Motivation for Maintaining a Constant Workload During a Mathematics Course for Engineers

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Abstract: Motivation to study is a crucial factor in passing courses. The problem of the lack of motivation is often present especially in mathematics courses for engineers because the relation between mathematics and engineering studies is not clear enough for students. In this paper, we analyze and present the reasons for students' initial motivation and the factors promoting motivation in a mathematics course for engineers. The analysis is based on qualitative data collected between 2010 and 2013 and on quantitative data collected from student interviews. In addition, we introduce pedagogical tools and analyze their effect on students' motivation to maintain a constant workload. According to the results, the tools proposed encourage students to work hard during the course, and the work done positively affects their learning results and the pass rate for the course. An important observation was also the fact that external factors like rewards from different tasks can support enough student's motivation to study the whole course.

Key–Words: Study Motivation, Extrinsic Motivation, Engineering Mathematics, Constant Workload

1 Introduction

Mathematics courses for engineering students have their own specific challenges. The interface between mathematics and major studies in engineering is not always clear to students. This factor was present in the interviews conducted for this study. If students have difficulties assimilating the mathematics studies as an important basis for more applicative engineering courses and practical work, students' motivation and enthusiasm for studying can suffer [1, 2]. The problems on inspiring undergraduate students to learn math are worldwide and many different solutions have recently been established [3, 4, 5].

If students' only goal is to pass the course, they may only try to memorize the solutions to the problems they think they will be asked on exams. Such students are said to be extrinsically motivated and usually use a surface learning approach for processing information [1, 6, 7]. This approach can be realized as neglecting the hard work that should be done from the first lecture to the last exam. This means poor learning results and poor results when the number of students who pass the course is counted.

The teacher of this kind of course faces a difficult question: How to motivate students so that they work hard during the entire course, not just before exams? In this study, we investigated pedagogical tools for increasing students' motivation. The starting point was December 2011 after the results of the mandatory course Mathematical Methods for process engineering students at the University of Oulu revealed a shocking fact. Only 16% of the students, who had taken at least one exam of the course, passed the course. Their lack of motivation was obvious during the course, and they admitted that to the teachers. It seems that the lack of motivation was not the only reason for the poor results in [8], but it was obviously one that was noticed by the teachers and students. Therefore, trying to improve students' learning motivation was chosen as the first vehicle on the way to improve their learning.

The situation was unacceptable for the students and the teachers, and something had to be done. The course was taught again autumn 2012. In that time, students were encouraged to maintain a constant workload during the course from the first lesson to the last exam. The aim was to increase students' motivation in the beginning and trying to feed it during the course. This was the core of the plan, and the implementation was a success: The pass rate was 80% that year.

In this paper, we describe the pedagogical tools developed and their effect on solving this problem. In addition, the question about increasing and maintaining motivation during mathematics course for engineering students will be studied.

This study aims to answer the following research questions:

- What are the students' initial motives for taking a mathematics course?
- What pedagogical tools increase the motivation during the course?

2 Theoretical Framework

2.1 Students' Motivation

Motivation is a commonly used concept when pointing at individuals' desire to do something. Hannula [9] has described motivation as the potential to direct behavior through the mechanisms that control emotion or simplified as the inclination to do certain things and avoid others. The same kind of statement to define motivation was presented in [10]: "Motivations are reasons individuals have for behaving in a given manner in a given situation." This means that a motive is, therefore, something that causes a person to act. These definitions provide us a good starting point to consider undergraduate engineering students' motivation in a mathematics course.

The motivation to do something, in this case to learn mathematics, is commonly divided into two distinct types according to the source of the motivation. Intrinsic motivation describes the desire to do academic tasks because one enjoys them. A student who is intrinsically motivated is interested in learning the content of a course. Extrinsic motivation, in contrast, describes the desire to do such tasks to earn rewards, such as credits, grades, or simply approval. Learning itself does not play an important role [1, 7, 8, 9, 10].

As pointed out in [8] and [9], many engineering students have a surface learning approach to mathematical studies. This observation indicates that the students' motivation is mainly extrinsic. Although students' initial motivation can be quite high, it can be very challenging to maintain that level if they do not get successful outcomes [10]. There is no possibility of success if a student is not willing to put in the effort to learn. This was the problem in the Mathematical Methods course.

The division of motivating sources to two types is also present in Herzberg's two-factor theory [11, 12] which tries to explain the effect of different factors that cause job satisfaction or dissatisfaction. This theory, however, states that only the internal factors, which refer to the source of intrinsic motivation, can increase the job satisfaction. If this motivation-hygiene theory holds true, the challenge for teacher to keep students working seems almost impossible. Even if the Herzberg's theory is still well regarded, many studies have, after all, revealed that both the external and internal factors can affect to satisfaction [13, 14].

2.2 Initial Situation

Engineering students' initial motivation in a mathematics course can often be derived from rewards such as completing the course [6]. This same phenomenon was also clearly present in the study by Savage et al. [1] in which all 422 interviewed engineering students commented on the need to get good grades or to pass the course. The need to pass the course can be almost the only force that drives students to study and cannot be neglected. The connection between these kinds of goals and motivation has been studied widely in the category of self-regulated learning [15, 16].

The reason for dominating extrinsic motivation can be explained mostly by the fact that engineering students cannot see the connection between mathematics studies and core engineering studies or the real world. This assumption has gained support from the research literature [10, 17, 18]. A straightforward method for improving this situation is to increase the number of applicative examples and problems in the course, which has proven to be a success in some cases [2, 5, 18]. A more applicative approach to mathematics can increase students' intrinsic motivation and, therefore, is a preferred method for enhancing the course [1, 17]. The problem that may arise from this kind of development is that it may be difficult to find real life engineering problems that are simple enough for the students. The use of computer can help in this kind of situation as pointed out in [3].

2.3 Factors Promoting Motivation within a Course

It is commonly thought that students' motivation is a stable emotional or mental state but, however, can be affected somehow within a shorter period [8, 10, 19]. As shown in [18], it can be possible to shift extrinsic motivation toward intrinsic by teaching a mathematics course from an application perspective. It sounds like a very reasonable method for improving the situation. We also took this point of view into account when we considered the pedagogical tools proposed to enhance students' motivation in our case.

The shift from extrinsic motivation toward intrinsic is a very desirable effect and is without a doubt one of the most important ways to make students study as pointed out in the literature [17]. However, in this case, we are especially interested in the factors that support extrinsic motivation, which initially exists, during the course. This point of view has not been paid much attention and should be investigated.

Savage et al.'s study [1] showed that the lecturer, as well as carefully constructed academic tasks, can make a strong impact on students' motivation. We also studied the effect of a teacher on study motivation. In addition, we concentrate on the effect of extra points given for different tasks and the effect of small-group learning on promoting students' motivation. The effect of group learning has also been studied in [4, 20], which indicated a strong positive effect on the learning outcome. Motivations arising from group work when learning mathematics were also noted by Walter and Hart [21], who referred to this type of motivation as social-personal motivation.

3 Background of the Case Mathematical Methods

The course Mathematical Methods has been mandatory for process engineering students since 2006, and for environmental engineering students since 2012. It is scheduled for the autumn semester of the second year and lasts from the beginning of September until the middle of November, and includes 40 hours of lectures and 20 hours of exercises. The number of participating students was about 40 per year before 2012, 77 in 2012, and 88 in 2013. The number of European Credit Transfer and Accumulation System (ECTS) credits for the course changed from 3 to 4 at the beginning of September 2013.

The teaching in the course is arranged so that the lecturer gives all the lectures and the assistant leads all the exercises so that they are synchronized carefully. Students can also earn bonus points by doing extra homework. In year 2012 and 2013, the students passed the course if they received 24 points out of 48 points, which is the maximum sum of points that can be earned from the two partial exams during the course.

The main goal of Mathematical Methods is to give students mathematical tools for analyzing control engineering systems as well as tools for understanding, for example, fluid dynamics. The content of the course is challenging, and students must know the previous mathematics studies quite well or work hard to gain adequate knowledge at the beginning of the course. This seems to be one of the main problems to be overcome so that the motivation level does not decrease too much immediately.

4 Tools for Maintaining Motivation and a Constant Workload

4.1 Background of the Development Process

After the unsuccessful year (2011), something had to be done to improve results. The main problem seemed to be the decrease of motivation, so the content of the course was chosen to be the same as in previous years. The changes made aimed to glue the lectures and exercise more closely together and give students more information about where they are going to need the different mathematical tools presented. In addition, students were encouraged to work independently before and after lectures and exercises by offering them extra points for exams. The number of extra points provided changed a little in 2013, and the points earned that year are shown inside parentheses. The tools presented in following sections were developed in conjunction with the Huippuopettajat ESR project.

This development project was implemented as part of the pedagogical training (25 credits) at the University of Oulu, Finland. The content of the training consisted of the basics of university pedagogy; the main content was the competence areas of university teachers, reflection, practical theory, teachers' professional identity, aligned teaching, shared expertise, and research-based teaching. The pedagogical training aimed to reinforce university teachers' interest in student-centered teaching and to support the construction of their professional identity. Collegial co-operation in spite of faculty boundaries was one target in this training as well.

The teaching practice (9 credits) consisted of mentored teaching practice that was connected to the student's work, which was the course Mathematical Methods in this case. The main goal in teaching practice was that all participants could find their own personal teaching style and that they were aware of their view of learning. The other significant goal was to improve university teachers' teaching skills and pedagogical thinking.

4.2 Pedagogical Tools Proposed

The interface between lectures and exercises was made more invisible with pre- and post-exercise homework. The pre-exercise problems were composed so that students could solve them with the information given in lectures without training. These problems, however, were as close as possible to the actual exercise problems, which were learned under the guidance of a teacher. The students who solved the pre-exercise problem and participated in the exercise concerning that problem earned 1/2 (1/3) points to be added to the total sum of points. The maximum number of points was restricted to 4 (3).

The main idea of the post-exercise homework was to provide an opprtunity to see how the learned and trained tools can be applied to real-world problems and how theory (lectures) and practice (exercises) match the engineering world. The problems given were much more complicated and applicative than the exercise problems. However, the problems were introduced in such a way that the students did not have to know anything about the context of the application, but they had to combine things learned during a period of two to three weeks. The number of post-exercises during the course was four, and it was possible to get 1 (3/4) point from each for the points total.

The students were also awarded extra points if they turned in a short lecture and learning diary together with the post-exercise homework. The diary was supposed to benefit the student and the teaching personnel. The students could take advantage of the diary to learn the best studying methods for themselves. The personnel could take the diaries as a feedback channel during the course. The maximum number of points available from the diaries was four in 2012. The lecture diary was replaced with pre-lecture problems in 2013, and it was possible to collect altogether three points from these problems.

The total number of extra points available for both years was, therefore, 12, which were added to the sum of the points from the partial exams. The total sum of points, however, could not exceed 48 points so the points gained from the homework can be thought of as real bonus points. The effect of bonus points was supposed to be small when compared to the points earned from the exams by the learning from the homework. This assumption proved to be true as shown by the results in the following sections.

This homework system seems to be quite heavy for students, and it is. The system, thus, makes the learning burden just before exams much easier by dividing the workload evenly during the course. The students were also individually supported by the teaching personnel. The weekly office hours (4 h in a row) of an assisting teacher were arranged in a small classroom so that students could come to solve their problems and get instant help in the same space. The students accepted this whole model amazingly well, and the mean value of collected extra points was 8.0 (7.5). This homework model seemed to work well for the main purpose, learning, as can be interpreted from the feedback collected and from the overall results.

5 Method

5.1 Research Persons and Data Collection

The research participants included of 88 students who participated in the Mathematics Methods course in autumn 2013. Data includes the students' learning diaries that were collected in four phases during the course. Based on the learning diaries, 13 students were chosen to be invited to the interviews. The students were chosen purposively so that it was possible to describe different kinds of changes occurred through them. Six students accepted the invitation. Two of the interviewed students felt that their motivation kept changing and two others that their motivation remained constant during the course. In addition, one of the students reported feeling increased motivation and one decreased motivation during the course. All six students passed the course with degrees varying from 1 (minimum, point sum 24-28 p) to 5 (maximum, point sum 44-48 p). Students who participated in both partial exams but did not pass the course were also asked for the interviews, but none accepted the invitation.

In-depth interviews were conducted during January and February 2014, and lasted about 20-50 minutes each. The students were asked about their experiences and motivation in the course. The students selected clearly illustrated the point, were particularly information rich [22], and expressed themselves vividly (see also [23]). Ethical issues were considered in the following ways: Confidentiality was assured, the purpose of the interview was explained, and the relationship between the interviewer and interviewees was established.

The main questions concerning this study asked during the interviews were as follows:

- What was your goal in this course?
- How did the different pedagogical tools used in this course affect your study motivation?
- What motivates you in your studies?
- How do you maintain your study motivation?

Four of the interviewed students had a similar situation in the sense that they should have completed the Mathematical methods course earlier. The course was scheduled for the second year of school, but these students were in at least their third year of study. One student was male, David, and three were females, Anna, Maria, and Jenny. This study focused on these

Student	Background	Motivation
Anna	PRO	Changing
David	PRO	Decreased
Jenny	PRO	Constant
Maria	ENV	Increased
John	B.Sc/PRO	Changing
Lisa	B.Sc/ENV	Constant

Table 1: Students interviewed

students' motivation before the course and motivation changes during the course. The two other students, John and Lisa, who were interviewed had different backgrounds compared to these four because they already had bachelors' degrees. Their experiences are not included in detail in this paper but will be presented in forthcoming publications. The interviewed students, their background, and the variation in motivation during the course are presented in Table 1. The background "PRO" indicates that the student's major subject is process engineering and "ENV" that the major subject is environmental engineering.

The quantitative data for this study was collected between 2010 and 2013. The data includes the number of participants in partial exams, the pass results from each year, and the number of participants in lectures, exercises, and homework exercises in 2013.

5.2 Data Analysis

We applied quantitative and qualitative data analysis. In quantitative data analysis, the number of students who participated in exams between 2010 and 2013 were compared to each other carefully, and factors that could have on impact on the compatibility of different years have been taken into account. Student activity in 2013 was analysed by comparing the number of participants in lectures, exercises, and other tasks week by week. In addition, the effect of extra points to the learning results was examined statistically.

In our qualitative data analysis, we applied narrative inquiry, in particular, the categorical approach (cf. [24, 25]). We carefully read all the data in which students talked about their experiences and motivation during the course. Each student's story was dissected, and sections belonging to the 'motivation' category (cf. [25]) were analyzed in detail. We searched the students' interview material for data excerpts that manifested the meaning of the course for students' motivation, and possible change processes. We were open to the different options present in the data. We connected the findings of earlier studies after analyzing the data. In all, we examined the similarities and differences between students' experiences, that is, a systematic comparison to yield a common conceptual manifestation among the cases.

6 Results

6.1 Quantitative Results

The results of this research are divided into two parts. This first part represents the quantitative results concerning the course and the effect of the proposed pedagogical tools. These results give strong support for the sentiment that the pedagogical tools used increased students' motivation and the learning results as the other research question assumed. However, the reasons behind the changes in numbers are complicated, and no deeper conclusions based on these numbers should be made.

The simplified aim of the educational tools proposed was to encourage students to maintain a constant workload during the whole course, from the beginning to the end. This goal was reached clearly if we look at just the numbers in Figure 1 and Table 2. The number of students in exercises and lectures was quite constant in 2013 as we can see in Figure 1. A student was counted as a participant if he or she completed the pre-exercises or participated in exercises or lectures, respectively.

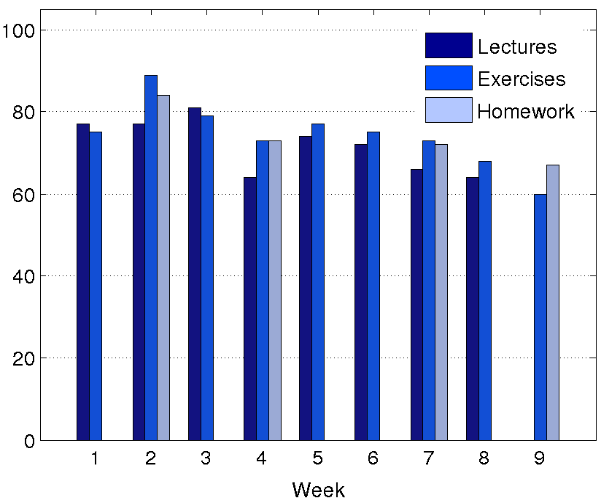

Figure 1: Number of Participants in the 2013 Course

The number of participants in the first partial exam decreased by only 11 students to the second partial exam in 2012 and by 16 students in 2013 if we

Year	Exam 1	Exam 2	Passed	Pass Rate %	Passed wo Bonus	Pass Rate wo Extra %
2010	40	21	17	42.5	16	40.0
2011	37	21	6	16.2	6	16.2
2012	75	64	60	80.0	46	61.3
2013	88	72	66	75.0	56	63.6

Table 2: Number of Students Who Took the Exams and Passed the Course

Year	Major	n	μ_B	σ_B	μ_E	σ_E	r	CI	Strength of Correlation
2012	PRO	50	8.58	3.77	22.34	10.38	0.62	[0.42,0.77]	Moderate/Strong
	ENV	19	9.26	2.60	21.42	9.82	-0.06	[-0.5,0.41]	None
2013	PRO	55	7.29	4.02	20.31	9.06	0.64	[0.45,0.77]	Moderate/Strong
	ENV	24	8.13	3.43	23.13	11.65	0.65	[0.34,0.84]	Moderate/Strong

Table 3: Correlation Between Extra Points and Exam Points Gained

look at Table 2. This is an excellent result if we compare it to the previous years: The difference between the numbers of students who participated in the first and the second exam was 16 in 2011 and 19 in 2010, even if the total number of students was much smaller.

The effect of extra points provided on the results should, of course, be taken into account. It is clear that these points increased the number of students who completed the course. This can be seen in Table 2, where the last column indicates the number of students who would have passed the course, if the extra points had not been taken into account at all. However, the number of students who needed the points to pass the course is acceptable: 14 in 2012 and 10 in 2013. This is a promising sign that the extra points could have steered the students to learn, not only to collect the points.

The effect of extra points gained can, thus, be investigated in a more precise way. If the extra points and the learning effort behind them work as supposed, the amount of extra points gained should predict the amount of exam points gained. The analysis for this is made as follows. The dataset examined consisted of the exam and extra points that the process and environmental engineering students gained in 2012 and 2013. This dataset was divided in four subsets according to the major subject and the year. Students who did not participate to the exams at all were not taken into account.

The number of students n in the subsets is shown in Table 3. The connection between extra and exam points was measured by computing the Pearson's product-moment correlation coefficient [26]. The parameters and correlations with interpretations for all four sets are also collected in Table 3, where μ_B is the mean and σ_B the standard deviation of the extra points gained. Analogously μ_E and σ_E are the mean and the standard deviation of the exam points. Symbol r indicates the computed correlation coefficient and CI the 95% confidence interval for r.

These results are convincing. Three of four sets reveals a clear positive correlation between points gained from different tasks during the course and the exam points. The 95% confidence interval shows also that the result for positive correlation is reliable in all of these three cases. The positive correlation indicates evidently the positive effect of extra points to the learning results. This connection can also be seen in Figure 2 which displays the scatter plot using the extra points and exam points students gained in 2013 as variables.

The only exception, when looking at the correlations, is the set that consists of the results of the environmental engineering students in 2012. However, there is quite a clear explanation for this result. The size of this set is small, $n = 19$, and there are two

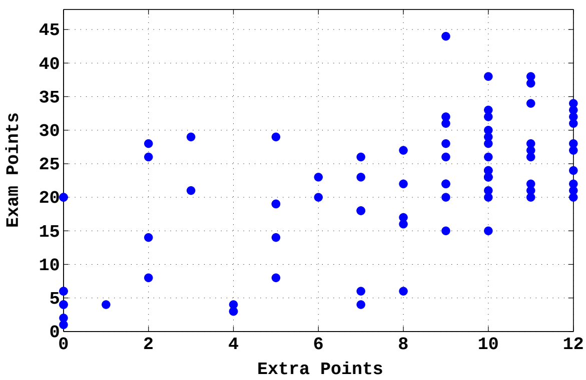

Figure 2: Extra Points vs. Exam Points in 2013

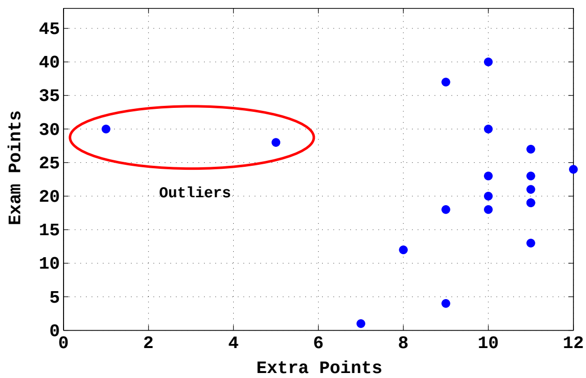

Figure 3: Detected Outliers

outliers as we can see in Figure 3. These outliers represent students that have succeeded well in the exams without collecting so many extra points. If these outliers are removed, the correlation coefficient $r = 0.41$ which can be interpreted as moderate positive correlation.

All these numbers show that the pedagogical tools proposed may have some positive effect. The effect can be seen in the statistical results and as the active participation in the course. However, the numbers do not give exhaustive reasons for the success. What is the role of proposed tools? Did they help to maintain motivation? Are there other reasons for the better results? These questions among others will be discussed in the following section.

6.2 Qualitative Results: Findings from the Interviews

This second part of the results introduces the findings and results from the interviews. The purpose of the interviews was to discover the reasons behind motivation before the course and reasons that affected students' study motivation during the course. The results from the interviews are divided into two main parts as suggested by the questions this study focused on. The first part represents students' thoughts about their study motivation before the course. The second part considers the students' experiences about their motivation levels and the reasons behind it during the course. The data collected from the interviews is studied in conjunction with the numerical data and reflections from reasons and results are presented.

6.2.1 Students' Initial Motivation at the Beginning of the Course

All four students, David, Anna, Maria, and Jenny, admitted that the strongest motive for taking this course was just to complete it. Jenny stated her goal and motivation as follows: "*Then, well, I thought that I have to accomplish it now. I'm not, I'm going to do my master's thesis after next summer, and I'm not coming back here anymore. I was in pressure that it have to be done now because, well, I know that those math courses are damn difficult, at least for me, to do alone or by participating in exercises and lectures. So, so, my motivation was at a good level. I was horrified before the start that I must work terribly hard, but I was quite open, though, I could say I had good motivation if compared to, for example, some my friends.*"

Maria thought the same way: "*I decided then in autumn that, well, I have to try it again by properly participating this time. The end of the course is that difficult. In the beginning, I was just thinking the way that I wish I'm going to finish this course...*"

Anna: "*Well, my goal was to pass the course. I had a thought that it must be done, it has been undone from previous years.*"

David also had the same goal: "*Well, it was more in that way that, well, that let's do now, let's do the undone math courses now. That was, that was the source of motivation, and, otherwise, when you have noticed that if there haven't been any math, you haven't tried math courses, there isn't any routine present, it needs some motivation that you somehow learn, learn things again.*"

Maria, Anna, and Jenny, however, had attempted the course earlier, which also affected their attitudes toward the course as can be observed from the preceding comments. One common factor, which was present on everybody's thoughts, was that they all had made a strong decision to complete the course this year, even though they all were aware that a lot of work had to be done. This indicates a good initial motivation level, even though the driving force was external. In addition, these students had much experience with academic studies. David, Jenny, and Anna had studied for four years or more, which also gives extra motivation, because the graduation is close. A summary of the initial motivation level, therefore, would be that all four students started the course with high extrinsic motivation. By keeping students focused on different tasks all the time, they worked like their driving force would have been intrinsic.

6.2.2 Factors Promoting Students' Motivation During the Course

The interviews revealed several factors that affected the students' motivation during the Mathematical Methods course. However, three main reasons observed by all four, Anna, Maria, Jenny, and David. These factors were as follows:

1. The effect of extra points from different sources,
2. The effect of small-group work on students' own time,
3. The effect of the teachers.

These three factors are discussed in detail in the following.

Effect of Extra Points The extra points given for homework were mainly planned to encourage the students to work constantly during the course. It was possible to earn half the points of a partial exam just by doing and turning in the pre- and post-exercise homework, including the learning diary.

The temptation was big enough as can be observed from Jenny's comment: "*It was the final course, and we wanted to complete it now. You could get awarded by some extra points, and we then got going to gain them.*"

Maria: "*Well, maybe. Of course, it depends on that way, that, well, there was a plenty of, I think, there was that extra point system. It encouraged us, of course, and that way and it helps quite a lot. It is clear that if you did all the homework, you also learned at the same time. Also, if you just work hard, you may learn, I guess.*"

Anna also thought the same thing: "*I would say that the system was, on the other hand, quite demanding because there were so many problems to do that could be returned for extra points. But we had, we had sort of a small group in which we were mostly studying, and when we all had this course somehow not completed, we were pushed to collect all the extra points provided so that everybody can for sure pass the course.*" It is obvious that the extra points encouraged these students to do homework, even if they had to work hard. Maria noticed also that the hard work made for the extra points was important for learning.

David noticed the same: "*It was nice that, that there was a lot of homework which gave you extra points and this way and this made you work with these problems by yourself. You know that if you do them, you can succeed also in the exams because you have got kind of a touch for your computing.*"

Jenny summed up also that the constant learning was especially useful: "*All the learning process has been continuous, not just before an exam. That could be one reason for success, and the other is the routine for computing achieved. You can't do those problems if you don't have that kind of routine. If you take a process engineering course, there is not so much computing if you compare to the courses of mechanical engineering, and this means that you have to catch the routines got in the high school.*"

These students' feelings indicate strongly that the extra points given worked as they had been planned. These four students tried to collect as many points as possible and worked hard for them. It was also clear that the hard work made the students learn as they observed.

Effect of Small-Group Work The learning diaries and other homework students completed during the course revealed that there were a lot of small student groups (3-8 students) that gathered quite regularly during the autumn to do homework together. The students were not steered intentionally to small groups, but they were encouraged to think about the problems together with other students. It was quite surprising that the small-group work was perhaps the most important factor for retaining, and in some cases even increasing, motivation.

Jenny, Anna, Maria, and David had also found a small group in which they worked during the whole course. All felt that the group was crucial for surviving in the course. Jenny explained that the small group was especially useful for her: "*Yes, I mean, I definitely am a kind of, especially when considering math problems, a group worker as can be... ...I need that, I mean, me and one of my friends were doing homework that was at least five pages long for sure. I was thinking that, no, I can't do this any further, and my friend was said that, yes I found it out. Then, it took about a couple of minutes and my friend was in trouble, and this time I could say, I know, how this goes.*"

Anna had the same kind of experience: "*In addition, which especially helped, was that my friends, that there were some of my friends, who had started studying at the same time with me and some others also, and they all wanted to pass the course without fail. When I was in the situation where I myself didn't* *see any way to get further and was ready to give up, some of my friends could have some power left and said, OK, let's try this a little time more.*"

Maria also thought that the small group of her friends was perhaps the most important source of motivation and fight: "*No, but I and my friends from the faculty of Environmental Engineering, who were taking this same course, had a feeling just from the beginning of the course that, well, this time we are going to beat the Mathematical Methods and we are all going to fight through this course now.*" All students benefitted from the group around them. This is obvious. They could get the important feelings from success together with friends which encouraged them to go forward.

The importance of group work for the students surprised the teachers of the course. It is clear that in the future, students will be encouraged even more to work in groups in supervised learning situations and outside the classroom. The observation from a good team spirit, which came through Maria's and Anna's comments, is also very interesting and should not be neglected.

Effect of Teachers The effect of teachers was quite evident. However, even if Jenny, Anna, Maria, and David all thought that the quality of teaching was good, they did not mention directly that it had affected their study motivation. However, the effect can be observed by examining, how and why the students participated in the lectures and exercises and did they have a feeling that teaching personnel was supporting them adequately. The increased amount of individual support was also thought useful.

Maria summed up her feelings about teaching arrangements as follows: "*Well, it was maybe so that, well, the biggest thing was that all the exercises were organized and led very well, especially before the first exam, which was thought of as a more difficult part in previous years. The first partial exam was constructed in such a way, and we had all those exercises so many of us got quite good points from the exam and that give us a bit more motivation somehow. I mean that all thought that maybe it is possible to accomplish now, even if everybody, including myself, was thinking that the course is extremely difficult and you can't pass it and that way, but quite many earned good grades nevertheless.*" She pointed out that well-planned exams played an important role in a course like this.

Jenny had also observed that lectures, homework, and exercises supported well each other: "*It was quite tough, but clear slides in lectures, and there was a connection between given examples in lectures and, for example, pre-exercise problems and other homework... ...which means that it is not just that there are some solutions for model problems, you can copy those, but those examples were gone through patiently, and when you tried to do some problems by yourself after that and noticed that, no this doesn't work, it was possible to get supported so that, well, you could try this way and that way further. I mean, that, yes, the lectures and exercises supported each other.*" Well-constructed examples in lectures were also thought useful and encouraged them to participate as Anna mentioned: "*I participated lectures more often this time than usual because examples were given there. This is because when you got those examples, it was much easier to do your own homework and something else as well.*"

These comments indicate that the plan to connect the lectures, homework, and exercises more closely together had been succeeded. In addition, as Maria stated, the whole course was thought of as a seamless package where different components supported each other and the arrangements were excellent. Jenny had the same feeling and summarized it: "*I got a good feeling from the course afterward so that the whole implementation of the course was good and the individual support got in office hours was all positive so that you have a time when you can go and ask things and, and overall, the course arrangements were great.*"

7 Discussion and Conclusions

The original research questions focused on the students' initial motivation and the pedagogical tools that promoted motivation during the course. The interviews conducted revealed many interesting things about the students' motivation and the reasons behind it. It was quite surprising that the extrinsic motivation students had was enough for them to reach the goal they had set. We did not find any significant sign of increased intrinsic motivation from the interviews. This makes the idea of supporting the extrinsic motivation relevant.

All the interviewed students had a strong extrinsic motivation for the course. They all had one clear goal: to pass the course. This kind of goal setting is common in mathematics courses, and in other courses to some extent, for engineers [1, 6]. In this case, the students were motivated enough to start working hard, make an effort on tasks they were given, and maintain this constant workload during the course. This indicates usually that they were waiting for successful outcomes [9, 10]. This is quite interesting because it was evident that the students were also aware that they had to work hard. One reason for the strong motivation was the extra points available from the homework as the interviews revealed. The second obvious reason was that the students were close graduating and this course had to be completed before. It will be interesting to study further the differences in the variation in motivation between these students and the students generally in the course.

The nature of the motivation of an individual person is quite complicated, and even if some argue if it can be affected within a short period [10, 19], it is quite obvious that it is possible. The interviews showed clearly that three main reasons affected study motivation within this course. The extra points were planned to tempt the students to work constantly and hard during the whole course. This aim was fulfilled when the opinions of the interviewed students are listened to. All students started to work with the problems from the beginning of the course and continued until the end. This can be also observed from the quantitative results provided. In addition, they all admitted that the hard work was also awarded by learning, not just by extra points. The numbers support this claim because the passing rate would have been quite high without the extra points. The bonus points can lead to unwanted side effects like copying, so the system should be considered carefully. Our suggestion is that the problems awarded should include various types of tasks with varying degrees of difficulty. This guarantees that almost everybody can get the feeling of success.

Small-group learning is proven to be a very efficient way to learn mathematics for engineers [20]. However, the small-group learning approach in this course was not fully intentionally planned. The students were, though, encouraged to solve the homework problems in small groups but nothing else. It was revealed that the students worked constantly and regularly in groups in steered exercises and outside the sight of the teachers. The teamwork provided such excellent results that it will be taken account when planning mathematical courses for engineers. If possible, it would be preferred that students can form groups freely, which allows good team spirit observed also from the interviews. This can make the groups also better balanced, which is important for effective learning [20].

The teachers' role behind students' motivation is evident as noted also by Savage et al. [1]. The most important task for a teacher to take care of students' motivation are the arrangements, instructions, and carefully constructed problems so that students believe they can do mathematics if they try [2, 10]. This is quite interesting and was present in the comments of the interviewed students. The students were also happy with the fact that they could get enough support if they needed it. Our suggestion is that the threshold for a student to ask something from a teacher should be lowered as much as possible. Increased number of office hours in a neutral place worked well in this course.

The tools proposed worked excellently for their purpose as can be seen from interviews and numbers. The results show that the students worked constantly during the course. This observation is important because the engineering math courses used to have a common problem at the University of Oulu: The number of students participating drops during the course. In addition, the students' motivation levels lasted from the beginning to the end, and the learning results according to students themselves and the passing rates were at very good level. All the interviewed students were also able to keep the workload constant which, helped them to get successful outcomes.

The main novel finding was that students' extrinsic motivation can be feeded so that it makes students behave as their source of motivation was intrinsic. We were not able to find other research revealing this aspect. In our case, the carefully planned rewarding system worked in this way.

Suggestions and Future Work As a conclusion, we present the following three suggestions to improve the students' motivation to work constantly:

- Students can be rewarded well if the rewards truly require learning.
- Students should be encouraged to small-group working but it have not to be mandatory.
- Teachers should be available for students so that the need for personal support can be fulfilled.

This study revealed many interesting things but there are still a lot of questions that should be examined further. As mentioned earlier, we are going to find out next how the students' background and earlier degrees affect to the study motivation in math courses. In addition, the effect of students self efficacy to the learning results and motivation, among other things, should be analyzed carefully.

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