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Norwegian freshmen engineering students' self-efficacy, motivation, and view of mathematics in light of task performance

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ABSTRACT: We report on 71 Norwegian freshmen engineering students' self-efficacy and motivation in mathematics. Students' responses to five-point Likert scales were analysed across three groups corresponding to different performance levels on a set of mathematical tasks. The groups were investigated to trace differences in self-efficacy, motivation, and the epistemological beliefs about the nature of mathematics. Results show that the Norwegian first-year engineering students' self-efficacy is closely related to task performance, but there is not a similar correspondence between task performance and the motivational values. The amount of higher performing students who regard mathematics as a set of (ready-made) tools for solving tasks is a little higher than the amount of lower performing students, while in the case of valuing problem-solving processes in mathematics, the distribution of students is opposite with lower performing students being a majority. The task performance levels are a significant predictor of how dynamic the distribution of the epistemological beliefs is.

Keywords: engineering students; motivation; orientations; self-efficacy; task performance

1 INTRODUCTION

Mathematics courses are a fundamental part of every engineering study program. Engineering students are confronted with substantial amounts of mathematics even if they have not chosen their course of studies for that reason. Rather, it is the other way around; in the study by Harris, Black, Hernandez-Martinez, Pepin and Williams (2015), very few students were aware of the demands on studying mathematics when starting their studies. In addition to this comes challenges relating to the transition from school to university, which often includes changes both in the social setting as students move to a new location, to a new environment with new friends, and in what and how to learn new subject areas. In mathematics educational research, this gap, often called the 'transition problem', concerns especially changes in learning processes and mathematical practices (Gueudet, Bosch, diSessa, Kwon, & Verschaffel, 2016) and their relation to students' performance and motivation (e.g. Anthony, 2000).

The present study is part of a larger project focusing on the transition problem among freshmen engineering students in Finland, Sweden, and Norway. Some results on the Swedish students separately (Tossavainen, Rensaa, & Johansson, 2021), and all three cohorts jointly (Tossavainen, Rensaa, Haukkanen, Mattila, & Johansson, 2021) have already been reported. The present paper examines students at a Norwegian university and provides some means to compare the outcome of the upper secondary mathematics education in Norway and Sweden. In addition to investigating students' motivation, we examine engineering students' views of mathematics in terms of certain orientations, i.e., the epistemological beliefs about the nature

of mathematics (Felbrich, Müller, & Blömeke, 2008; Grigutsch, Raatz, & Törner, 1998).

Our starting point for the analyses is the variation in the students' performance in a given set of mathematical tasks. We focus on investigating how Norwegian students at various task performance levels differ from one another in self-efficacy, motivation, and with respect to their orientations, while our previous studies focused on surveying at somewhat more general level what kind of relations there are between motivation, self-efficacy, task performance and students' distributions of orientations.

Previous research has revealed deficiencies in the secondary students' mathematical knowledge in Norway, making the transition to university mathematics quite challenging for many of them (Nortvedt & Siqveland, 2018). For students who struggle already with basic tasks, motivational factors are especially important if they are to succeed in their studies. Thus, as stated by Dyrberg and Holmegaard (2019 p. 92),'It is important that teachers are aware of students' motivation for learning on their course in order to apply teaching strategies to foster these motivations and facilitate effective learning'. We aim at contributing to such knowledge in the present paper. Our investigation can be taken as a sequel to the study by Nortvedt and Siqveland (2018). However, while they consider only the extrinsic and intrinsic motivation for mathematics of both engineering and calculus students, our range of motivational values is more distinctive and we focus only on engineering students. The latter restriction is relevant since engineering students often have priority interests in engineering subjects more than mathematics (Kümmerer, 2001).

In the coming sections, we first present our framework and give a review of previous literature relevant to our investigation. Then we describe our methodology and research questions. Finally, the result section is followed by a discussion of our findings and conclusions.

2 CONCEPTUAL FRAMEWORK

The present paper is based on two theoretical perspectives. One is related to investigating self-efficacy and motivation, the other is to examining orientations to mathematics.

The expectancy–value theory (EVT) is one of the most used theories of motivation. The model range from previous experiences and socialization influences to achievement related choices at a domain specific level (Eccles et al., 1983; Eccles & Wigfield, 2020). In this theory, value-based beliefs like motivation in education is predicted by values associated with a task and expectancies of success. It puts an individual's motivational task value into four groups: attainment values, intrinsic values, utility values, and relative cost (Eccles & Wigfield, 2020). In our context, the attainment values are related to the perceived importance of being good at mathematics, whereas the intrinsic values refer to the enjoyment of and interest in studying mathematics. Further, the utility values represent the perceived usefulness of knowing mathematics for short- and long-range goals, and the lastly mentioned values stand for the cost of engaging in studying mathematics relative to the benefits.

In the EVT model, both subjective task values and expectation of success in future are assumed to be influenced by an individual's goals and general self-schemata (Wigfield & Eccles, 2000). Included in this is self-concept of ability beliefs, and ability beliefs are by Wigfield and Eccles defined as an individual's view of own current competence. According to Bong and Skaavik (2003), self-concept and self-efficacy share some main similarities as both predict motivation, emotions and performance. Self-efficacy, however, act as a predecessor

for self-concept as the latter has a fundamental social component in relying on appraisals from significant others. Self-efficacy, in contrast, is about individual's expectations of what they can accomplish without comparing to others (Bong & Skaalvik, 2003). The formal definition of self-efficacy offered by Bandura (1997) shows this, stating that perceived self-efficacy is about 'beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments' (Bandura, 1997, p.3).

We address subjective task values in EVT, and perceived self-efficacy has by researchers been informed to be more predictive on students' mathematics performance than mathematics self-concept (Pajares & Miller, 1994). Previous research has shown that an individual's judgement of her/his self-efficacy is task and domain specific (Pajares, 1996) as students avoid tasks which they do not feel confident and competent in and engage in those which the do. An example of how self-efficacy determines students' behaviour in task solving situations is that students with low self-efficacy in mathematics may try to avoid demanding mathematical tasks while those with high self-efficacy may see them as challenges to overcome and master.

Nevertheless, we are aware of the fact that the items in our questionnaire used for measuring the respondents' self-efficacy can be interpreted to stand for self-concept. This is because self-efficacy is often considered to be future-oriented, whereas self-concept is seen to be past-oriented. Our items are clearly past-oriented. However, we motivate using self-efficacy by the fact that, in mathematics, self-efficacy is assumed to be formed essentially through an individual's experiences from how well she has solved the tasks she has met during her previous learning trajectory, cf. Arens, Frenzel, and Goetz (2020). Our students are freshmen, thus what they think of their capacity in the moment of answering the questionnaire is based on previous experiences.

The expectancy–value theory is sometimes complemented by other theories on an individual's conceptions of oneself as learner. Bandura (2012) combine expectancy-value theory with agentic social-cognitive theory, addressing the functional properties of self-efficacy in context. An example of this is given by Goff, Mulvey, Irvin and Hartstone-Rose (2019) who use the combination in their study of the effect of students' involvement in informal science and mathematics environments before entering university. Another possibility is to add theories that describe the object of learning and then investigate how the motivational values are related to the qualities of the learning object. Our theoretical framework represents this approach by combining the expectancy–value theory with a categorization of epistemological beliefs about the nature of mathematics. A conceptual framework offers such flexibility to combine theories (Lester, 2009), and this particular combination has successfully been done in previous works (Tossavainen, Rensaa, Haukkanen, et al., 2021; Tossavainen, Rensaa, & Johansson, 2021; Tossavainen, Viholainen, Asikainen, & Hirvonen, 2017).The epistemological beliefs concern the structure, quality, certainty, but also the source of mathematical knowledge (Hofer & Pintrich, 1997). In Germany, Grigutsch, Raatz, and Törner (1998) studied mathematics teachers' beliefs, identifying four categories of beliefs or orientations to mathematics. Based on this, Felbrich, Müller and Blömeke (2008) have argued how these categories are suitable for investigations of student teacher's beliefs. The categories are the following.

- A formalism-related orientation views mathematics as an exact science having an axiomatic basis and being developed by deduction (e.g., 'Mathematical thinking is determined by abstraction and logic.').

- A scheme-related orientation regards mathematics as a collection of terms, rules and formulae (e.g., 'Mathematics is a collection of procedures and rules which precisely determine how a task is solved.').
- A process-related orientation considers mathematics as a science that mainly consists of problem-solving processes and finding structure and regularities (e.g., 'If one gets a good grip with a mathematical problem, one often discovers something new (connections, rules and terms).').
- An application-related orientation emphasises mathematics as a science that is relevant for society and life (e.g., 'Mathematics helps to solve daily tasks and problems.').

Formalism and scheme-related orientations are of a static nature; focus is on the structure of mathematical knowledge or seeing mathematics as a 'toolbox' of ready-made tools that can be used for solving mathematical tasks. Process- and application-related orientations, on the other hand, emphasise developing and discovering the nature of mathematics. These are dynamic activities. The difference between the two dynamic orientations is that the application-related orientation concentrates on solving tasks and problems arising from the real world and society, while the process-related orientation acknowledges abstract and scientific mathematics as being interesting on its own. As pointed to by Felbrich and colleagues, orientations are not exclusive; individuals may have beliefs representing several orientations (Felbrich et al., 2008). For this reason, it is more appropriate to study distributions of orientations than focus only on a single orientation. Still, some orientations may fit better with a student's view of mathematics than others.

3 LITERATURE REVIEW

Engineering students are often more interested in engineering subjects than mathematics (Kümmerer, 2001). In fact, the study by Harris and colleagues (2015) shows that, in the beginning of their studies, very few prospective engineers were aware of how mathematically demanding their studies were going to be. Some of these students even reported that they would have chosen another study program if they had known this. Many engineering students consider mathematics to be the most problematic part of their studies. Harris and colleagues (2015) conclude that a reason is that students have difficulties in perceiving the correspondence between mathematics and engineering subjects. This may give a feeling of insecurity about the purpose of mathematical studies; if mathematics is considered isolated from its use in engineering, the use-value of mathematics is lost (Harris et al., 2015). The use-value refers here to how freshmen engineering students speak about mathematics in terms of being valuable to engineering courses. Another value is the exchange-value of mathematics, i.e., mathematics being valuable for subsequent employment and getting well-paid jobs. This value is in Harris' study most often emphasized as important by more experienced students; these students were motivated to study mathematics by knowing the future relevance of mathematics (Harris et al., 2015). In some aspect, this exchange-value is in line with an application-related orientation, as it underlines the relevance of the subject in society.

Engineering students also have intrinsic values for studying mathematics. Alves, Rodrigues, Rocha, and Coutinho (2016) examines the relations between self-efficacy, mathematics anxiety and the perceived importance of mathematics among a group of Portuguese undergraduate engineering students. They noticed that the importance of mathematics was rated 'high'. The students' self-efficacy was also relatively high, whereas mathematics anxiety was rather low. There were, however, significant differences between the study programmes in this perceived importance and anxiety (Alves et al., 2016). In Norway,

Zakariya et al. (Zakariya, Nilsen, Goodchild, & Bjørkestøl, 2020) have shown that engineering students with low self-efficacy bring about surface approaches to mathematics learning while students with high self-efficacy bring an adoption of a deep approaches to learning. Thus, self-efficacy beliefs is a relevant component when investigating task performance among engineering students.

While the above-mentioned research refers to engineering students' view of mathematics in more meta perspectives like those related to professional use and motivational values, there are also studies that have investigated engineering students' views of mathematics as a subject. Engelbrecht, Bergsten and Kågesten (2012) found that students often take mathematics as procedural knowledge, e.g., step-by-step procedures for solving tasks and using symbolic representations in doing this. Conceptual knowledge, on the other hand, is about relationships and connecting knowledge. The distinction between procedural and conceptual knowledge in mathematics is highly complex (Engelbrecht et al., 2012; Star, 2005), but in the Engelbrecht study, engineering students in Sweden and South Africa show more confidence in their ability to solve procedural tasks than conceptual ones. In line with this, Rensaa (2018) reports that the instrumental approaches are also preferred by engineering students at a Norwegian university. Still, the instrumental tasks may well serve as motivators for mathematics and nourish eagerness to find solutions to problems (Rensaa, 2018).

There is a significant amount of literature on the freshmen engineering students' transition problems to university. For instance, Thomas and colleagues (Thomas et al., 2015) have considered social, study-oriented, and course-related challenges. One of their concerns is the freshmen students' decreasing mathematical knowledge – which is indicated, for instance by the long-time trends in the PISA and TIMSS surveys – but they have also paid attention to the limited cognitive preparedness for formal mathematical thinking (Thomas et al., 2015). A similar concern is explicated by Nortvedt and Siqveland (2018), who deal with Norwegian students entrance to university studies in mathematics. Their paper is of particular relevance to our study, asking the opportune question "Are beginning calculus and engineering students adequately prepared for higher education?". Nortvedt and Siqveland examined prior knowledge and skills of both engineering students and students who study mathematics as discipline, the latter called 'calculus students'. They build on data from a nationwide assessment administered by the Norwegian Mathematical Council (NMR) and the results show that calculus students score significantly better than engineering students on the tasks.. Nortvedt and Siqveland (2018) also discuss some motivational values of the Norwegian students based on feedback on five attitude statements. Their analysis shows positive relationships between inner motivation and achievement. The relationship was stronger for calculus students than engineering students, but with no, or only small, positive correlations between the instrumental motivation and achievement. Zakariya et al. (2021) use the same type of data from an NMR test to measure prior knowledge among engineering students at a Norwegian university. Based on this, they conclude that there is a substantial relation between prior mathematical knowledge, a surface approach to learning and poor performance measured by scores on a final exam. A similar result is not substantial for deep approaches to learning.

4 RESEARCH QUESTIONS

To interpret engineering students' task performances, we combine expectancy value theory having self-efficacy as a vital component and categorization of epistemological beliefs about the nature of mathematics. A conceptual framework recognize such a combination (Lester, 2009). By doing so, both

self-perceptions and perceptions specific to mathematics are taken into account, both playing essential roles in a student's task performance. Thus, our research questions are

- *How do the self-efficacy and motivation of freshmen engineering students relate to their task performance?*
- *How do the orientations to mathematics of freshmen engineering students relate to their task performance?*

In our study, the students' task performances are measured with a set of seven mathematical tasks. More precisely, the participating students are distributed between three different score levels according to their success in these tasks. The tasks will be introduced in the next section.

5 METHODOLOGY

5.1 Participants

Data for the present study were collected from a Norwegian class of freshmen engineering students, enrolled in a basic calculus course. This course is compulsory for all engineering programmes at the university, these programs being within electrical, mechanical and process engineering in addition to construction technology and computer science. The total number of students registered as campus students were 83, online students were not included in our investigation. The questionnaire used was distributed to all students attending class the very first day of the course, thus the students had few experiences with their engineering program at this point. They were given time to answer and submit their answers during a regular lecture. All questions and statements were translated to Norwegian language to increase familiarity with the formulations. This made the response rate rather high. Out of the 83 campus students, 71 students submitted answers, thus a response rate of about 86%.

Admission requirement for engineering educations in Norway is the maximum mathematics component from upper secondary school or similar educations. This means that students have completed both R1 and R2 or similar courses (NDET, 2017). These courses typically contain topics within geometry in both two and three dimensions, algebra including recursive relations and sequences, properties of functions, Combinatorics and probability, differential equations. According to the curricula, applications to illustrate the use of mathematics should also be included. Some familiarity with these topics could therefore be expected when students enter engineering studies. However, in light of the results by Nortvedt and Siqveland (2018), Norwegian students struggle in solving tasks both of conceptual, computational and problem solving types. In the discussion, we draw some parallels to the results on the Swedish students (Tossavainen, Rensaa, & Johansson, 2021). Admission thresholds of Norwegian and Swedish engineering students are similar in practice but this is not pertinent for the discussion in the present paper.

5.2 The questionnaire

In addition to a section surveying a student's educational background, our questionnaire consisted of two parts; one containing five-step Likert scales (from 1 = "totally disagree" to 5 = "totally agree") measuring the orientations, self-efficacy, and motivation, and one containing seven mathematical tasks. The first part of the questionnaire was based on the instrument developed and used by Tossavainen and colleagues (2017). For complete details, see Appendix.

The second part of the questionnaire contained tasks, the first three meant to be 'warming up' tasks requiring only straight-forward calculations. The other four tasks were designed in several cycles, involving also experienced teachers of mathematics in engineering education, to embrace the four orientations. In the first task, the students were asked if the sequence $a_{n+1} = 2a_n + 1, n = 1,2,3, \ldots$ is increasing. With reference to the curriculum in R1 and R2 (NDET, 2017), students should know about sequences and recursive relations, thus being aware of the importance of checking initial conditions. The task was intended to measure the students' ability to argue why a formula alone is not a sufficient condition to provide a solution.

In the second task, the number of bacteria in a fluid was represented by the formula $N(x) = \frac{4x^3}{2^x}$, where x was the number of days a medicine had been applied on the fluid. The task was to explain whether the medicine was effective or not, thus measuring the student's ability to argue and represent a problem relevant to the society. It stands for an application-related orientation. Again according to the curriculum of R1 and R2 (NDET, 2017), students should have been introduced to applications of mathematics, and tasks related to the one given in our questionnaire may be found in textbooks from upper secondary schools (e.g. Heir, Erstad, Moe, & Skrede, 2008 p.171). Our task, though, has a more complex formula.

In the third task, focus was put on the definition of a decreasing function, hence representing the formalism-related orientation. Student were asked for the definition along with giving an explanation why the function $f(x) = -3x^2 - 1$ is decreasing when $D_f = \mathbb{R}^+$, the set of positive numbers. This task may be somewhat unfamiliar to Norwegian students if consulting a R2 textbook (Heir et al., 2008) since this does not focus as much on definitions. Still, definitions could have been discussed in classrooms at least briefly when increasing and decreasing functions have been introduced.

The final task emphasized the process-related orientation as it asked if it is possible to find an increasing or decreasing function with values between -1 and 0 whenever the variable is an odd number. Both verbal and graphical solutions were accepted, and the aim with the task was to measure the creativity shown by students. Naturally, an ability to work on such creativity tasks depends upon which aspects of mathematics that have been emphasised in the upper secondary school level.

5.3 Validity and reliability

When it comes to validity and reliability of the items and tasks used in the questionnaire, we motivate the validity by the fact that the items and tasks have been designed and commented on by several experienced researchers and teachers. Moreover, the items related to motivation and the orientations are based on the items which have been tested and used in a previous study (Tossavainen et al., 2017), see also (Felbrich et al., 2008). For reliability, each latent variable has been measured – following Wigfield & Eccles (2000) – using two items. The Crohnbach alphas for the sum variables describing the motivational values varies between 0.5 and 0.8, except for the attainment value (Items 2.9 and 2.13 in Table 1 below) for which it is as low as 0.1. A further analysis of our data shows that the reason seems to be that a half of the participating students do not want to take the exam again if they pass the course with a low grade. In other words, they interpret performing "as well as possible" in another way than the other half of the students. Anyway, the low value of the alpha shows that the sum variable Attainment is not internally consistent although, in our opinion, both items clearly measures the importance of performing well. This fact has an effect, e.g., on the correlations of the sum variable with other variables. The error due to this should not, however, lead to false

conclusions about relations that really do not exist. On the contrary, the observed correlations are likely going to be weaker than they would have been if the sum variable Attainment had been measured using a more consistent instrument.

5.4 Analyses

Students were asked to explain their answers in all tasks. The responses were scored on the scale 0 = 'no answer/completely wrong answer', 1 = 'a correct answer without any explanation/a partly correct answer with a major fault in the explanation', 2 = 'an almost correct answer with one or more minor faults in the explanation', 3 = 'a correct answer with a sufficient explanation'. Two researchers and an assistant graded all responses individually, and for the analyses students were distributed into three groups according to their sum scores in the tasks. The cutting points for the division were chosen so that the three groups would be of equal size as closely as possible. For simplicity, the groups were named Low, Average and Better performers, yet the students' performance in general was not especially high.

We applied One-way analysis of variance with Bonferroni's post hoc -tests, linear regression, and Crosstabulation with Chi-Square test in order to analyse how students' motivation, self-efficacy and orientations differ from one another between the groups. In some items, a few students did not give any response. Therefore, the number of included responses and, consequently, the degree of freedom may vary slightly across the tables in the next section.

6 RESULTS

Table 1 summarises the answer to our first research question.

Statement	Groups	N	Mean	Std. Deviation
2.5. In school, I was good in mathematics.	Low	27	3.00	.88
	Average	23	3.52	1.04
	High	21	3.71	.96
	Total	71	3.38	.99
2.6. In school, I was able to understand the most of what was expected from us in mathematics.	Low	27	3.41	.69
	Average	23	3.57	.66
	High	21	3.90	.70
	Total	71	3.61	.71
2.7. I really like studying mathematics.	Low	27	3.52	.75
	Average	23	3.65	.89
	High	21	3.76	.99
	Total	71	3.63	.87
2.8. I am motivated to study mathematics mostly because it is useful to my other studies.	Low	27	4.04	.59
	Average	23	4.22	.52
	High	21	4.14	.57
	Total	71	4.13	.56
		27	4.56	.51

2.9. I want to succeed as well as possible in my mathematics studies.	Low			
	Average	23	4.70	.47
	High	21	4.62	.50
	Total	71	4.62	.49
2.10. I would be ready to suspend my hobbies in order to have enough time to prepare myself for exams in mathematics.	Low	27	4.04	.81
	Average	23	3.74	.92
	High	21	3.81	.98
	Total	71	3.87	.89
2.11. I could do extra exercises to guarantee that I succeed well in mathematics exam.	Low	27	4.41	.50
	Average	23	4.26	.81
	High	21	4.29	.78
	Total	71	4.32	.69
2.12. Even if it was not compulsory I would study mathematics because every engineer must know some mathematics.	Low	27	3.78	.70
	Average	23	3.91	.95
	High	21	3.90	.70
	Total	71	3.86	.78
2.13. If I pass a mathematics course with a low grade, I want to take the exam again.	Low	27	3.44	1.01
	Average	23	3.00	1.00
	High	21	3.62	.92
	Total	71	3.35	1.00
2.14. Mathematics is full of interesting problems and results.	Low	27	3.74	.81
	Average	23	3.78	.60
	High	21	4.19	.81
	Total	71	3.89	.77

Table 1. Motivation and self-efficacy

In Table 1, there are statistically significant mean differences only in two items, in 2.5 ($F(2,68)=3.68$, $p<0.05$) and in 2.6 ($F(2,68)=3.17$, $p<0.05$). In both items this concerns Low vs. Better performers. Both items are designed to measure self-efficacy at a general level, whereas all other items in Table 1 are intended to measure the motivational values. Consequently, the better performing students also express higher self-efficacy, but they do not differ from other students in motivation to study mathematics. This is a quite surprising finding, see the next section.

Students were also asked to choose between four metaphors – which correspond to scheme-, application, process-, and formalism-related orientations – and select the one representing best what they think mathematics essentially is about. A single metaphor can be interpreted to stand for the individual's primary or dominating orientation to mathematics. Table 2 reveals that differently performing students are distributed rather equally with respect to their metaphors of mathematics. The only differences are between Low and Better performers when Toolbox and Problem-solving metaphors are concerned. The differences are however

not significant; if only these two metaphoric categories are concerned, the result of a Chi-Square test suggests retaining the null hypothesis ($\chi^2(2) = 2.29$, p>.05).

Group	Toolbox	Applications	Problem-solving	Exact reasoning	Total
Low	8	2	12	1	24
Average	10	2	8	1	21
High	11	2	7	1	21
Total	29	6	28	3	66

Table 2. The distribution of metaphors (N=66)

Table 3 shows how students' views of the nature of mathematics are distributed over all orientations.

Statement	Groups	N	Mean	Std. deviation
3.1. A very important feature of mathematics is that it can be used to describe real world.	Low	24	3.67	.70
	Average	23	3.43	.90
	High	21	4.19	.60
	Total	68	3.75	.80
3.2. It is not mathematics if it cannot be proved theoretically in an exact way.	Low	24	3.33	.87
	Average	23	3.61	.99
	High	21	3.52	.81
	Total	68	3.49	.89
3.3. Mathematics is a collection of formulas and concepts.	Low	24	3.63	1.01
	Average	23	3.83	.78
	High	21	3.48	1.03
	Total	68	3.65	.94
3.4. Mathematics is solving problems.	Low	23	4.09	.73
	Average	23	4.00	.91
	High	21	4.14	.91
	Total	67	4.07	.84
3.5. The purpose of mathematics is to maintain functionality in the society and improve people's life.	Low	24	3.17	.92
	Average	23	3.52	.85
	High	21	3.49	.96
	Total	68	3.39	.91
3.6. Mathematics is discovering structures and regularities.	Low	23	3.87	.55
	Average	23	3.65	.78
	High	20	3.95	.76

	Total	66	3.82	.70
3.7. The main task of mathematics is to give the correct rules for calculations.	Low	24	3.75	.68
	Average	23	3.57	.79
	High	21	3.43	.75
	Total	68	3.59	.74
3.8. A very important feature of mathematics is that all concepts are defined in a precise and clear way.	Low	24	3.88	.80
	Average	23	3.57	.99
	High	21	4.05	.74
	Total	68	3.82	.86

Table 3. Orientations in more detail

Surprisingly, there is only one item in Table 3 with statistically significant mean differences between the groups. It is Item 3.1 ($F(2,65)=2.62$, $p<.01$). Further, the significant difference in Item 3.1 is between Average and Better performers, not between Low and Better performers. Interestingly, Average performers have the lowest or highest mean also in several other items, yet the differences are not statistically significant at the level $p<0.05$. It is difficult to hypothesise what could be a reason for this.

We complete our answer to the second research question by combining the groups Applications and Problem-solving, respectively, and the groups Toolbox and Exact reasoning, respectively. We do this in order to study whether there is a significant relation between the students' distribution into the performance groups and the distribution of dynamic vs. static views of mathematics – measured with aid of a metaphor. If we use a Chi-Square test for studying this question, the answer is negative ($\chi^2(2) = 1.92$, $p>.05$). However, by constructing the following sum variable out of items in Table 3 via

$$StatDyn = (3.1 + 3.4 + 3.5 + 3.6) - (3.2 + 3.3 + 3.7 + 3.8),$$

we get a new and more sophisticated scale. It measures how dynamic and static orientations are emphasised in the students' distributions of beliefs. The more positive the value of $StatDyn$ is, the more dynamic the distribution of orientations is. Similarly, the more negative the value is, the more static the distribution is. Now, the linear regression model in Table 4 and, especially, the positive coefficient of the variable standing for the task performance levels, reveals that the dynamic orientations are related to the higher task performance. Further, the distributions seem to be more dynamic than static in general, because of the positivity of the coefficient and the values of variable representing the task performance levels, which are on the interval 0–2.

Group	B	Std. error	Beta	t	P
Constant	-.37	.43		-.86	>.05
Task performance levels	.76	.34	.27	2.25	<.05

$F(1,63)=5.08$, $p<.05$; R-Square = .08

Table 4. A linear regression model predicting the focus of orientations (N=65)

The task performance levels do not explain more than 8% of the variation of $StatDyn$, so other factors are also needed for explaining this variation. Interestingly our further regression analyses revealed that, for instance, gender and age are not such factors. This issue would deserve more attention in future research.

7 DISCUSSION

Our research questions concentrate on students' self-efficacy, motivation and orientations in relation to task performance. From the results presented in the previous section, the answer to our first research question contains both expected and less expected findings. First, the Norwegian students' self-efficacy is closely related to task performance; higher performing students have higher self-efficacy. This result is in line with previous research literature, showing that such beliefs in own capabilities correlate with achievement, cf. (Pajares, 1996; Pajares & Miller, 1994; Zakariya et al., 2020). Second, there is not a similar correspondence between the task performance and motivational values. This outcome is unexpected in the light of the social learning literature, e.g., Bandura (1997, 2012) and Anthony (2000). For Norwegian calculus and engineering students, however, the study by Nortvedt and Siqveland (2018) shows that students were motivated for mathematics but still struggled to master the mathematical content of the NMR-assessment. This supports our result showing that performance and motivation may not be directly connected. It is surprising especially when compared to the findings from the neighbouring country Sweden which culturally is not very far from Norway. Also, Norwegian and Swedish students have about the same mathematical background when entering their engineering studies. However, Tossavainen and collegues (2021) have reported from the Swedish first-year engineering students' answers to the same questionnaire, and they found several significant direct relations between task performance and the motivational values (ibid., Table 7).

Previous studies (e.g. Felbrich et al., 2008; Tossavainen et al., 2017) have shown that both teachers and students have multidimensional and versatile views of what mathematics is. Tables 2–4 summarise our answer to the second research question which concerns these views. They show that there are relatively more higher performing students who regard mathematics as a set of (ready-made) tools to be used for solving tasks than lower performing students, but the case is opposite when problem-solving processes alone are concerned. One might expect these distributions to be the other way around, i.e., those students who have learned upper secondary mathematics well would also acknowledge the value of problem-solving better. An explanation for this outcome may be that the Norwegian secondary mathematics education focuses more on surveying the fundamentals of calculus, geometry and other areas of mathematics than on problem-solving and heuristic mathematical thinking. Another explanation may be that problem-solving abilities are not what motivates Norwegian engineering students who learn secondary school mathematics well. As pointed to above, there was no immediate correspondence between motivational values and performance among the present engineering students. Then, their preferences may diverge from what is expected as well, like preferences to ready-made mathematics. This latter is illuminated by the result in Table 2, showing that the most commonly chosen metaphor is Toolbox. It parallels with an emphasised procedural view of mathematics. According to Engelbrecht and colleagues (2012), engineering students often view mathematics as procedural. Such approaches may however work as motivation to study mathematics for some engineering students (Rensaa, 2018). The other common metaphor is Problem-solving, yet our results do not indicate that engineering students emphasising this view of mathematics were better in solving problems.

In fact, there were almost twice as many Low performers in the group of students choosing the Problem-solving metaphor as better performers. It shows that the Norwegian engineering students' views of mathematics do not directly relate to their task performance.

If we contrast Table 2 with the corresponding results from the Swedish cohort, the most distinctive difference is that there are clearly more higher performing engineering students in the Swedish group Exact reasoning. Further, the Swedish group Problems-solving has the second highest mean scores, whereas in the Norwegian data they have most Low performers (Tossavainen, Rensaa, & Johansson, 2021, Table 5). In this perspective, the results in Table 2 are again somewhat unexpected.

Perhaps, the most surprising result in the present study is that the students at different task performance levels do not have significantly differing views of mathematics. An exception is Item 3.1 emphasizing mathematics as useful to describe the world. This exception corresponds well with what Harris et al. (2015) came to see in their investigation; engineering students need to see the user-value of the mathematics in order to get motivated for studying mathematics. It is also in line with Nortvedt and Siqveland's result on instrumental motivation for mathematics (2018). For engineering students, they found a small positive correlation between achievement in the assessment and a statement saying that making an effort in mathematics is worthwhile since it is of help in future work. In the Swedish data the appreciation of exact reasoning was a strong indicator of significantly better task performance (Tossavainen, Rensaa, & Johansson, 2021). It raises a question why this is not as evident among the Norwegian students. We hope to be able to answer this in our future research.

Lastly, the finding that the task performance levels are a significant predictor for how dynamic the distribution of orientations is, is interesting. The relationship between the views and task performance is probably reciprocal. Table 3 gives a clue to what the result would be if we wanted to predict the task performance level with the aid of variables 3.1–3.8; the "Stepwise" method in SPSS linear regression procedure confirms that 3.1 would be the only significant predictor of these variables. This fact underlines the conclusion that we already made in the previous paragraph.

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