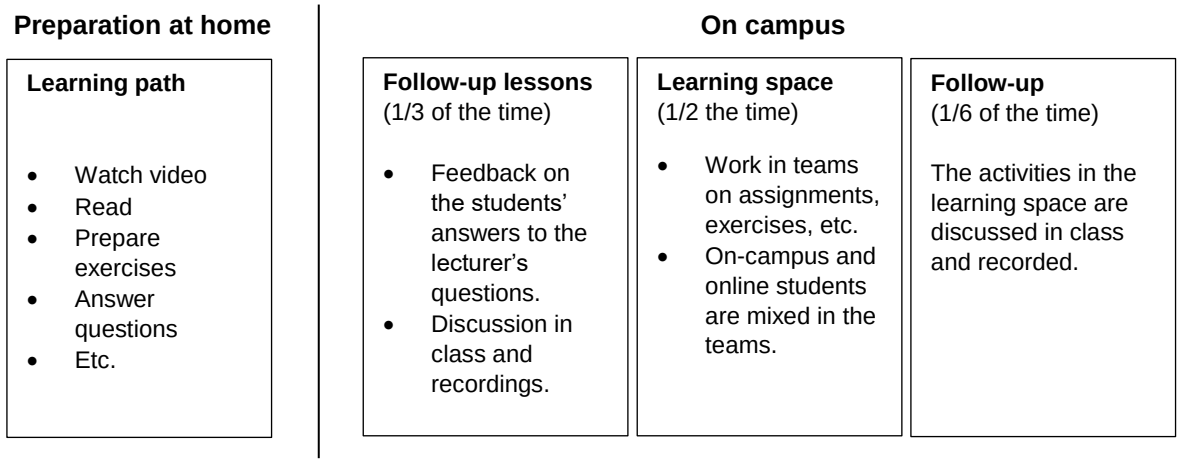


Figure 1: The structure of the flipped learning teaching method.

Overall, the students at the study programme can be divided into three different groups.

- Students studying on campus in Herning.
- Synchronous online students: Students following the teaching synchronously and attending the teaching directly via an internet connection, i.e. synchronously.
- Asynchronous online students: Students following the class on their own schedule. They attend the teaching via the recordings, i.e. asynchronously.

The Electronics Engineering study programme is structured in the following way: Each week, four follow-up lessons are allocated each course, plus four hours for preparation. Each semester includes five theoretical courses and one project course conducted in a 14-week teaching period. An example of a timetable is displayed in Figure 2 below. In the timetable, all activities related to the study must be included, which gives an expected workload of approx. 50 hours per week corresponding to a normal workload of 1620 hours.

In order for the students to gain professional competencies such as collaborative skills, methodological approaches, communicative skills and self-management, the project work is an integrated part of the study programme. The students are in charge of managing their project work; in other words, they are freer to organise their project work as opposed to the 'controlled' theoretical lessons. All projects involve planning, collaboration and application of learned as well as new theory to conduct the project. The project assignment, which requires the students to design a solution to a relatively open problem, is given by a lecturer or a company. Examples could be designing a robot that can climb stairs or a robot bottle opener. The students must find a solution on their own, i.e. the teaching method is problem-based learning.

Saturday	Sunday	Time	Monday	Tuesday	Wednesday	Thursday	Friday
	Electronics (preparation)	08.20-09.55	Electronics	Digital	Electronics	Physics	Mathematics
	Physics (preparation)	10.10-11.45	Physics	Mathematics	Programming	Digital	Programming
		12.15-13.50	Workshop course	Project teaching	Project work	Mathematics (preparation)	Project work
	Project work	14.05-15.40	Project work	Electronics (preparation)	Physics (preparation)	'Programming' (preparation)	
		16.00-18.00	Digital (preparation)	Programming (preparation)	Digital (preparation)		
		18.00-20.00	Mathematics (preparation)				

Figure 2. Example of a timetable at the Electronics Engineering study programme.
Yellow: preparation time; green: theory-based teaching; light blue: project work; dark blue: spare time.

1.1 Problem

The chosen flipped learning teaching method gives the students a very structured daily life. However, it seems that using the method in the theory-based teaching is more time-consuming than when it is used in the problem-based teaching. Consequently, if the students do not have time to study on their own, they may not gain the necessary professional skills. This paper studies the impact of the flipped leaning method on students' study opportunities related to the problem-based teaching at the Electronics Engineering study programme in Herning.

Is there a contradiction between problem-based learning and flipped learning?

- What does it mean to "study"?
- What are the essential criteria for adult education?
- What are the characteristics of problem-based learning?
- What are the characteristics of the flipped learning method?
- What are the differences between problem-based learning and flipped learning?

2 METHOD

In Herning, we strive to apply a problem-based form of instruction. To examine how adults learn best, Malcom Knowles' theory on andragogy is used [3]. Andersen and Larsen's didactic and structure model has been applied to study if the teaching is in fact problem-based [1]. The didactic model is used to visualise whether the learning is assimilative or accommodative based on whether there is a high problem-orientation and participant-centred control. The structure model is applied to visualise the lecturer-centred control versus student-centred control in the teaching. To describe the flipped learning teaching method, Bergmann and Sams' book "Flipped learning: Gateway to Student Engagement" has been used [2]. The students were invited to complete a questionnaire survey, answering the following questions:

- How much time do you spend on your studies and other activities?
- How much time do you spend on your studies?
- Do you have enough time to manage your study load?

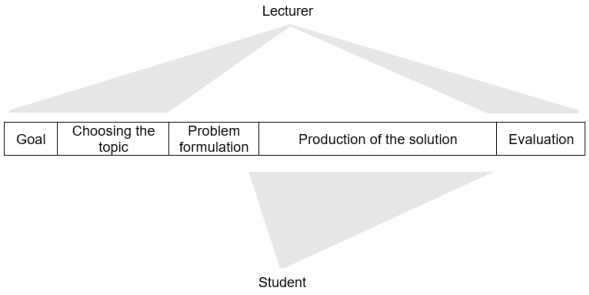
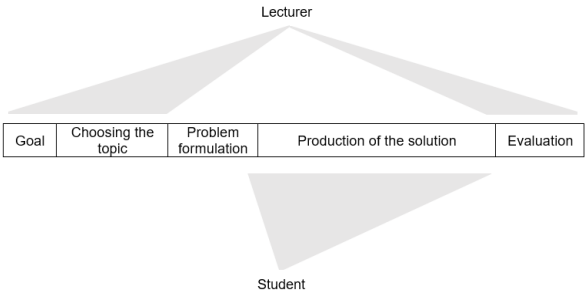
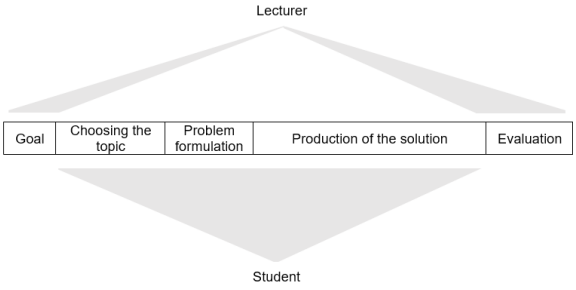
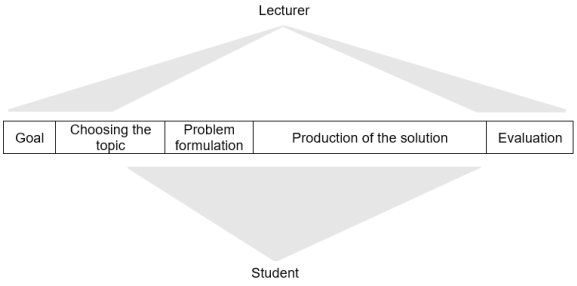
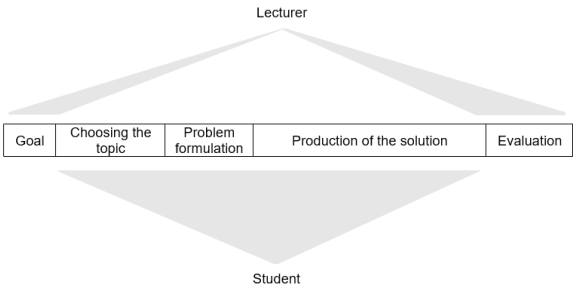
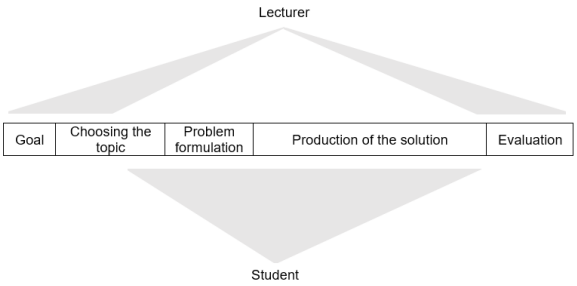
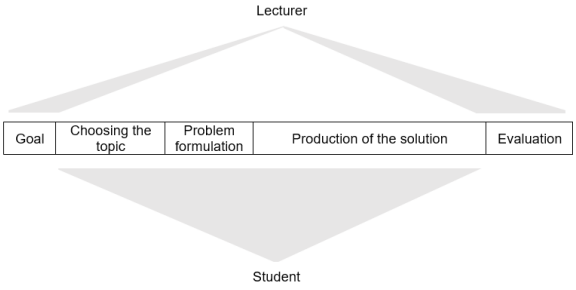
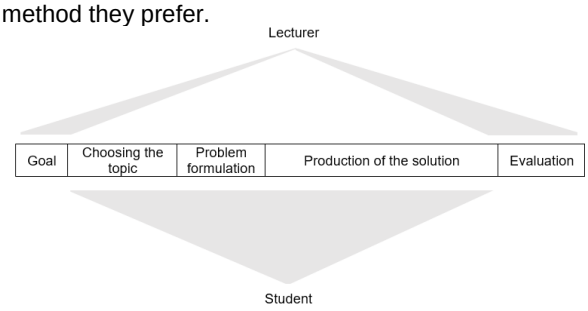
3 RESULTS

The result of this study can be divided into two parts. The first part deals with how didactic strategies support the students' learning. This paper focuses on the levels of the students' learning from the perspectives of assimilative or accommodative learning. Whereas assimilative learning involves incorporation of new routines in known structures, accommodative learning requires a restructuring of existing knowledge as well as an understanding of structures. Compared to assimilative learning, accommodative learning thus provides a more reflective learning experience, which indeed is key in gaining extensive knowledge of a topic. The second part deals with the questionnaire survey, which examines the students' time consumption and if they are able to manage their study load.

3.1 The result of the didactic part of the analysis

The students at the Electronics Engineering study programme in Herning are not involved in the planning of own learning; the lecturer prepares the learning path for each lesson. S/he is in charge of planning the first part of the teaching, which consists of the preparation at home as well as follow-up lessons. This part provides the students with an assimilative learning, see Table 1 below ('Theory-based teaching part 1: Learning path and follow-up lessons'). When the students participate in the learning space, they will achieve better learning outcomes. If the students are involved in creating the learning space, they will develop their accommodative learning, see Table 1 below (Theory-based teaching part 2: Learning space, example 1'). Thus, the didactic method determines whether they achieve accommodative learning and experience a student-centred learning. The students plan all their projects on their own, but not always the project contents. The teaching is practice- as well as project-oriented and is highly relevant to the students' future work. In Table 1, the project work for each semester is illustrated according to the structure model. There is a clear progression throughout the semesters (see Table 1); as the students progress through the study programme, they will experience more student-centred control and a less lecturer-centred teaching approach.

Tabel 1. Lecturer-centred versus student-centred control in each semester as well as in the teaching based on the structure model [1].

Theory-based teaching part 1: Learning path and follow-up lessons: The students must learn new knowledge (topic) and answer questions. They follow the learning path as prepared by the lecturer. 	**Theory-based teaching part 2: Learning space, example 1:** The students must solve a given problem prepared by the lecturer. 
Theory-based teaching part 2: Learning space, example 2: The students must find a problem to be solved in the learning space. 	**1st semester project:** The students must solve a given problem prepared by the lecturer. They must apply 1st semester theory and learn a new topic. 
2nd semester project: The students must find a problem to be solved and solve the problem in an innovative way. The lecturer conducts the evaluation together with an internal co-examiner. 	**3rd and 4th semester projects:** Part of the theory used to solve the two projects is based on the theory from the teaching. Additionally, the students must apply new theory. The students are required to use the EUDP project development method [5]. 
5th semester project: The students are required to use the EUDP project development method [5]. 	**Bachelor project:** The students can use whichever method they prefer. 

The didactic model in Figure 3 below also shows a clear progression throughout the semesters in terms of participant-centred and problem-oriented project work; the students move to more student-centred and problem-oriented approaches as they progress in their studies.

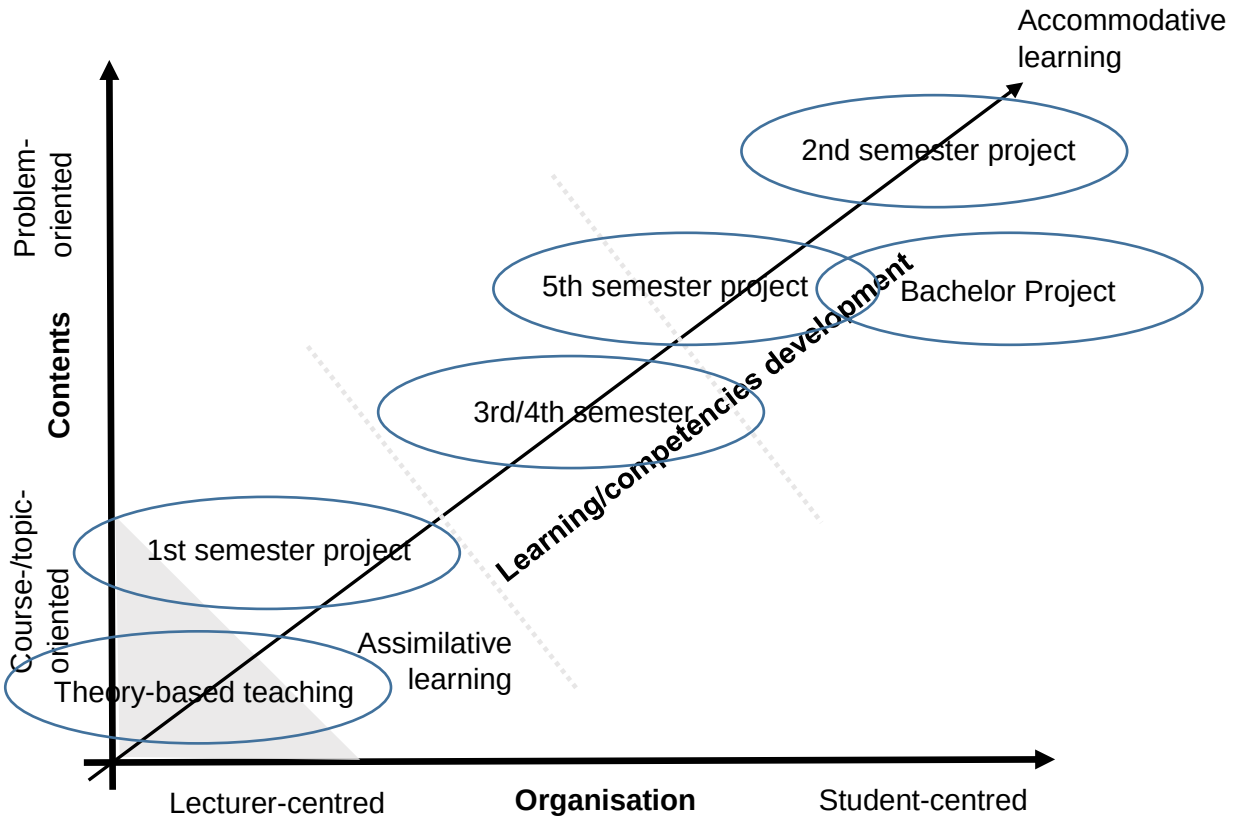


Figure 3: All projects and theory-based teaching illustrated in the didactic model for problem-based learning.

The theory-based teaching is predominantly lecturer-centred (see Figure 3), and the learning style is assimilative. The 1st semester project is highly lecturer-centred, i.e. the students are not to learn a large amount of theory on their own as opposed to the 2nd semester project, which is highly student-centred, leaving it to the students to the find the theory to be used. There is a clear progression from the 3rd, 4th and 5th semester projects to the Bachelor Project in the 7 semester; as the students progress through the study programme, they will experience more self-control and less lecturer-centred teaching. Since a project is given by a lecturer/customer, and it is the lecturer/customer who partly determines the solution to the project, none of the projects at the study programme are completely problem-oriented. The learning of the project work in the final semesters can be characterised as accommodative, and according to Andersen and Larsen's definition [1], it is highly problem-oriented.

3.2 The results of the questionnaire survey

43% of the students at the Electronics Engineering study programme participated in the questionnaire survey.

3.2.1 Time consumption

The workload of on-campus students compared to online students varies significantly. Whereas on-campus students spend more time on their studies than on other activities, the opposite applies to online students, i.e. they spend more time on other activities. The time spent on the studies and other activities is almost the same. As the students progress through the programme, the time they spend on their studies increases. At the same time, they spend less time on other activities. Their total time consumption, however, does not change much. The average number of hours students spend on their

studies and on other activities is 54.3 per week. Some students work much less than the average; others much more (see Figure 4).

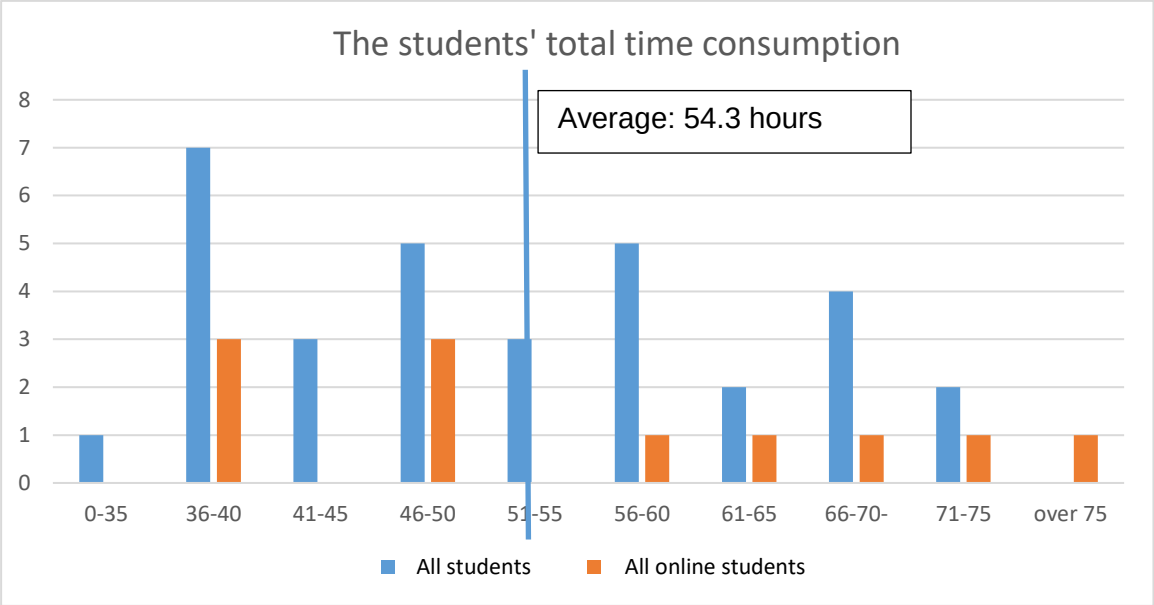


Figure 4: The distribution of the students' total time consumption per week on their studies and other activities.

The majority of the students spend up to 40 hours per week studying. The online students spend least time studying; only two online students spend more than 50 hours per week. As can be seen from Figure 5, most students do not spend more than the 50 hours per week as is expected of them.

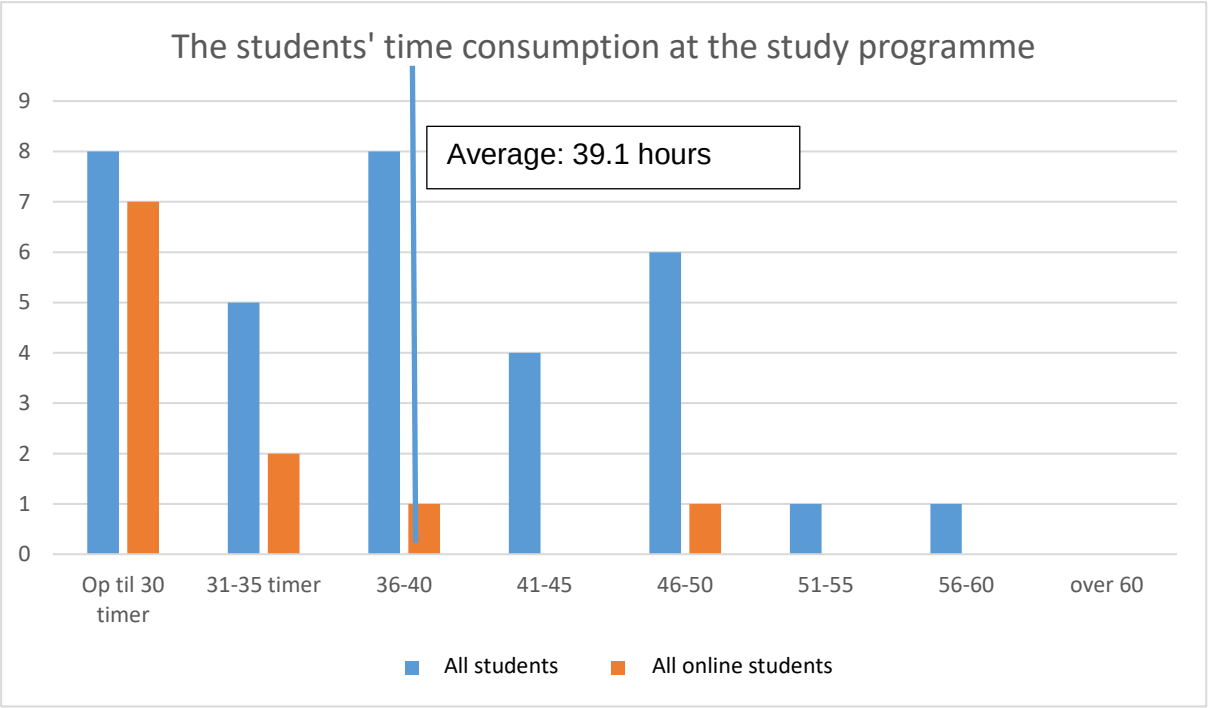


Figure 5: The distribution of the students' total time consumption per week at the study programme.

3.2.2 Lecturer- versus student-centred control

A majority of the students (64%) find themselves to be in charge of deciding what to work on. This number, however, is somewhat different as to the online and 1st semester students with less than half

of the students perceiving that they are in charge. In other words, the higher the semester, the more student-centred control. Most of the students (85%) want to be able to decide what they are working with.

3.2.3 Summing up the survey results

The students spend an average of 39.1 hours per week on their studies. The majority of the students spend less than 40 hours per week on their studies, most of which spend up to 20 hours on other activities in addition to their studies. The average time the students spend on their studies and other activities is 54.3 hours per week.

A little less than half of the students think that they either spend too much or too little time on their studies. 50% of the students who think they spend too little time on their studies spend a total of 50 hours per week on their studies.

11 students do not think they have time enough available for studying and other activities. Two out these students spend more than 50 hours per week on their studies; however, 10 out of the 11 students spend more than 50 hours per week on their studies and other activities.

The vast majority of the students (85%) want to be able to decide what they are working on; 64% think that the study programme provides a good opportunity for this.

4 CONCLUSION

The conclusion has been divided into subparts in order to answer the problem formulation: Is there a contradiction between problem-based learning and flipped learning?

4.1 Flipped learning versus time consumption

At a semester evaluation meeting, the students commented on the form of teaching, stating that the flipped learning teaching method takes too much of their time to just be students.

The results of the questionnaire survey showed that the students do not spend more than 50 hours per week as allocated. The majority of the students spend less than 40 hours per week on their studies; meanwhile, they do not spend their time on other activities.

Some students also think they have too little time and too much to do. However, most of these students do not spend enough time on their studies. From the survey, there is no evidence that the students find it difficult to follow the timetable at the Electronics Engineering study programme in Herning. Bergmann and Sams [2] state that students do not need extra time when using the flipped learning method. The students just spend their time in different ways; instead of working with tasks at home, they spend the time preparing for classes [2].

4.2 Adult learning

As Malcolm Knowles states, adults learn best when they are involved in relevant, problem-oriented learning [4]. When the students are given a relevant problem to solve, they will automatically feel in control. Adult learners take responsibility for own learning [4]. From these statements, the following definition of ‘student’ can be applied: **A student is an adult learner independently seeking new knowledge**.

The Electronics Engineering study programme gives the students the opportunity to be students when they are working on projects.

4.3 Flipped learning versus problem-orientation

At the bachelor’s degree programme in Electronics Engineering, the projects are problem-oriented, leaving it to the students to find new theory to be learned. According to the survey, the majority of the students believe they can influence their learning outcomes; the higher the semester, the more control they have. This fits very well with the progression in the projects illustrated in the didactic model.

The theory-based teaching is highly lecturer-centred, thereby limiting students to influence their own learning. The course descriptions contain learning objectives, and based on these, the lecturer choses the didactics to be used for the teaching.

The study programme provides the students with the opportunity to be students when it comes to projects – not in the theory-based teaching. According to Bergmann and Sams, the flipped learning method will individualise the teaching and provide a learning space on campus [2]. For on-campus students, this is achieved by the didactics used in the theory-based teaching. However, the way that the didactics is organised means that the students are not in control of what they learn; they are forced to follow a carefully planned timetable, which basically does not allow them to be students.

There is no contradiction between problem-based teaching and flipped learning if the students experience the freedom inherent in a flipped class approach as compared to a traditional didactic setting.

The didactics applied at the bachelor's degree programme in Electronics Engineering in Herning could fruitfully be changed to a more problem-oriented didactic teaching style based on flipped learning.

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