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Attitudes towards mathematics, achievement, and drop-out intentions among STEM and Non-STEM students in Norway

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ABSTRACT

High mathematical ability is central in many domains. In the present study, we investigated relations between students' high school mathematics background and current study program, and various mathematics-related outcomes. We expected that students who had attended higher-level mathematics courses in high school would report more positive attitudes towards mathematics and higher achievement in math-related classes at university than students who had attended basic mathematics courses in high school. We expected to find the same difference between STEM and non-STEM students. In addition, we expected that mathematics self-efficacy, but not general study-efficacy would predict students' grades in mathematics-related courses. Lastly, we investigated whether STEM and non-STEM students differed in their drop-out intentions, and whether general study-efficacy and mathematics self-efficacy were related to students' drop-out intentions. Data from a cross-sectional online questionnaire (N = 264; 177 women, 87 men) of Norwegian university students showed that high-school mathematics background is related to all aspects of students' attitudes towards mathematics, even after controlling for GPA and general study-efficacy, whereas their current field of study is only related to the subjective value of mathematics. As expected, mathematics self-efficacy, but not general study-efficacy predicted grades in mathematics-related courses. Finally, drop-out intentions did not differ significantly between STEM and non-STEM students, and they were related to general study-efficacy.

1. Introduction

Mathematics education in high school has an impact on students' lives far beyond graduation. First, mathematical concepts are an integral part of human culture, and they constitute the basis of our quantitative understanding of the world. Therefore, important parts of our everyday life only become accessible through understanding mathematics. For example, mathematical skills are essential for considering a loan (percentage calculations) or making health decisions (probability calculations, see for example Reyna & Brainerd, 2007). Second, learning mathematics contributes considerably to developing one's general reasoning skills (e.g., Attridge & Ingils, 2013; Cresswell & Speelman, 2020), something that is beneficial in any study or career field. Third, students' experience with high school instruction further shapes their attitudes towards mathematics (Mata et al., 2012; Moyer et al., 2018). Fourth, students' mathematics background impacts their choice of study and career path in at least two ways: Besides entry requirements related to a certain level of high school mathematics or a certain grade average, students' attitudes towards mathematics also play a role in how likely they are to choose to study and later work in a field related to science, engineering, technology, and mathematics (STEM; Betz & Hackett, 1983; Chipman et al., 1992; Hackett, 1985; Hackett & Betz, 1989; Lent et al., 1991; O'Brien et al., 1999; Pajares, 1996). Fifth, both the types of high school mathematics course and students' mathematics skills predict their later academic performance (Alcock et al., 2008; Ballard & Johnson, 2004; Hudson & Liberman, 1982; Johnson & Kuennen, 2006; Opstad, 2018). Sixth, there are findings showing a link between university students' mathematics background and their drop-out (Kiss et al., 2019). Taken together, a broad variety of reasons exist why mathematical skills are of crucial importance. For this reason, by focusing on the four last issues, the present research investigates whether different high school mathematics backgrounds and study

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majors (STEM vs. non-STEM) affect students' attitudes and achievement in mathematics and their drop-out intentions.

1.1. *Mathematics in the Norwegian education system*

In Norwegian high schools (grades 11 to 13), students can choose between two different main directions for their mathematics education (Direktoratet for høyere utdanning og kompetanse, 2020): They can either choose a two years long path of practical mathematics (P), which focuses on practical use of calculations in different contexts which can be found in daily life, for example, percentages and fractions, areas and volumes of geometric objects and elementary statistics. Or students can choose a path with a focus more on theoretical aspects of mathematics (T), which includes algebra and calculus. Following the "T mathematics" in grade 11, this second path further differentiates into mathematics for natural sciences (R for "realfag") and mathematics for social sciences (S for "samfunnsfag"). Both of these have the same amount of class hours per year, but the former contains more abstract concepts relevant for science, for example differential equations, whereas the latter focuses on more concrete concepts, for example logarithms and applications in statistics. Students who chose "T mathematics" in grade 11 need to take at least one year of these courses (S1 or R1) but may also choose to go on for a third year of mathematics (S2 or R2). For admission to many science programs, two years of S courses (S1+S2) are considered equivalent to one year of R course (R1).

The entry requirements to many math- or science-related study programs include higher-level school mathematics courses, but some do not (for example business studies). It can be easier to be admitted to study programs that do not require higher-level school mathematics with basic than with higher-level mathematics courses, because in basic courses it is easier to receive good grades (cf. Opstad, 2018, Table 1). Thus, when aiming to apply to study programs that do not require higher-level school mathematics, choosing basic courses can be a good strategy for increasing the likelihood of acceptance. However, this choice might have unintended, negative consequences for students' success at university, as mathematical background has been found to be related to students' performance in their studies (Alcock et al., 2008; Ballard & Johnson, 2004; Hudson & Liberman, 1982; Johnson & Kuennen, 2006; Opstad, 2018). Findings of a large-scale study conducted in Norway confirmed that enrolling in a higher-level mathematics course can be seen as a measure of challenge-seeking that can be increased by a growth mindset intervention (Rege et al., 2020). Importantly, the authors point out that the intervention impacted the rates of *passing* a higher-level mathematics course to the same degree as it did the rates of enrollment in such a course. This hints to the existence of student populations who have the abilities to master higher-level mathematics but do not choose it because of their mindset or motivation. This is in line with findings showing that Norwegian students' attitudes towards mathematics, i.e., their enjoyment of learning mathematics, confidence in mathematics, and subjective value of mathematics, are below the international average, and that their enjoyment and confidence in mathematics decrease substantially between 5th and 9th grade (Mullis et al., 2020). This suggests that many of them start high school with mixed attitudes towards mathematics.

1.2. *Attitudes towards mathematics*

Based on a confirmatory factor analysis of a short version of the Attitudes Towards Mathematics inventory, Lim and Chapman (2013) propose that attitudes towards mathematics encompass three components: enjoyment of mathematics, self-confidence in mathematics, and perceived value of mathematics. According to the definitions by Tapia and Marsh (2004, p. 17, cited by Lim & Chapman, 2013), enjoyment of mathematics refers to "the degree to which students enjoy working (on) mathematics", self-confidence in mathematics refers to "confidence and self-concept of (their) performance in mathematics", and perceived value of mathematics refers to "students' beliefs on the usefulness, relevance and worth of mathematics to their lives". As Lim and Chapman (2013) report, these three measures correlate positively with each other, supporting the notion that they are components of the same overall construct, and they correlate positively with achievement in mathematics and negatively with mathematics anxiety, which shows construct validity.

Relying on this three-component model, a study with Norwegian business school students found that students' choice of high school mathematics course was related to their attitudes towards mathematics, with former students of higher-level courses reporting more positive attitudes towards mathematics than former students of basic courses (Opstad & Årethun, 2019). The relation between attitudes towards mathematics and participation in higher-level mathematics courses is stronger in Norway than in the US or Canada, as found in a large-scale study by Ercikan et al. (2005). The authors explain this finding by different entry requirements to university studies in the different countries, i.e., that US-American and Canadian students are required to take higher-level mathematics in high school if they want to apply to a mathematics-related study program. This implies that not all students who take higher-level mathematics courses in these countries are fond of the subject; some merely bite the sour apple in order to pursue their long-term goals (Ercikan et al., 2005). Such students might be a rarity in Norway, where higher-level high school mathematics courses are not even required for entry to business school (Opstad, 2018; Opstad & Årethun, 2019). In sum, due to flexible entry requirements, first-year students across a wide range of study programs at Norwegian universities start their studies with large differences in their mathematical

Table 1
Descriptive statistics including mean, standard deviations, and correlations between the main variables and participants' demographics.

Variable	*n*	*M*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. STEM vs. non STEM faculty	264	0.28	0.45	-											
2. Gender	264	1.33	0.47	.309**	-										
3. Age	264	24.59	5.13	.084	.108	-									
4. University math grade	108	4.48	1.11	.024	.065	.073	-								
5. High/low level of math (high school)	246	1.57	0.50	.233**	.024	.021	.032	-							
6. Self-efficacy (math)	264	3.74	1.71	.104	.133*	.091	.487**	.414**	-						
7. Attitudes	264	3.85	1.48	.132*	.093	.048	.361**	.414**	.831**	-					
8. Values	264	4.63	1.36	.132*	.279**	-.007	.292**	.236**	.309**	.446**	-				
9. Self-efficacy (general)	264	4.75	1.23	-.041	.056	.137*	.166	.061	.261**	.136*	.128*	-			
10. Reasons for drop-out (general)	264	1.88	1.42	.05	-.04	-.091**	-.200*	-.163*	-.219**	-.236**	-.101	-.537**	-		
11. Reasons for drop-out (math)	263	1.59	1.32	.099	-.004	-.152*	-.291**	-.137*	-.32**	-.253**	-.168**	-.414**	.651**	-	
12. Drop-out intentions	264	2.47	1.38	.111	.002	-.113	-.22*	-.04	-.141*	-.131*	-.114	-.396**	.576**	.447**	-

skills and their attitudes towards mathematics, both of which are likely to be predictive of their success throughout their studies.

1.2.1. Mathematics self-efficacy

Self-efficacy, which is defined as the belief in one's capacity to execute a specific behavior (Bandura, 1977), is positively related to academic achievement (Hwang et al., 2016; Komarraju & Nadler, 2013; Multon et al., 1991; Zimmerman, 2000). Self-efficacy is task-specific: For example, one can believe more strongly in one's capacity to perform well in mathematics than to perform well in English (Bong, 2001). Consistently with findings on academic achievement in general, studies have shown that achievement in mathematics is positively related to mathematics self-efficacy, i.e., "confidence in one's ability to perform well with regard to particular mathematics tasks or in particular math and math-related courses" (Hackett, 1985, p. 48), see Hackett, 1985; Hall & Ponton, 2005; Kaya & Bozdag, 2016; Lent et al., 1997; Pajares & Kranzler, 1995; Pajares & Miller, 1994; Randhawa et al., 1993; Rastegar et al., 2010. A possible mechanism of this effect has been revealed in a Norwegian study that found that middle-school students' mathematics self-efficacy was positively related to both intrinsic motivation for mathematics (i.e., enjoyment of mathematics) and persistence when working on difficult mathematics tasks, even after controlling for pupils' grades (Skaalvik et al., 2015).

1.3. Choice of study and career path

Mathematics self-efficacy predicts students' career and study choices in that students with higher mathematics self-efficacy are more likely to choose math- or science-related study programs or careers than students with lower mathematics self-efficacy (Betz & Hackett, 1983; Hackett, 1985; Hackett & Betz, 1989; Lent et al., 1991; O'Brien et al., 1999; Pajares, 1996; but see Parker et al., 2014, for contrasting results). These findings on the relation between mathematics self-efficacy and the choice of future mathematics-related challenges is consistent with findings showing a positive relation between general self-efficacy and students' persistence (Multon et al., 1991; Pajares, 1996), presumably via a growth mindset that helps students stay on course when they are facing a challenging task (Komarraju & Nadler, 2013). Relatedly, self-efficacy has been found to be an important predictor of university students' drop-out intentions (Nemtcan et al., 2020) and study completion (Larson et al., 2015).

1.4. Mathematics background and achievement in higher education

Many students both in Norway (Nortvedt & Siqveland, 2019) and in other countries (Bailey, 2009; Duranczyk & Higbee, 2006) begin their university studies with insufficient mathemathematics skills and understanding, even in study programs that rely heavily on mathematics (Nortvedt & Siqveland, 2019). Further, it seems that mathematics skills have declined over the years among students in various study programs, for example in psychology (Carpenter & Kirk, 2017; Mulhern & Wylie, 2004) and bioscience (Tariq, 2002). This is a worrying trend, because students' mathematical background (type of high school course and skills) can predict their performance in various subjects (Ballard & Johnson, 2004; Hudson & Liberman, 1982; Johnson & Kuennen, 2006; Opstad, 2018), even in those unrelated to mathematics (Alcock et al., 2008). The finding that mathematical skills can predict performance in subjects that do not include any mathematics underscores the role of mathematics education in the development of reasoning skills (cf. Attridge & Ingils, 2013; Cresswell & Speelman, 2020), and it points to the importance of positive experiences that enable the development of mathematical skills for every student. Unfortunately, mathematics is associated with exceptionally high levels of anxiety (Dowker et al., 2016), which can lead students to avoid challenging mathematical problems and higher-level mathematics courses, and restrict their opportunities for developing advanced mathematical understanding (Carey et al., 2016; Devine et al., 2018).

1.5. Preparedness, achievement, and drop-out

Completion rate in higher education, i.e., the proportion of students who complete their studies, is lower in Norway (59%) than in the neighboring countries Denmark and Finland (both above 75%), or even the OECD average (68%, OECD, 2014). A large-scale study of Norwegian university students' retention and departure from their studies found an 11% drop-out rate after the first semester, an 18% drop-out rate after five years, and a 52% transfer rate to a different institution, with more than half transferring to a university college (Hovdhaugen, 2009). In addition to a descriptive overview of the proportion of students who left their studies –with other words, their drop-out rate- at different stages, Hovdhaugen also investigated predictors of students' drop-out, i.e., factors that were significantly related to students' leaving their study program before graduation. Along with demographic variables, student motivation and effort, high-school grades were also predictive of student drop-out, with good grades being associated with a lower likelihood of drop-out (Hovdhaugen, 2009). These results are consistent with findings of a systematic review that identified low prior (i.e., high-school) and current academic performance as some of the most important predictors of university students' drop-out (Larsen et al., 2013). Furthermore, there are findings showing that poor academic performance and high study requirements are the main reasons for a relatively high drop-out rate in STEM compared to non-STEM study programs (Larsen et al., 2013). There is reason to believe that mathematics is an essential part of the high study requirements experienced by STEM students. Mathematics is the basis of all natural sciences, but, as discussed above, many students even in STEM fields arrive at university with relatively poor mathematics skills (Bailey, 2009; Carpenter & Kirk, 2017; Duranczyk & Higbee, 2006; Mulhern & Wylie, 2004; Nortvedt & Siqveland, 2019; Tariq, 2002). Furthermore, an analysis of 10000 students' information on record at a university of technology identified students' background knowledge in mathematics (as assessed in the first week of the first semester) as a significant predictor of drop-out (Kiss et al., 2019).

1.6. The present research

In the present study, we investigated the relations between students' high school mathematics background and current field of study and their attitudes towards mathematics, achievement, and drop-out intentions in a sample of students of a Norwegian university, representing a wide variety of study programs. We first hypothesized that the kind of mathematics classes students had taken in high school would be related to their current mathematics achievement and attitudes towards mathematics. More precisely, we tested the following hypotheses:

H1a) Students who took higher-level mathematics courses in high school will report higher mathematics self-efficacy than students who did not (in line with Opstad & Århethun, 2019).
H1b) Students who took higher-level mathematics courses in high school will have better grades in mathematical university courses if they took any than students who did not (in line with Opstad, 2018).
H1c) Students who took higher-level mathematics courses in high school will report more enjoyment of mathematics than students who did not.
H1d) Students who took higher-level mathematics courses in high school will report higher subjective value of mathematics than students who did not (in line with Opstad & Århethun, 2019).

Second, we hypothesized that students' current study program would be related to the same variables, namely mathematics self-efficacy and achievement, as well as their enjoyment of mathematics and subjective value of mathematics. More specifically, we predicted:

H2a) Students in STEM will report higher mathematics self-efficacy than students studying other subjects.
H2b) Students in STEM will have better grades in math-related university courses than students studying other subjects.
H2c) Students in STEM will report more enjoyment in mathematics than students studying other subjects.
H2d) Students in STEM will report higher subjective value of mathematics than students studying other subjects.

In a next step, we predicted:

H3) Mathematics self-efficacy, but not general study-efficacy (defined as the belief in one's capacity to do well in their studies), will be a strong predictor of students' grades in mathematical university courses (in line with Ercikan et al., 2005).

Finally, we explored students' drop-out intentions. Although much of previous research investigated the predictors of drop-out, i.e., students' leaving their study program before completion, in this study we focused on students' *intentions* to drop-out. We argue that insights into the correlates of drop-out intentions can help inform possible interventions aiming to retain students who consider leaving their studies. First, we aimed to investigate whether students depending on their field of studies (STEM vs. non-STEM) differed in their drop-out intentions. Second, we aimed to investigate whether self-efficacy (general study-efficacy or mathematics self-efficacy) was related to students' drop-out intentions. According to a meta-analysis of studies investigating different aspects of student drop-out (Larsen et al., 2013), there is an indication that drop-out rates are higher in STEM than in other study programs, as the majority of the reviewed studies found especially high drop-out rates in "the hard sciences", "mathematics, physics, and chemistry", and "mathematics/the natural sciences and engineering" (Larsen et al., 2013, pp. 113-114). However, such a difference in drop-out rates across study programs was not found by others (Larsen et al., 2013), in particular by Hovdhaugen (2009), who analyzed data from a large sample of Norwegian students. Therefore, our predictions regarding the differences in STEM- and non-STEM students' drop-out intentions were non-directional and explorative.

2. Method

The present study was part of a larger research project that investigated the studying and working conditions of students and employees at a Norwegian university. Participants were able to choose whether they wanted to answer the questionnaire in Norwegian or English. About half of the questionnaire were the same for students and employees, but the other half differed for the two groups. In the present analyses, we only report the results of the students' questionnaire. Ethical approval was received from the board of research ethics at the first authors' institution and approval was received from the Norwegian Center for Research Data (NSD).

2.1. Participants

Participants were recruited via email lists and social media. Two hundred and seventy seven students participated in the online study. Of these 277 students, 13 students did not answer the attention check correctly ("This is an attention check. If you read this, please select the 3.") and therefore, were excluded from further analyses. From the remaining 264 students (177 women, 87 men), 222 chose to answer the questionnaire in Norwegian, the remaining 42 in English. Participants' ages ranged from 18 to 54 years (due to privacy laws in Norway, age was measured as a categorical variable including the following categories: 18-24 years: 163 participants; 25-34 years: 95 participants; 35-44 years: 3 participants; 45-54 years: 3 participants).

2.2. Procedure

First, participants answered questions about the studying climate at university, including attributions of success and failure, negative stereotypes, sense of belonging to university, social motivation, and their social engagement at the institution. Then they answered the scales of interest for the above presented research questions: mathematics self-efficacy, enjoyment of mathematics, value of mathematics, general study-efficacy, and drop-out intentions. Finally, they reported their demographics (including their faculty, the kind of mathematics courses they took in high school and their grades in university mathematics courses), before being debriefed and offered the opportunity to participate in a lottery for five gift cards (500 NOK each).

2.3. Materials

Only the scales relevant for the hypotheses and exploratory research questions will be reported below. All original items in both languages are presented in Appendix A. If not indicated otherwise, scales were answered on a 7-point Likert scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*.

2.3.1. Attitudes towards mathematics

Relying on Lim and Chapman (2013) and Opstad and Århethun (2019), we assessed three components of attitudes towards mathematics: self-efficacy, enjoyment of mathematics, and perceived value of mathematics.

2.3.1.1. Mathematics self-efficacy. Mathematics self-efficacy and mathematics self-confidence show large conceptual overlap. For this reason, we used the mathematics self-confidence scale by Opstad and Århethun (2019) in the present study. This scale consisted of six items. Example items are: "I have a lot of self-confidence when it comes to mathematics." and "I expect to do fairly well in any mathematics class that I take."). Cronbach's alpha was high (α = .96). In the following we will refer to this scale as mathematics self-efficacy.

2.3.1.2. Enjoyment of mathematics. Students' enjoyment of mathematics was assessed with six items using the scale by Grundmeier (2002). Example items are: "Mathematics is enjoyable and stimulating for me." and "I have never liked mathematics and it is my most dreaded subject." (reverse coded). Again, Cronbach's alpha was high (α = .87).

2.3.1.3. Value of mathematics. In order to assess students' value of mathematics, we used the scale reported by Opstad and Århethun (2019). This scale consisted of six items. Example items are: "Mathematics is a very worthwhile and necessary subject." and "I can think of many ways in which I use mathematics outside of school." Again, Cronbach's alpha for this scale was high (α = .89).

2.3.2. General study-efficacy

Mirroring the five items of the mathematics self-efficacy scale, we developed parallel items referring to university studies in general to assess general study-efficacy. Example items are: "I have a lot of self-confidence when it comes to my field of study." and "I expect to do fairly well in the subjects that I take."). Cronbach's alpha for this scale was also high (α = .89).

2.3.3. Drop-out intentions

We also assess students' intentions to drop out of their studies. We adjusted the scale by Hardre and Reeve (2003) to the specific context of our study and measured drop-out intentions with four items (e.g., "I sometimes consider dropping out of university before graduation"; "I sometimes think that other job opportunities suit me better than those I can get with my current education."). An exploratory factor analysis (see

Appendix B) showed that all four items loaded on one factor. The scale showed good reliability (α = .78)[1].

2.3.4. Demographics

Participants indicated their gender, age, the faculty at which they studied, and whether they or their families had a migration background. Based on the faculty that students indicated, students were assigned to STEM ($n = 75$) versus all other study programs ($n = 189$). Of the STEM students, 74% reported to have attended higher-level mathematics courses at high school and 49.5% of the non-STEM students. In addition, students reported their GPA from high school, whether their study contained mathematics ("Have you taken courses at university that included a large amount of mathematics [meaning that more than 25% of the course content was math-related]?", answering options: yes/no; 117 participants chose yes, 147 no), average grade in mathematics at university ("Please indicate the average grade you received in the last three math-related courses you completed at university. If you only completed two, please indicate the average of the two, if you only completed one, please indicate this grade."; these were transformed from university grades ranging from A to F in Norway with A being the best grade and F failing the class to school grades ranging from 1 being the worst grade to 6 being the best grade), highest level of mathematics at high school ("What was the highest level of mathematics you completed at high school (videregående skole, VGS)? This also includes VGS-level mathematics you redid later."), and mathematics grade at high school ("What was your final grade in mathematics in high school?"). Based on the specifics of how mathematics is taught in Norwegian high schools, the highest level of mathematics at high schools was recoded into two categories (1 = basic: all P courses and S1; 2 = higher-level: R1, R2 and S2). Of all participants, 246 participants' high school mathematics courses could be assigned to one of the two categories. Detailed information for 18 participants was missing, thus, we could not assign them to either of the two categories.

2.4. Statistical analyses

Analyses were conducted with IBM SPSS version 28. To test the predictions that students who participated in higher-level mathematics courses in high school would report higher mathematics self-efficacy (H1a), better grades in mathematical university courses (H1b), as well as higher enjoyment of mathematics (H1c), and higher subjective value of mathematics (H1d), we used a multivariate ANOVA controlling for GPA and general study-efficacy. Second, to test whether STEM students would have higher mathematics self-efficacy (H2a) and better grades in math-related university courses (H2b), as well as higher enjoyment of mathematics (H2c) and a higher subjective value of mathematics than students majoring in other subjects (H2d), we again used a multivariate ANOVA.

Third, we tested whether mathematics self-efficacy, but not general study-efficacy, would be a strong predictor of students' grades in mathematical university courses, with a linear regression model adding both variables as predictors simultaneously (H3). Finally, we investigated students' drop-out intentions. First, using a univariate ANOVA, we compared drop-out intentions between STEM and non-STEM students. Second, using a linear regression model, we investigated whether self-efficacy (general study-efficacy or mathematics self-efficacy) was related to students' drop-out intentions.

3. Results

Table 1 shows the descriptive statistics including mean, standard deviations, and correlations between the eight main variables and participants' age and gender.

3.1. Relationships between high school mathematics courses and mathematics-related outcomes

The multivariate ANOVA showed statistically significant effects of higher-level mathematics courses (Wilks' Lambda = .82, $F(3, 223) = 15.84$, $p < .001$) and general study-efficacy (Wilk's Lambda = .91, $F(3, 223) = 7.05$, $p < .001$). As predicted, the level of high school mathematics courses students took was related to their attitudes towards mathematics (H1a, 1c, 1d; see Table 2). Controlling for GPA and general study-efficacy, students who had taken higher-level mathematics courses in high school reported higher mathematics self-efficacy than students who had not done so (see Table 2), $F(1, 225) = 43.76$, $p < .001$, $\eta_p^2 = .16$; higher enjoyment of mathematics, $F(1, 225) = 39.64$, $p < .001$, $\eta_p^2 = .15$; and higher subjective value of mathematics, $F(1, 225) = 21.71$, $p < .001$, $\eta_p^2 = .05$. Interestingly, GPA was not significantly related to any of the dependent variables (all $ps \geq .12$). General study-efficacy was significantly related only to mathematics self-efficacy, $F(1, 225) = 14.63$, $p < .001$, $\eta_p^2 = .06$.

Next, we tested whether the participants who had indicated that they did take courses with a considerable amount of mathematics in the past differed in their average grade in these courses depending on which type of mathematics courses they had taken at high school (H1b). We had all necessary information for 94 of our participants. Results of a univariate ANOVA controlling for GPA and general study-efficacy showed, surprisingly, that there was no difference in grades for these two groups, $F(1, 90) = 1.58$, $p = .212$, $\eta_p^2 = .02$. Students who had taken higher levels of mathematics in high school ($n = 65$) reported similar grades in math-related university courses to students who had taken basic mathematics in high school ($n = 29$, see Table 2). Again, general study-efficacy, $F(1, 90) = 17.96$, $p < .001$, $\eta_p^2 = .17$, but not GPA ($p = .67$) was a significant covariate.

3.2. Relationships between students' study programs and mathematics-related outcomes

The multivariate ANOVA showed a non-statistically significant effect of study program, Wilks' Lambda = .97, $F(3, 235) = 2.12$, $p = .099$. However, the effects of the covariates GPA and general study-efficacy were significant (Wilks's Lambda = .05, $F(3, 235) = 4.01$, $p = .008$, $\eta_p^2 = .049$ and Wilks's Lambda = .09, $F(3, 235) = 7.80$, $p < .001$, $\eta_p^2 = .091$, respectively). In contrast to our predictions, field of study was significantly related only to students' subjective value of mathematics (H2d), $F(1, 237) = 5.89$, $p = .016$, $\eta_p^2 = .02$. STEM students ($n = 66$) reported higher subjective value of mathematics ($M = 4.94$, $SD = 1.39$) compared to non-STEM students ($n = 175$; $M = 4.47$, $SD = 1.33$), controlling for GPA and general study-efficacy. Neither general study-efficacy nor GPA were significantly related to the value of mathematics (both $ps \geq .052$). For mathematics self-efficacy and attitudes towards mathematics, STEM and non-STEM students did not differ (both $ps \geq .094$) when controlling for GPA and general study-efficacy. Finally, in contrast to H2b, a univariate ANOVA showed that from the 99 students from whom we had all necessary information, STEM students ($n =$

Table 2
Means and standard deviations depending on students' high school mathematics courses. Standard deviations are presented in parentheses.

	Level of math (high school)	
	Higher level	Basic
Mathematics self-efficacy	4.37 (1.44)	2.92 (1.54)
Enjoyment of mathematics	4.35 (1.17)	3.14 (1.48)
Subjective value of mathematics	4.89 (1.19)	4.24 (1.47)
Grade in mathematics classes at university	4.49 (1.02)	4.34 (1.20)

[1] In addition, we asked students for reasons of their intentions to drop-out. Since we later realized that the items we self-constructed were not clear in their meaning, we report this analysis only in Appendix C.

43) reported similar grades like non-STEM students ($n = 56$) in their math-related courses, $F(1, 95) = 0.38$, $p = .541$, $\eta_p^2 = .004$.

3.3. The relationship between mathematics self-efficacy and performance in mathematics

In order to test the third hypothesis, we conducted a linear regression analysis with general study-efficacy and mathematics self-efficacy as predictors and university grades in mathematics-related classes as outcome. The complete regression model was significant, $F(2,105) = 16.50$, $p < .001$, $r^2 = .24$. As predicted, the regression coefficient of mathematics self-efficacy was significant, $\beta = .47$, $p < .001$, 95 % CI [0.206, 0.445]. The regression coefficient of general study-efficacy was not significant, $\beta = .05$, $p = .56$.

3.4. The relationship between study program, self-efficacy and drop-out intentions

We tested whether students studying STEM subjects differed in their drop-out intentions from students studying other subjects, controlling for GPA and general study-efficacy. A univariate ANOVA showed no significant main effect of study major, $F(1, 237) = 3.32$, $p = .070$, $\eta_p^2 = .014$. Descriptively, however, the data indicated that STEM students ($M = 2.72$, $SD = 1.28$) reported higher slightly drop-out intentions than did non-STEM students ($M = 2.42$, $SD = 1.41$). GPA did not have a significant effect on drop-out intentions ($p = .90$), but general study-efficacy did, $F(1, 237) = 8.86$, $p = .003$, $\eta_p^2 = .036$. Next, we tested whether general and mathematics self-efficacy were related to students' drop-out intentions. The complete regression model was significant, $F(3,260) = 17.51$, $p < .001$, $r^2 = .17$. But only the coefficient of general study-efficacy was significantly related to drop-out intentions, $\beta = -.378$, $p < .001$, 95% CI [-0.555, -0.295].

4. Discussion

The aim of this study was to investigate relations between mathematics background, current study program, and attitudes towards mathematics, achievement in mathematics-related courses, as well as drop-out intentions in a large sample of students from different study programs of the same university. We expected that both students' mathematics background and their current study program would be related to math-related outcomes, i.e., that students who had attended higher-level mathematics courses in high school and students who currently study a STEM subject would report higher mathematics self-efficacy and better grades in math-related subjects, as well as higher enjoyment and a higher subjective value of mathematics than students who had attended basic mathematics courses in high school and students who currently study a non-STEM subject. In addition, we explored students' drop-out intentions in relation to their field of study, and general and mathematics self-efficacy. The results supported most of our hypotheses.

Students' mathematics background was positively related to all mathematics-related outcomes except for grades in mathematics-related courses. Across study programs, students who had attended higher-level mathematics courses in high school reported higher mathematics self-efficacy, higher enjoyment, and higher subjective value of mathematics than students who had attended basic mathematics courses, even after controlling for GPA and general study-efficacy. This is in line with previous studies (Ercikan et al., 2005; Opstad & Årethun, 2019). However, further research is needed to determine whether higher-level high school mathematics courses are a cause or a consequence of more positive attitudes towards mathematics. On the one hand, high school students with already more positive attitudes towards mathematics might be more likely to choose higher-level mathematics courses than students with less positive attitudes towards mathematics. On the other hand, attending higher-level mathematics courses might lead to a better understanding of mathematics and higher competence, which in turn can have a positive effect on attitudes. The latter effect could be tested in an intervention study, which, if successful, would have important implications for high school mathematics education.

Contrary to our hypotheses, students with a higher-level vs. basic mathematics background did not differ in their self-reported grades in mathematics-related university courses, and the average grades were high in both groups (between B and C on the A-F grading scale). This is in contrast to previous findings on the relation between mathematics background and achievement in mathematics-related university courses (Alcock et al., 2008; Opstad, 2018). We need to highlight that our finding should be interpreted with caution, as only 94 of the 264 participants provided sufficient data for this analysis, and the majority of them had attended higher-level mathematics courses in high school. This likely reflects the overlap between study programs that include mathematics-related courses and those that require higher-level mathematics courses (at least R1) for admission. In addition, we did not have an objective measure of university grades, but rather relied on self-reports. Further research should rely on objective measures of grades.

Whereas students' mathematics background was significantly associated with most mathematics-related outcomes even while controlling for GPA and general study-efficacy, contrary to our hypotheses, this was not the case for students' current field of study. Field of study only had a significant effect on the subjective value of mathematics. Our results preclude any conclusion about the origins of this difference between STEM- and non-STEM students. Students who value mathematics more might be more likely to enroll in a STEM program, but it is equally plausible that they gain an appreciation of the value of mathematics once they engage in university studies of a field strongly relying on mathematics. While previous research has found that high school students' mathematics self-efficacy is positively correlated with their choice of mathematics- and science-related study programs (Betz & Hackett, 1983; Hackett, 1985; Hackett & Betz, 1989; Lent et al., 1991; O'Brien et al., 1999; Pajares, 1996), our results indicate that these effects are driven by more general factors, such as GPA and general study-efficacy. Also contrary to our hypotheses, the two groups of students (STEM vs. non-STEM) did not differ in their self-reported grades in math-related university courses, and both reported high average grades (between B and C on the A-F grading scale). As discussed above, this finding also needs to be interpreted with caution due to the potentially low reliability of self-reported grades.

As expected, mathematics self-efficacy was a significant predictor of students' grades in mathematics-related courses, but general study-efficacy was not. This is in line with previous findings demonstrating that self-efficacy is most likely to predict performance when the two concepts are measured on matching levels of specificity (Pajares, 1996; Pajares & Miller, 1995), for example self-efficacy specific to a course predicting term grades in that course (Choi, 2005).

Furthermore, our findings revealed that students' general study-efficacy was related to their drop-out intentions. This is consistent with previous findings showing a positive relation between self-efficacy and academic persistence (Multon et al., 1991; Zimmerman, 2000). Overall, students' drop-out intentions were weak (see Table 1), but slightly stronger among STEM-students than among non-STEM students (nonsignificant trend). Importantly, however, we need to notice that the measure we used to assess drop-out intentions contained not only students' intentions to drop out of university completely, but also contained one item that referred to transfer intentions (i.e., "I sometimes consider changing studies"). We decided to keep this item in the present analysis since an exploratory factor analysis (see Appendix B) found that it loaded on the same factor as the drop-out intentions. Nevertheless, future research should differentiate between drop-out- and transfer intentions, as suggested by Larsen et al. (2013). In addition to the limitations discussed above, a further weakness of the study is that for data protection reasons, we did not ask about students' study programs, only their faculties. Therefore, our categorization of STEM vs. non-STEM students might not correspond perfectly to the usual categories. Despite its limitations, however, this study yielded important insights into the relations between mathematics background and their attitudes towards mathematics as well as measures of adjustment (grades and drop-out intentions) in a large sample of students representing various study programs of one university. Compared to studies focusing on students from single study programs, the broad recruitment strategy of the present study increases the generalizability of the findings. At the same time, limiting recruitment to one university reduces the amount of possible confounding variables that result from institutional or regional differences.

4.1. Conclusions

To conclude, our findings show that students' mathematics background is related to all aspects of their attitudes towards mathematics, which underscores the potential impact of high school mathematics education for students' subsequent academic life. Contrary to this, our data show that students' current field of study (STEM vs. non-STEM) is only related to their subjective value of mathematics, but not to their mathematics self-efficacy and enjoyment of mathematics. Thus, high school mathematics background seems to be particularly important for students' attitudes towards mathematics. In addition, the finding that mathematics self-efficacy, but not general study-efficacy, was a significant predictor of students' grades in mathematics-related university courses across fields of study indicates that an adequate mastery of mathematics (and related belief in one's mastery) can benefit students not only in STEM, but also in other fields of study. Since neither the entry requirements to Norwegian universities nor our data indicate a clear relationship between the types of high school mathematics classes and whether or not students would subsequently have any mathematics-related subjects at university, it is important to foster high school students' mathematics self-efficacy (which goes hand-in-hand with mathematical skills: Kaya & Bozdag, 2016; Pajares & Kranzler, 1995; Randhawa et al., 1993) in all types of mathematics classes to equip them for the challenges of university studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijedro.2023.100230.

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