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Engineering Students' Varying Motivation and Self-concept in Mathematics*

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This study investigates engineering students' views about the factors which have influenced their motivation, mathematical self-concept, and their performance in mathematics. Eleven students from three engineering programmes at one Swedish university were interviewed about their experience from studying mathematics in university. All students were motivated to study mathematics in the beginning of the first year at university but some of them lost motivation after the first year, mostly because of private reasons. However, independent of their study performance, students reported that they had become more self-confident in studying mathematics after the first year which in turn enhanced their mathematical self-concept. Furthermore, a majority of students indicated that transition to online education, prompted by the COVID-19 pandemic, had a negative impact on their motivation and performance. Specifically, they highlighted the absence of in-person communication as a significant challenge. Additionally, students conveyed that receiving continuous feedback and engaging in practice-oriented lectures would greatly benefit their mathematics studies.

Keywords: engineering student; motivation; self-concept; online education

1. Introduction

Students' mathematical self-concept and motivation play an important role in their performance in mathematics. These notions are reciprocally related, but there are also many other factors which influence on the development of students' mathematical self-concept. For example, the transition from secondary school to university challenges students' view of themselves as learners of mathematics in many ways as it requires adopting new practices, sociomathematical norms, and other expectations for how to operate in a new social environment. The relationship between students' self-efficacy beliefs, such as expectations of success and views on their mathematical abilities, and their performance in mathematics may also change significantly under the first year in university, cf. [1, 2].

Similarly, online education which suddenly came to students' life during the COVID-19 has challenged their mathematical self-concept. This switch has created a new concept of studying mathematics and this continues to affect students' motivation and beliefs even today, cf. [3].

The motivation behind the present study can be traced back to our recent cross-sectional investigation [4] involving Swedish engineering students. This investigation explored the relationship between their study habits, views of mathematics, and mathematical self-concept. The findings from the study surprised us to some extent; engineering students express a quite high level of motivation for studying mathematics at the outset of their academic journey, but this motivation experiences a significant decline during the first year. Although third-year students displayed slightly higher motivation compared to second-year students, the motivation among engineering students to engage with mathematics appears to diminish also beyond that point.

In the study programmes involved in [4], the third year is the last year to take compulsory courses in mathematics. In order to better understand the observed variation in students' mathematical self-concept and motivation, we collected complementary data by interviewing eleven students from one of the participating universities about their perception of the described phenomenon and the possible reasons for such a variation of students' motivation. The participating students had also experienced the COVID-19 pandemic and a radical swich to online education. Therefore, we extended the focus of the present study to cover also their experiences from having studied engineering mathematics online. Our hypothesis was that their responses can provide insights into how online teaching may impact students' mathematical self-concept and motivation.

So, the present study surveys how students percieve changes in their mathematical self-concept

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and motivation. Specifically, we aim to investigate how engineering students view the reasons for the changes they have undergone during their education. Our research questions are as follows.

1. How do engineering students articulate their experiences of studying mathematics in terms of motivation and their perception of mathematical self-concept?
2. How do they perceive the changes in their motivation and mathematical self-concept during their first and second year of education?
3. What kind of reasons do they discern for these changes?
4. What kind of measures do they propose to sustain or enhance their motivation?

2. Theoretical Framework

There are several self-constructs in educational research. A probable reason for this is the well-known fact that an individual's concept of him-/herself is an important factor in studying human behaviour. This has led to the introduction of several conceptualisations of self-concept which are close to one another. Consequently, research has shown that notions such as self-efficacy, self-concept, and anxiety are related to achievement also in the context of learning mathematics. This is not surprising because these notions are quite often operationalised (at least, partly) in a same way despite being conceptually distinct.

In this study, we use the term mathematical self-concept in the same sense as general self-concept was defined in the review of classic self-concept research [5]. For us, mathematical self-concept refers to an individual's multidimensional self-perception that develops through his/her experiences and interpretations of studying mathematics. These include, for example, feelings of self-confidence, self-worth, self-acceptance, competence, and ability [6]. The multidimensionality of mathematics self-concept is evident; in the modern literature of mathematical self-concept, notions such as math self-concept, outcome expectancy, and generalized math self-efficacy are taken as self-concept-like constructs, see [6].

We consider students' motivation in the framework of the Expectancy–value theory, e.g., [7]. This theory can be used to explain how an individual's expectations and values affect his or her learning behaviour. In the present study, we do not investigate students' learning outcomes or their actual behaviour in studying mathematics, but the theory is useful also in describing a student's relationship to the subject he/she is supposed to study.

According to this theory expectancies and values represent beliefs. Expectancies concern the expected chances of succeeding in the future, whereas values represent valuations and the perceived abilities in the present situation. These beliefs are based first and foremost on past experiences. An individual's motivational values are distributed into four categories: intrinsic value, attainment value, utility value, and cost. In the context of studying mathematics, intrinsic value refers to the enjoyment of and interest in studying the subject. Attainment value stands for the perceived importance of being good at mathematics, and utility value is related to the perceived usefulness of being good at mathematics for the other goals. Cost portrays how much an individual is ready to invest his or her resources in studying mathematics.

3. A Review of the Literature

First-year engineering students usually have intrinsic motivation to study mathematics and rather high self-efficacy in the subject [4, 8, 9]. However, in light of previous research, e.g., [1, 8, 10], first-year engineering students' mathematical self-concept is not a good predictor of their success in the beginning of their studies. Students often tend to overestimate their abilities. On the other hand, a combination of four factors – self-efficacy, type of motivation, study habits, and students' view of mathematics – can quite well predict engineering students' success in a later phase of their university studies [1]. It was observed in [1] that already after one year at university, students' self-efficacy and motivation were strongly correlated to students' success in engineering mathematics.

It has also been investigated, how engineering students' mathematical self-concept depends on their study habits and their views about mathematics [4]. Students' study habits and views about mathematics are related to their mathematical self-concept. For example, students who value deep learning approaches and exact reasoning also demonstrate higher mathematical self-concept compared to those who perceive mathematics merely as a toolbox. A similar result was reported also in [11], which investigated relations between students' mathematical self-efficacy and approaches to learning mathematics among first-year engineering students at a Norwegian university. Interestingly, surface approach to learning can also be a significant predictor of first-year engineering students' performance [12]. While this factor had a negative effect on students' performance, the deep approach to learning had no significant effect on first-year students' performance. A negative correlation between self-evaluated study success in

mathematics and students' toolbox-view of mathematics has also been reported in [13].

As a result of the COVID-19 pandemic, many universities switched their mathematics education from regular to distance education, which in turn has influenced students' motivation and mathematical self-concept. There are several studies reporting both positive and negative aspects of online education for engineering students. This may indicate that there are cultural (including economical and political) differences which affect how easily students can adopt new forms of education.

According to [4], under normal circumstances, physical participation in lectures is one of the preferred and prevailing study habits among engineering students. Therefore, it does not come as a surprise that many engineering students have reported lack of face-to-face communication as one of the most negative effects of distance education, e.g., [14–16]. For instance, in an investigation [14] surveying how engineering students in Lithuania and Romania perceived the usefulness of distance education, it was noticed only a relatively low perception of usefulness of online learning. Moreover, when the usefulness was considered in the four-dimensional framework – the social usefulness of online lectures, the usefulness of online learning platforms, learning effectiveness, and the usefulness for performance – the most appreciated dimension was online learning platform, and the least appreciated aspect was the social usefulness.

Similarly, when both students and instructors from six engineering education departments at an American university were examined [16], it was found that distance education had a negative impact on students' motivation. Besides the lack of interaction, students have identified multiple challenges related to distance learning, including lack of access to private study space, difficulties with time management, lack of engagement and peer-support, as well as the issue of 'Zoom fatigue'.

4. Method

4.1 Interviews with Students

The data for the present study were collected from one Swedish university during Autumn 2022. The participants of the study were second-, fourth-, and fifth-year engineering students from three different programs: Engineering Physics and Electrical Engineering, Mechanical Engineering, and Sustainable Energy Engineering. All students from these programmes were informed about the possibility to be interviewed; eleven students volunteered, i.e., the participation was not obligatory and no reward was promised. Six of them are female (2 fourth-year students, and 4 second-year students) and five are male (1 fifth-year student, 2 fourth-year students, and 2 second-year students), see Table 1.

Semi-structured interviews were recorded and conducted face-to-face, with each interview lasting between 20 and 45 minutes. The majority of students were interviewed individually, with the exception of S3 and S4. In the beginning of interviews, students were shown graphs on the results on engineering students' motivation reported in [4] and described in the Introduction. The interviews were divided into several sections, covering topics such as students' expectations and experiences in studying mathematics in university, the support they received during their studies, and the changes in their self-confidence in mathematics throughout their time in university.

The interviews focused on students' motivation especially from the perspective of intrinsic value, utility value, and cost. Attainment value was also discussed at the interviews, but there were no direct questions related to it. When it comes to mathematical self-concept, we inquired especially about self-confidence and issues related ability beliefs. The interviews were conducted either in Swedish or English, depending on the student's language preference. The topics covered during the interviews

Table 1. Summary of the interviewed students

Student	Year	Gender	Program
S1	2	female	Sustainable Energy Engineering
S2	2	female	Sustainable Energy Engineering
S3	2	female	Sustainable Energy Engineering
S4	2	female	Sustainable Energy Engineering
S5	2	male	Sustainable Energy Engineering
S6	2	male	Mechanical Engineering
S7	4	female	Engineering Physics and Electrical Engineering
S8	4	female	Engineering Physics and Electrical Engineering
S9	4	male	Engineering Physics and Electrical Engineering
S10	4	male	Mechanical Engineering
S11	5	male	Mechanical Engineering

are provided in Appendix, along with examples of specific questions.

4.2 Analyses

The interviews were first transcribed and verified by two of the authors. Thereafter, the transcripts were analysed separately by three of the authors using content analysis. It is possible to discern three main traditions in the methodology of content analysis [17]. The traditions differ from one another especially in the question, to which extent we can assume that the meaningful content is explicitly present in the interviewees' utterances or does the essential content emerge in the process of a researcher analysing the interviews. Our premise is that students are able to explicitly describe the changes which they have perceived (cf. the first research question), but in order to understand how they perceive the changes and the reasons behind them, we have to interpret their utterances with aid of our theoretical framework.

4.3 Limitations of Study

Obviously, eleven students is only a small sample of the population; the participating university enrolls more than 600 engineering students annually. This raises a question, to what extent one can generalize the results of this study. On the other hand, eleven is rather large number of interviewees in qualitative research. Therefore, we assume that our data can provide useful information also at a general level.

We remark also that all interviewed students did not necessarily take part in the online questionnaire conducted and analysed in [4]. We do not know this because we experienced that we do not have an ethical right to ask about it. Therefore, one cannot say that the present study automatically deepens the very findings reported in [4], although the interviewees represent three engineering programmes which were contained in that study.

4.4 Ethical Issues

When it comes to collecting, analysing, and handling of the data of this study, ethical recommendations given by The Swedish Research Council (https://www.vr.se/english) were applied. No sensitive personal information was collected. All the participants were, at least, 18 years old and they were informed about the purpose of the study and how the anonymity of their responses would be protected.

5. Results

5.1 The First Research Question

Our first research question concerns engineering students' experiences from studying mathematics in university. As most mathematics courses are supposed to be taken in the first and second years, we are interested in their mathematical self-concept and motivation especially during these years. We divide our answer to it into a few sections and start by reporting on their expectations and how they were fulfilled.

In the following, we use the codes S1–S11 to indicate how students' responses vary across their study year and gender.

5.1.1 Expectations and Experiences

When students were asked whether their mathematical studies in university have gone as they had expected, four students (S3, S4, S5, and S10) said so, three students (S7, S8, and S9) thought that it has been easier than what they had expected, and four students (S1, S2, S6, and S11) reported the opposite experiences. Too high tempo, workload, and distance education were the most common difficulties which students mentioned in the interviews:

> "I think it was more difficult than I thought it would be. It goes a lot quicker, you don't have as much communication with teachers, it's not easy to ask for help, and especially in the first course I did during the lockdown, it was online and I think probably it had an effect as well" (S1).

> "I have good experience of studying math but when I came here in the first year it was quite a lot, like I wasn't used to tempo, it was a lot to do" (S11).

5.1.2 Utility and Intrinsic Values

All students reported that they find mathematics useful because of its applications in other courses and in engineering. However, only four students acknowledged the usefulness of mathematics in life in general:

> "(. . .) it helps you to understand the world and how it works" (S1).

> "I think, like, analytical skills, I think it still improves. You think deeper in some way, maybe. So, I have become better at thinking. I feel that I have developed it, at least" (S3, translated from Swedish).

> "(. . .) it's just everyday things, just economics, just calculating or just trying to draw conclusions about everyday situations" (S7).

> "(. . .) Oh, a lot of stuff. It's engineering, in everyday life, just kind of like . . . in economy" (S8).

Students S1, S3, S4, S6, and S11 stated that they consider mathematics merely as a toolbox. Two other students (S9 and S10) said that it's a toolbox but they also want to have deep understanding about it. Two students (S7 and S8) said that they just like mathematics and enjoy studying it:

> "I just see how it can be applied and also it's like a toolbox. (. . .) I feel like it is more about knowing that there is this technique, but I don't maybe need to know it exactly. If I need to use it then I can look it up and understand how it works" (S9).

> "It is a little so that it is not only a toolbox for problem. You also want to have understanding why it works so" (S10, translated from Swedish).
>
> "I have obviously liked math and I still like it and I want to take more courses" (S7).
>
> "Well, I like math. For me the first year was the most fun year because we had only like math courses. (. . .) And then maybe we use math in all our courses because it's physics, so it's math . . . but still . . . I kind of like it when it's more just math" (S8).

5.1.3 Perceptions of Abilities (Self-concept)

Almost all students expressed that the mathematical problems they meet during the courses are challenging to them, but, for example, solving equations is easier for them than proving some statement. Only S6 and S7 said that they find it more difficult to solve equations than prove theorems:

> "I think probably solving an equation is harder because (. . .) sometimes I forget minus signs and numbers. (. . .) I really like proof, because I was always really bad at math, because I didn't understand the logic behind it. When I started proving things, when I get introduced to the concept of proof then I started understanding it" (S7).

One student doubted in his answer:

> "I think a little bit of both. (. . .) I don't know. I mean, it's not most fun actually to prove some statement. It's more fun to solve equation, so I rather do that" (S11).

However, challenging problems do not seem to challenge students' mathematical self-concept in such a way that it would lead to decreasing interest in mathematics. When they were asked to evaluate two statements presented in Table 2 using five-point Likert-scales (1 = very negative, 2 = slightly negative, 3 = neutral, 4 = slightly positive, 5 = positive), all of them indicated that they find mathematical problems quite interesting although they are challenging.

5.1.4 Self-confidence

Students were asked about the development of their self-confidence in mathematics compared to their first year in university. Most students reported that they feel now more confident than in the beginning of their first year. Only S11 said that his self-confidence has not changed over time and S7 and S8 were not sure about their views.

For some students' mathematical self-confidence, the crucial point is whether or not they pass an exam in mathematics. For example, S2 reported that she failed first two courses in mathematics but when she succeeded on the third one, it gave her remarkably more self-confidence to proceed with her studies. As a result, she took re-exams and passed also the first two courses in mathematics:

> "I needed a little boost to feel that I can do something, and it was Calculus 3 which made it. [. . .] It becomes easier to study other courses. [. . .] You have self-confidence and know that you can do it and it is just to put time that needed" (S2, translated from Swedish).

Similar conclusions can be drawn on the response from S3:

> "I was very afraid that I would fail all the exams first year, but I passed them all. Now it feels more like "Ahh, I know what is required" [. . .] how much it is required for me to study to be able to pass exams" (S3, translated from Swedish).

Student S5 had passed all courses in mathematics so far, except for the second one. He reported that now his self-confidence has awaken:

> "Now it feels good, now it feels that it is fun to open a difficult problem and try to solve it. In Calculus 1 and 2 it was hard to open difficult problem and try to solve it. But it is much more fun now to study mathematics" (S5, translated from Swedish).

To summarize our answer to the first research question, students perceive that they were motivated to study mathematics in the beginning of their studies, but their expectations how well they would succeed in mathematics in university differed to some degree from their actual performance. Further, most of the interviewed students stated that they have gained in mathematical self-confidence during their time in university as their abilities have developed, which is indicated by the fact that they have passed the exams.

5.2 The Second and Third Research Questions

In this section, we report how students described the changes in their motivation and mathematical self-concept, and the eventual reasons for them.

Students S3, S7, S8, and S9 stated that their motivation to study mathematics had dropped during the second year. However, S4, S5, S6, S10,

Table 2. Engineering students' views at mathematical problems

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
I find mathematical problems interesting	3–4	4	4–5	4–5	3–4	3	5	4–5	4	5	3–4
I find mathematical problems challenging	4	3	4	4	4–5	4	5	–	3	4	4–5

and S11 reported that their motivation had not decreased during the second year. Moreover, S5 and S6 thought that their motivation to study mathematics is higher than during the first year. Student S11 said that he has been highly motivated each year during the first three study periods, but in the last period before summer his motivation has always dropped.

Students S5, S7, and S8 thought that decreasing interest to succeed in mathematics during the second year is not necessarily due to mathematics, but the reason is that other things than studying become more central in students' life during the second year in university. This perception indicates a quite remarkable change also in their mathematical self-concept as it depicts a change in their idea of being a university student.

> "When I came here I became very tempted to start studying again, I was very tempted to do something [. . .] therefore my motivation was very high in the beginning and I can agree with those graphs saying that my motivation falters a little, not just for mathematics in particular but for everything after the first year" (S5, translated from Swedish).

> "I feel like the first year I was very good at keeping up speed and then for my second and third year I think my motivation was . . . the lowest last year. [. . .] I had stuff outside of school like participating in student life, it took a lot of my time" (S8).

Student S7 reported that she lost her motivation to study mathematics already at the end of the first year because of a sudden switch to distance education due to COVID-19. However, like S5 and S8, she also acknowledges that her motivation decreased as the novelty value of studying in university vanished and her mathematical self-concept underwent a change from being very good to being uncertain and directionless:

> "I was motivated at that time (end of the first year) but then I didn't see anyone for a few months and then I lost my interest [. . .] I was very good in the first year and then I had like a dip second going to the third year [. . .] I want to blame CORONA but I don't know if that was the reason. In the beginning it's all new and you are like "Oh, I am gonna do this!" and you start to learn techniques etc. and then you sort of lost it for a while" (S7).

> "During the third year I was not interested in the courses which were given. I didn't have math at all. We had statistics, it was math, but it's . . . (laughing)" (S7).

Also S1 thought that students' motivation can be lower during the second year in general and this is not particularly related to mathematics. However, speaking about mathematics, she mentioned that one of the reasons for lower motivation during the second year can be that they have too many courses in mathematics during their first year. This leads to that they become tired of mathematics:

> "I think that maybe people a little bit in general drop off. I think that might be one of the reasons at least, because at the beginning you are a little bit nervous when everything is new and at second year you have three more years left and there is no reason to stress [. . .] so I think in general people drop off a little bit in the second year. With math I am not sure, maybe also. I had three courses my first year, I know some others have four the first year, that's a lot of math and I think you maybe get a little bit tired of it, actually, because you get no break" (S1).

Similarly, S3 reports that she became tired of her studies. She had passed all mathematics courses on the first shot. However, in the beginning of the second year she was not as motivated as she was before:

> "I still want to pass courses, but I am very tired now also [. . .] I don't think that I have the same strong motivation as I had during the first year. It is not only to pass the courses; one must sleep and rest also [. . .] I am rather prepared to take a year in university to have a funny student life [. . .] I prioritised to study instead of having fun" (S3, translated from Swedish).

Student S4 is one of the students who had not lost their motivation. Interestingly, her motivation or self-concept were not disturbed by the fact that she had not passed every course; she had passed two courses in mathematics (Calculus 1 and 3) but failed Calculus 2. Being a second-year student, she was studying the fourth course in mathematics:

> "I think I have the same motivation as I had. I think mathematics is very interesting subject" (S4, translated from Swedish).

The same applies to S6 who had not passed any of the courses in mathematics but, in the beginning of the second year, he felt even more motivated to study mathematics than before. It seems that he had found a new kind of conception of himself as student of mathematics:

> "I feel more motivated to succeed in math now than I did in my first year [. . .] now I realize how important it is to study the math. In the first year it was "Ok, maybe I will make it", but now I feel more like I need to study a lot more, I need to get into the math a lot more" (S6).

Some students' mathematical self-concept seems to be quite stable as they do not experience radical changes personally. For example, S10 had passed all courses in mathematics at the first attempt. He was studying his second year and his motivation was continuously high and he felt self-confident but he reported that he knew many students who dropped off the studies because courses were too difficult, he was sorry about the troubles his peers were experiencing:

> "I know many with whom I study who has dropped a

little [. . .] if they felt that the program was not the one they wanted to study or they thought that courses were too difficult. I had a friend who dropped off and started to work instead. [. . .] I think that first courses in mathematics are quite difficult for many. I think it is combination with university, it requires so much to study, it is a high tempo, courses are often difficult, mathematics comes at the beginning. . .'' (S10, translated from Swedish).

In addition to private reasons, the switch to distance education due to COVID-19 was one of the most common reasons for decreased motivation or challenged self-concept:

''I thought that we would have more communication with the teachers and it would be easier to get help in general. And I do think that it was kind of weird during the lockdown because we couldn't meet teachers'' (S1).

''I think absolutely that online course in mathematics also did that one was not so active [. . .] it makes quite big difference at least for me'' (S2).

One student was successful during the first year and had passed the first three courses in mathematics but then she failed the fourth one:

''That was the first course we did remote. So, I really didn't put effort there. [. . .] I didn't have class to go since it was during COVID. I think if I have gone to class it would be easier, at least for me, because I need teacher interaction and I need talking to my peers'' (S7).

Even more experienced students had had challenges with online education. One student was studying his fourth year and had passed all exams in mathematics, except for the course in mathematical physics, which was given online.

''During distance education I had a lot of difficulty keeping interest. It wasn't the same, it wasn't interesting. We had pre-recorded lectures, watching those really didn't work out'' (S9).

On the other hand, three second-year students reported that they didn't experience a significant difference between studying online and on site.

''I don't think that it was a big difference. One must only with discipline watch videos, and when we stopped watching videos and there were no exercises to do then I just studied old exams and then I passed the course'' (S3, translated from Swedish).

''Being online or here at school, that's basically the same'' (S6).

5.3 The Fourth Research Question

At the interviews, students provided several suggestions of what kind of measures would help them to perform better in their mathematical studies. Five second-year students mentioned explicitly one of their courses as a good example having a supporting structure. They appreciated especially having quizzes and smaller examination tasks all the way during the course. Also extra points for such assignments motivated them to study:

''. . . Calculus 3, the third course, that was the best one I have done because it's structured very good and everybody that I talked to loved that one. [. . .] It had a little all these like little tests in between and quizzes and stuff like that, that you had to stay on top with studies and you had points to keep doing that. And also after a week of studying you get to try a real exam type problem to apply what you learn and we didn't have that in any other courses and I really liked that'' (S1).

''I think that the structure of the Calculus 3 was very good. It helped me a lot anyway that one had task assignments that became as a small homework for every week. [. . .] Extra points were nice, it was fun. But what I thought was very good is that [. . .] you always needed to be in phase to be able to do the assignments. So, it became like ''Ok, now I have done that this week'' and so you got an overview of what you had learned. You got a summary of what you had learnt during the week. It was very good to get extra points, of course, but I thought it was more for myself, to be in phase and sort of did what you are supposed to do to pass the course'' (S2, translated from Swedish).

''Concerning Calculus 3, I think it was the best course in mathematics we have studied. The way the teacher planned the course was very good. You can get extra points and it motivates a lot to study and do those tasks. There were also quizzes, they were knowledge questions and equation-type questions'' (S4, translated from Swedish).

Five students also reported that they would like to have not only lectures in mathematics but also some practical exercises where they could work together with teacher:

''I also like the math 4 [=nickname of a course] with the problem-solving type of lessons or something what we have in other courses where you just sit, and you solve by yourself and then you just raise your hand and ask if you had any questions'' (S1).

''We get like three tasks, we sit for a quarter of an hour and then go through them on the blackboard. It is very good. I like this very much'' (S3, translated from Swedish).

''I went to like one of the lecturer, one of the teachers, he started every lecture with a question from the last week or last lecture and he put it up on the board, solve this, you get 5-10 minutes and then you solved it and then he solved it so we could see if we did it right. And that was really good. I think he was only one I had who did it in that way'' (S11).

Several students reported problems with too high tempo during the courses in mathematics. An access to uploaded lecture notes and other materials before lectures would help them:

''Upload lecture notes. I think it is very difficult, I don't really have time to make notes and listen at the same time. It becomes only: ''Ahh, now I sit and just write'' and then I lose focus on the lecturer and on what he says and instead I just write what he writes. If one doesn't want to upload lecture notes, then upload some hints or guidelines how one takes the notes during the

> lecture in the best way. They write very fast on the blackboard, and I don't have time to write myself either'' (S4, translated from Swedish).
>
> ''. . . it's good that some of the lectures have pre-recorded videos and that's good if you go to the lecture and you don't understand then you can go back and watch the video in the Canvas room'' (S11).

One student suggested that more real-life examples should be discussed:

> ''So, I don't really know what to improve for me personally. But I think, in general, this is the classic: what are you using math for, maybe have more real-life examples for people that they know that it's important to have math'' (S7).

Another student reported that he would like to combine lectures on site with Zoom-meetings:

> ''I really like a Zoom-meetings when you can ask questions, it's probably a good idea to have like every week, I would still like to have lectures on site and also like teacher writes everything on blackboard. . .'' (S11).

Summing up, many students expressed that their motivation to study mathematics changed during the first and second years at university. A lot of reasons were listed by the students for the changes in their motivation and mathematical self-concept. The switch to online education was the most often mentioned reason for the decreasing motivation. Another common reason was getting tired of too many mathematical courses given in a row. When it comes to mathematical self-concept, students reported that clear structure of the courses and continuous feedback from the teacher would help them to strengthen their abilities and self-confidence, as it would help them to learn how to study mathematics, how to prepare for exams and how much time and energy they should invest in the course.

6. Discussion

Previous research has shown that the Swedish first-year engineering students are motivated to study mathematics in the beginning of their studies in university but their motivation begins to decrease quite soon, e.g., [1, 8]. The interviews with students further support these findings. Some students reported that they had lost their motivation during the second year, mostly because of private reasons. However, we also met students who oppositely reported that they have been motivated to study mathematics, at least, as much as during the first year. It is interesting to note that these students are very different in how well they have succeeded in mathematics. Student S6 had not passed any course in mathematics, but he reported that he – a second-year student – is more motivated to study than during the first year. In contrast, student S4 found her motivation to study mathematics after she successfully passed the third course.

Table 2 shows that all students who took part in the interview find mathematics both interesting and challenging. In other words, meeting challenging problems in mathematics does not necessarily prevent engineering students to consider mathematics interesting and motivating. Even those students who reported that they had experienced a loss of motivation during the second year (e.g., S3, S7, S8, and S9), at the same time, agreed or strongly agreed on the claim that mathematical problems are interesting. These students were also quite able to reflect over their mathematical abilities even though they were struggling with the content of their courses in mathematics.

Most students reported that they perceive mathematics merely as a ''toolbox'' which is compatible with many previous studies, e.g., [2, 4]. However, the fourth-year students expressed that they are genuinely interested in mathematics and they were searching for a deeper understanding about mathematics. For the second-year students, ''toolbox'' view of mathematics seems to be quite common. A plausible reason for this is that mathematics in upper secondary school focuses much more on, e.g., solving equations than proving mathematical claims. This may explain why many students' motivation decreases during the first year in university; it takes time to develop a new concept of what studying mathematics is.

In our data, distance education appeared to be one of the most common reasons for a lack of motivation. Indeed, most students reported negative experiences from the switch to online education. In particular, they mentioned that they had missed face-to-face communication with fellow students and teachers. They also found it more difficult to ask their teachers for help online than in classroom. These outcomes support previous findings, e.g., [14, 16] and underline the importance of having, at least, some of the classes on site at university, especially for first-year engineering students. Moreover, as mentioned in [4], many students need help in developing their metacognitive skills to use online learning materials in an effective way. Yet some students had succeeded in the switch to studying online. They were self-organized in their studies and reported that they had become more self-confident in studying mathematics.

The interviewed students offered valuable insights and suggestions for enhancing their studying process. Among the most frequently mentioned measures were the need for continuous feedback from teachers, a well-defined course structure, the integration of practical lessons, and easy and early

access to online course materials. In particular, five students out of eleven reported that having quizzes and task assignments every week or every second week helped them in preparing for exam. The importance of continuous feedback from teacher were highlighted in several student responses. Also previous research has shown that continuous feedback helps students to perform better in their studies, e.g., [18].

7. Conclusions

Table 2 shows that engineering students find mathematical problems interesting independent of their success. However, many of them view mathematics as a "toolbox" and as a result of that, very often their intrinsic motivation to study mathematics is weak. An important positive conclusion related to our first research question is that there are engineering students who, perhaps, do not seem achievers but actually they are potential achievers because they find mathematics interesting and are per se willing to succeed in their studies. However, they need more guidance and support to realize this potential.

Our second and third research questions concern how students describe the changes of their motivation and mathematical self-concept, and reasons for these changes. Distance education was reported by students as one of the main reasons of dropping out of studies and loosing motivation. Our conclusion is that the importance of face-to-face communication with fellow students and teachers cannot be overstated. In addition, students should develop their metacognitive skills and self-concept before they can benefit from distance education. Also this underlines the importance of having classes on site at university, in particular for first-year engineering students.

When it comes to our findings related to the fourth research question, our conclusion is that engineering students can be motivated for active learning in mathematics by providing them feedback more often. It is important to notice that some students reported that they are shy, and they don't ask teachers for help even when they have questions. Giving continuous feedback should help these students to overcome those fears and thus encourage them to become more active in teaching situations. It may require more teaching resources for conducting mathematics courses in this way. However, if it helps to significantly reduce the drop-out rate – which is quite high, at least, in the Swedish engineering education – this investment should pay back itself.

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Appendix – The Interview Topics

Below we present those topics discussed during the interviews which are relevant to the present study.

1. *General experiences from studying in university.*
   - How would you describe your experiences from studying mathematics at university?
   - Do you feel that you were successful? If yes, then describe during which periods? If no, for what reasons?
   - Has there been something you have been disappointed at your mathematics education? If yes, then what? If no, did everything go as you have expected?
2. *Questions related to motivation and self-concept.*
   - Evaluate on the scale 1 = very negative, 2 = slightly negative, 3 = neutral, 4 = slightly positive, 5 = very positive:
     (a) I find many mathematical problems interesting.
     (b) I find many mathematical problems challenging.
   - Do you think that mathematics is useful in our life? If yes, then give examples, if no – why not?
   - Which one do you find more difficult in mathematics: to solve some equation or to prove some mathematical statement? Do you feel more secure when solving equations or when proving some statements?
   - Do you usually put a lot of effort to pass exam in mathematics? Describe your experiences.
3. *Questions related to experienced challenges and self-confidence.*
   - When you face some problem with understanding material or solving some mathematical tasks, do you feel that you have enough support available to proceed (e.g., good books, easy to ask teacher, discuss with friends)?
   - Describe how confident you are in studying mathematics courses after your first year in university?
   - For 4th and 5th year students: In what ways your confidence in succeeding in mathematics has changed over time?
4. *Interest in mathematics.*
   - Do you have mathematics courses during the third and fourth year of your education? If no, would you like to have?
5. *Discussion how to improve mathematics education for engineering students.*

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