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Business students' attitudes towards mathematics and performance in business mathematics: A case study of a Norwegian business school

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ABSTRACT

Mathematical abilities and skills are useful knowledge for success in economic administrative studies. This article focuses on business students' attitudes towards mathematics, their mathematical pathway in upper secondary school, and achievement in the compulsory course in business mathematics. The sample is from a survey of 260 business students from a university in Norway. The analysis is based on the framework of the attitudes towards mathematic inventory (ATMI). By comparing mean values this paper displays a strong link between students' selection of mathematical level in secondary school and their performance in business mathematics. This result is confirmed by using a linear regression model. However, by bringing in ATMI in the model this article shows there is no longer any significant correlation between choices regarding mathematics in upper secondary school and achievement in business mathematics. Nor did gender or grade point average from high school have any significant effect. Only elements included in ATMI (self-confidence and motivation) had a significant effect. The reason is probably that it is not the students' selection of mathematical level in secondary school, but their attitudes towards mathematics, that can explain success in business mathematics.

Keywords: ATMI, business students, performance mathematics

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INTRODUCTION

Skills and knowledge in mathematics are key factors in explaining success in business subjects and especially in subjects based on quantitative analysis (Ely & Hittle, 1990; Ross, 2022). In Norway, students from upper secondary school can choose between three kinds of mathematics: practical oriented (P-maths), one focused on social sciences (S-maths), and one on natural sciences (N-maths). Upon admission to business schools in Norway there is no requirement about the mathematical background. All three directions qualify for an entry ticket. The ranking of students is based mainly on grade point average (GPA) (from secondary school) achieved. Several studies have pointed out that students with P-maths do significantly poorly in business subjects compared to students who have a background in theoretical mathematics from upper secondary school (Opstad, 2018). Since students with practical oriented mathematics underperform in most of the business courses, there is a discussion in Norway about admission criteria for business schools. Many in education administration want to set requirements for mathematical knowledge for entry to business schools (Opstad et al., 2017). Other countries face this type of problem. In Spain, for example, there are different pathways to select within upper secondary school regarding mathematical subjects with various contents and breadths (Asian Chaves et al. 2022). Many students do not choose advanced mathematics since this can lead to poorer results and fewer points. There is a risk that this will affect the likelihood of getting a place at the preferred school.

The research also shows that there is a clear correlation between students' attitudes to mathematics and their achievement and preferences. This affects, among other things, the choice of majors and subjects (Opstad, 2019). Students who have positive attitudes towards mathematics tend to choose quantitative majors such as finance, while those with low scores prefer specialization in fields like organizational theory and marketing. Furthermore, there is a significant correlation between the choice of mathematical direction in upper secondary school and attitudes towards mathematics (Opstad, 2021; Opstad & Årethun, 2019). The published articles do not provide answers to the following key questions: Is the poor performance of many business students due to the choice of mathematical level in the upper secondary school or is it because the students have poor attitudes towards mathematics? Students with low abilities in mathematic tend to choose P-maths. Many students dislike mathematics and maybe they would not have performed better in business subjects by choosing a different mathematical direction at upper secondary school. For these students, the choice of theoretical mathematics can be perceived as difficult and demotivating. Students with low scores in mathematical courses also have a high degree of mathematical anxiety (Yenilmez et al., 2007). Mathematical skills and mathematical achievement are closed linked to each other (Williams & Williams, 2010).

The purpose of this article is to investigate possible causal relations between the students' choices during upper secondary school, attitudes towards mathematics, and performance in the compulsory introductory course in mathematics for business studies. We want to find out whether it is attitudes towards mathematics or choice of mathematical direction during upper secondary school that can explain the performance in business mathematics.

The outline of this article is, as follows: First part clarifies the link between attitudes towards mathematics and achievement in mathematics. Next segment presents the literature on the relationship between mathematical skills and performance. A separate section explains the choice of model and research question. The methodology section explains the selection of quantitative approach. After presenting the results, the findings are analyzed. The article ends with presentation of limitations and a conclusion.

CONCEPTUAL FRAMEWORK

In this study the focus is on two factors linked to performance in business mathematics, namely attitudes towards mathematics and mathematical skills.

Attitudes Towards Mathematics and Performance

Mathematical skills are important for good performance in business subjects, and especially in quantitative courses (Opstad, 2018). Therefore, business students believe in learning mathematics. There is a positive relation between students' belief in learning mathematics and success in business studies (Tahir & Bakar, 2007). This is also why many business schools require compulsory courses in mathematics before one can take the exam in business subjects. This is especially the case in quantitative courses such as finance. Several researchers show a clear positive correlation between attitudes towards mathematics and success in finance subjects (Ross & Wright, 2020). But also, in subjects such as accounting, there is a correlation between positive attitudes towards mathematics and success. Furthermore, the students believe that good mathematical skills contribute to becoming proficient in accounting (Du et al., 2019).

It is important to distinguish between those students who are looking to find the right answer and those who focus on learning more and studying harder. The last group achieves better results and has a more positive attitude towards mathematics (Ross & Wright, 2020). A positive attitude towards mathematics has been found to be associated with better performance and greater motivation to engage with mathematical concepts. On the other hand, negative attitudes towards mathematics can lead to avoidance behaviors, decreased motivation, and lower performance in mathematics-related courses. High mathematics anxiety is associated with poor performance in mathematics (Mutegi at al., 2021). One of the reasons is that high anxiety causes one to dislike mathematics, become less motivated and less interested in the subject. Furthermore, there is a strong positive link between attitudes towards mathematics and mathematical achievements (Ajisuksmo & Saputri, 2017). Therefore, positive attitudes towards mathematics are crucial factors for success in mathematical and quantitative courses.

Various methods have been developed to measure attitudes towards mathematics. One approach that has gained great recognition is the attitudes towards mathematics inventory (ATMI) developed by Tapia and Marsh (2000). It is widely used and has great recognition. ATMI consists of 40 questions and measures four factors affecting attitudes: self-confidence (15 items), value of mathematics (10 items), enjoyment of mathematics (10 items), and motivation (five items). In this article, the original version of ATMI is used. No separate factor analysis has been performed since many researchers have confirmed its high factor validity using the division into ATMI (Lim & Chapman, 2013; Majeed et al., 2013; Primi et al., 2020).

ATMI is a tool used to measure an individual's attitudes towards mathematics. Research has shown that attitudes towards mathematics can impact students' performance and success in mathematics-related courses, including business courses. According to Kilman (2015), students' self-confidence and motivation towards mathematics are strongly related to mathematical skill. Even most of the students find mathematics important for the career. Kislenko et al. (2007) report about 50% of the students find mathematical topics boring.

The findings from applying ATMI can provide useful information for individuals and educators, as it can help identify areas, where individuals may need additional support to develop a more positive attitude towards mathematics and improve their chances of success in business courses. However, it is important to note that other factors such as study habits, prior knowledge, and access to resources also play a role in success in business courses.

Mathematical Skills and Performance in Business Courses

Good mathematical skills can help students to better understand these concepts and make more informed business decisions. Mathematical skills are important for success in business courses, as many business concepts and calculations rely on a strong understanding of math. This includes areas such as finance, accounting, economics, and statistics. Many studies find that the grade in mathematics is a good indicator of achievement in business subjects (Lee & Lee, 2009; Masui et al., 2014). Tanveer et al. (2015) suggest business students cannot pass subjects like marketing, accounting and finance without possessing some mathematical knowledge and abilities. In line with this, Babalola and Abiola (2013) report a positive link between mathematical skills and success in accounting.

Quantitative abilities are a key factor for being able to do good analysis in finance (Guidry, 2020; Ross & Wright, 2020). Therefore, requiring quantitative skills is essential in this field. Despite quantitative prerequisites, many students struggle in business courses. An important explanatory factor is that many students have poor mathematical skills (Terry, 2002; Trine & Schellenger, 1999).

Basic mathematical abilities are important for good performance in economics courses like microeconomics (Ballard & Johnson, 2004). Opstad (2018) reports a strong positive relation between choosing theoretical mathematics in upper secondary school and performance in business mathematics, business statistics, business economics, financial analysis, and economics. Such an impact is also substantial, but not so strong, for subjects like accounting, management, marketing, and business law. Hence, mathematical background seems to be an important factor for success in business courses.

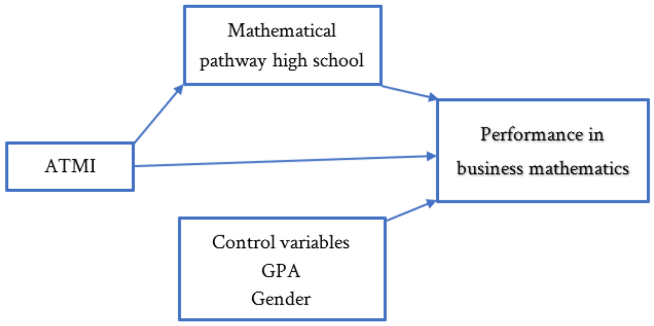

Figure 1. The model (gender, GPA, & mathematical background are correlated to performance in business mathematics & ATMI have a direct & indirect impact on success in mathematics via choice of mathematical level at upper secondary school) (Source: Author)

RESEARCH QUESTION AND THE MODEL

This analysis is based on the model presented in **Figure 1**. GPA (from upper secondary school) and gender are control variables. A lot of studies find a positive link between GPA and performance in business schools (Brookshire & Palocsay, 2004; Opstad, 2018).

There is a rich literature about gender and performance in economics and business subjects, but with mixed results. Several studies in recent years cannot find any gender difference (Ajisuksmo & Saputri, 2017; Opstad & Årethun, 2020).

Based on previous results, it is assumed that both ATMI and mathematics backgrounds from secondary school are strongly correlated with the grades in business mathematics. When we connect these two variables, the assumption is that only ATMI is linked to success in business mathematics. This results in the following:

Research question: Are attitudes towards mathematics related to achievements in business mathematics?

The assumption in this analysis is that the student's attitude towards mathematics is decisive for the choice of mathematical pathway from upper secondary school. If we take this into account in a simultaneous model, then there is no link between math choice in upper secondary school and success in business mathematics.

Gender and GPA are control variables in this model. Many authors discuss the link between these two factors and performance in mathematics. But that's not the focus of this article.

METHODS

Research

This study applies a quantitative analysis to investigate the data obtained by asking undergraduate students at a business school in Norway. The research design is based on the links between the variables presented in **Figure 1**.

Sample

The data is based on information from a questionnaire distribute to the students attending an obligatory course at a business school in Norway, Fall 2018 and Fall 2019.The purpose was to capture students' attitudes towards mathematics by using the original version of ATMI About 55% of the students gave personal details so the survey could be related to administrative information about the grades in business mathematics. This is not a random sample. It does not capture those students who were absent from the lecture when the survey was conducted. Previous studies indicate that those students receive slightly weaker grades (Bonesrønning & Opstad, 2015). This may influence the results of this study. **Table 1** provides an overview of the data used in this study. Almost 50% of the students have an S-maths background. Note the high score of the factors self-confidence and value of mathematics. This is in line with previous research showing that engineering students and business students see the benefits of mathematics and have good skills (Lee & Lee, 2009).

Data Analysis

The quantitative methodological approach is divided into two parts. In the first phase, a partial comparison of mean results for students with different mathematical choices from upper secondary school is made. This background information is valuable for assessing the alignment of our findings with prior research. Specifically, our aim is to verify whether there are notable disparities in business mathematics achievement and attitudes towards mathematics based on the chosen mathematical pathway. The assumption is that there is close link between the choice of mathematics direction and ATMI. By using a standard t-test for comparison of mean values one cand identify statistically significant differences.

To answer the research question, we will conduct a simultaneous analysis to determine how both ATMI scores and the mathematical pathway at upper secondary school are influenced by students' attitudes towards mathematics.

For this purpose, a linear regression model based in **Figure 1** is used (phase 2). This has the following specification:

$$Y_i = a_0 + a_1 X_{1i} + a_2 X_2 i + a_3 X_{3i} + a_4 X_{4i} + a_5 X_{5i} + a_6 X_{6i} + a_7 X_{7i} + a_8 X_{8i} + \varepsilon_I,$$

where Y is grade attained in business mathematics (1: E, 2: D, 3: C, 4: B, and 5: A), i is student, α_0 is constant, X_1 is gender (0: F and 1: M), X_2 is upper secondary school GPA, X_3 is dummy variable for P-maths (0: non P-maths and 1: P-maths), X_4 is dummy variable for N-maths (0: non N-maths and 1: N-maths), X_5 is self-confidence in mathematics (7-point Likert scale, 1=strongly disagree and 7=strongly agree), X_6 is value of mathematics (7-point Likert scale, 1=strongly disagree and 7=strongly agree), X_7 is motivation in mathematics (7-point Likert scale, 1=strongly disagree and 7=strongly agree), X_8 is enjoyment of studying mathematics (7-point Likert scale, 1=strongly disagree and 7=strongly agree), and ε is stochastic error.

The spotlight in this article is the estimated parameters of the two dummy variables X_3 and X_4 and for the variables catching ATMI (X_5-X_8). Due to high variance inflation factor (VIF)–all four factors cannot be included in one model. Hence, this study presents two versions. Model 1does not include the factor motivation, while model 2 consists of self-confidence and motivation. P-maths and N-maths are included as dummy variables. The interpretation then is that the value of these estimators is compared to those that have S-maths.

FINDINGS

This study shows that students with N-maths from upper secondary school achieve much better results in business mathematics (**Table 2**). The mean difference in performance in business mathematics for those with N-maths and P-maths is over one letter grade, while it is slightly lower for the difference S-P.

Table 1. Descriptive statistics from the sample

Variable	Minimum	Maximum	Mean	Standard deviation
Gender (1:M & 0:F)	0	1	.44	.50
GPA (upper secondary school (n=167)	46.9	66.7	51.24	3.32
Performance mathematics (1: E, 2: D, 3: C, 4: B, 5: A, & F is not included (n=147)	1	5	3.51	1.30
Self-confidence (n=260)	1.6	6.7	5.03	1.07
Motivation (n=260)	1.3	7.0	4.81	1.12
Value (n=260)	2.4	7.0	5.01	.95
Enjoyment (n=260)	1.0	7.0	4.56	1.25
P-maths (1: P, 0: Non-P, & n=260)	0	1	.18	.39
S-maths (1: S, 0: Non-S, & n=260)	0	1	.46	.50
N-maths (1: N, 0: Non-N, & n=260)	0	1	.32	.47

Note. Four ATMI dimensions were measured on a 7-point Likert scale, where 1=strongly disagree & 7=strongly agree

Table 2. Comparing mean values depending on mathematical pathway (independent sample t-test & equal variances assumed)

	N-maths	S-maths	P-maths	N-S	N-P	S-P
Performance maths	3.91 (1.15)	3.56 (1.21)	2.71 (1.24)	.35*** (.129)	1.19*** (.178)	.85 (.185)
Attitudes						
Self-confident	5.52 (.86)	4.99 (1.00)	4.21 (1.12)	.53*** (.134)	1.31*** (.175)	.78*** (.178)
Value	5.30 (.95)	4.99 (.88)	4.58 (.94)	.31** (.129)	-.72*** (.171)	.41*** (.159)
Motivation	5.23 (1.07)	4.78 (1.27)	4.07 (1.14)	.44*** (.147)	1.16*** (.200)	.72*** (.179)
Enjoyment	5.05 (1.17)	4.52 (1.12)	3.65 (1.24)	.53*** (.163)	1.41*** (.223)	.88*** (.204)

Note. ***p<.01

Table 3. Regression models. (Dependent variable: Performance in Business mathematics (Motivation is not included in Model 1. Alternative approach (Model 2) contains two of the ATMI dimensions: Self-Confident and Motivation. Standardized B-values)

Explanatory variables	Model 1		Model 2	
	B	t-value	B	t-value
Gender	.000	.001	.010	.153
GPA	-.008	-.113	-.037	-.551
P-mats	-.066	-.917	-.064	-.915
N-mats	.058	.776	.048	-663
Self-confidence	.430	4.380 ***	.298	2.723 ***
Value	.080	.891		
Motivation			.331	2.922 **
Enjoyment	.129	1.104		
	ADJ. R^S= .356		ADJ. R^S=.370	
	N=145		N=147	

Note. *p<.1; **p<.05; & ***p<.01

There are also significant impacts regarding ATMI. Those with practical mathematics have the lowest values, while those with S-maths are in the middle. For instance, is the mean difference in motivation for students with N-maths and P-maths 1.41. The differences are generally so high that it is significant at less than 1% level. The exception is the grade gap between S-maths and P-maths.

The regression analyses show no significant effects of gender or GPA (**Table 3**). The estimated values of the coefficient B and the t-values are close to zero for both model 1 and model 2. There is also no significant correlation between performance in business mathematics and mathematical pathway. Only ATMI factors are significantly associated with success in business mathematics: Both self-confidence and Motivation have strong positive effects. B is .298 and .331 respectively with significance levels below 1% (model 2). This result confirms the research question in this article.

DISCUSSION

Gender and GPA and Success in Business Mathematics

As a result of more gender equality, research shows that the traditional gender difference has narrowed. In some countries, female students outperform male students, also in mathematics (Nollenberger et al., 2016). Hence, there is no surprise that this study does not find any gender difference.

More surprisingly, GPA from upper secondary school is not correlated with achievements in business mathematics. Markussen et al. (2011) report a positive link between GPA from secondary school in Norway and academic success. One possible reason why this study cannot demonstrate such a connection is that we limit ourselves to looking at the subject mathematics. To succeed in mathematics, special skills are required. GPA captures all the subjects.

ATMI, Mathematical Background from Upper Secondary School and Performance in Business Mathematics

This research confirms previous findings of a close link between students' mathematical choice in upper secondary school and success in mathematics by using a partial analysis (Opstad, 2018). Comparison of mean values show that both achievements and attitudes towards mathematics are significantly different depending on mathematical pathway. Those with natural science mathematics get highest scores, while students with practical mathematics get lowest mean values.

By using a linear regression model and analyzing a simultaneous relationship, the effect of mathematical background is eliminated. According to this study, an important factor in explaining students' performance in mathematics is the attitudes students have towards mathematics. Students who have high self-confidence and are motivated to study mathematics are strongly positively related to success in mathematics.

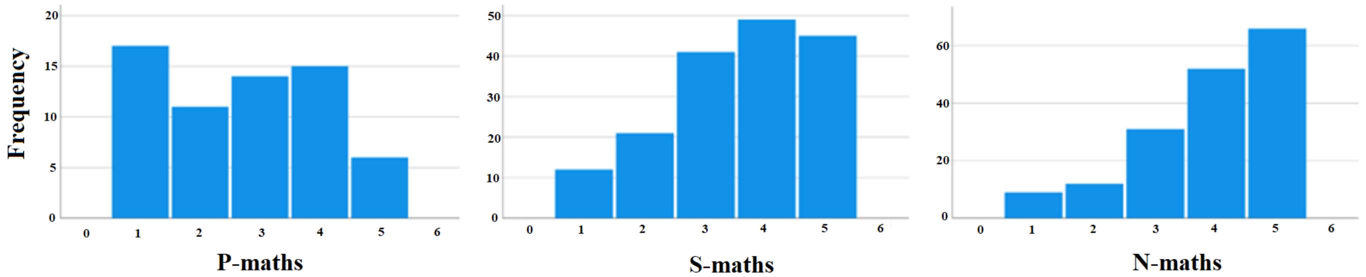

Figure 2. Performance in business mathematics depending on pathway chosen in upper secondary school (2018-2019) (E: 1, D: 2, C: 3, B: 4, & A:5) (Source: Author)

This is in line with the literature (Hwang &Son, 2021; Kilman, 2015; Naungayan, 2022; Panerio, 2016; Tanveer et al., 2015). Students' attitudes towards mathematics are strongly linked to students' performance in business mathematics and other quantitative subjects like statistics (Primi et al., 2020). By including ATMI in the regression model, the dummy variables on the choice of mathematics at the secondary school do not have any effect. There is nevertheless considerable variation in performance in business mathematics independent of the mathematical pathway during secondary upper school (**Figure 2**). Some students with N-maths background achieve weak results in business mathematics, and there are students with practical mathematics who get top grades in this subject. This analysis suggests that this is related to the values of ATMI. Students with high scores tend to achieve good grades in business mathematics regardless of the mathematical pathway during secondary school. Conversely, students with low values of ATMI largely get poor results in business mathematics independent of their mathematical choices in upper secondary school. This suggests that the reason for the large differences in achievement depending on the mathematical pathway (see **Table 2**) is due to the fact that students who struggle with mathematics and have little self-confidence choose P-maths. Those who score high on ATMI tend to choose N-maths.

This is useful knowledge for those who administer criteria for admission to business studies. Attitudes and skills in mathematics are a key factor for success in business studies. Choosing theoretical mathematics in the upper secondary is no guarantee of success at business schools. It depends on what skills and attitudes towards mathematics the individual student has. Requirements for theoretical mathematics from upper secondary school do not necessarily lead to achieving the desired goal. One must try to implement a system that attract students who have good skills, confidence, and motivation in learning mathematics. Based on the findings from this paper, it is recommended to encourage and motivate students to take more interest in mathematics. Perhaps math grades should count more for admission to business studies since ATMI scores are strongly related to success in business education (Opstad, 2023). However, note that mathematical skills alone do not necessarily guarantee success in business. Other factors such as critical thinking, communication, effort and personality traits influence students' performance in business subjects.

Limitations

The analysis in this study has some limitations. The biggest objection is that ATMI was measured after admission to business studies. Ideally, this should have been measured before the choice of mathematical path during upper secondary school. Data is from only one business school. Nevertheless, there is reason to believe that the result has golden unity for other business schools. Probably there are many other factors that affect students' performance in business mathematics, but there are no data available to include them in analysis.

CONCLUSIONS

Many argue for theoretical mathematics as a requirement for an entry ticket for business schools. This will increase the quality of the students attending business courses. This conclusion may be a little bit hasty. In line with previous research this study shows students with practical mathematics from upper secondary school have initially weaker mathematical skills. Therefore, those students struggle with mathematics, and they tend to choose practical mathematics. But even if they choose theoretical mathematics, they will still have a problem handling business mathematics.

The critical factors for success in business mathematics are mathematical attitudes (ATMI) and skills. Therefore, it is not enough just to focus on mathematics background from upper secondary school upon admission to business education One must also capture the students' interest and ability in mathematics since this is important for further success in business education. Perhaps one should take a closer look at the criteria for admission to business schools.

This study also shows that gender and GPA from high school are not correlated with achievements in business mathematics.

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Declaration of interest: The author declares no competing interest.

Data availability: Data generated or analyzed during this study are available from the author on request.

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