An Overview of Attitudes Toward Mathematics Across Different Disciplines, Gender and STEM

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ABSTRACT: In this research study, the aim is to inspect the attitudes toward mathematics amongst disciplines, gender, and STEM and non-STEM students. To attain this objective, a questionnaire-based research was chosen; this instrument with 20 items in total consisted of four components, namely, self-confidence, enjoyment, motivation, and value. A total of 391 university students answered the questionnaire; the data is tested and analysed using SPSS 20. Since the data was not normally distributed, the Kruskal-Wallis Test for each factor was performed to check for significant differences across disciplines and post hoc tests in all cases to confirm which pairs have differences. Results of pair comparison revealed that a significant difference in all factors exists between Math Education (with higher mean rank) and other disciplines. To provide evidence of the possibility of group differences between STEM and non-STEM students in self-confidence, value, enjoyment, and motivation, the Mann-Whitney U Test is used. Findings detected slightly more positive attitudes among STEM students than non-STEM students. Performing the Mann-Whitney U Test for each factor revealed a significant difference between them with a medium effect size. Related to gender, no significant difference was detected. Whereas a significant difference was detected regarding gender among students in STEM disciplines. Evaluating attitudes of the respondents towards mathematics revealed that students had a moderately high level of enjoyment, self-confidence, and motivation in learning mathematics.

KEYWORDS: Attitudes, Mathematics, Motivation, Self-confidence, STEM.

INTRODUCTION

As mathematics, it is an important subject with a great contribution to the development of other fields such as mathematics education, information technology, science, business, economics, etc. no one can get away from learning mathematics. Some of us are disposed to learn mathematics while others aren't, as we walk the path of education. Some of us like mathematics while others don't. Some of us succeed in mathematics while others fail. Why are some of us confident in learning mathematics? Why do some of us have the motivation to gain new mathematics knowledge while others don't?

Regarding this subject, over the years, professors and researchers have conducted searches to understand which factors influence students to learn mathematics and measure the attitudes toward math. Recent searches (Yunos et al. (2022)) have revealed that learners from social sciences showed higher mathematics anxiety compared to science and technology or business students. In their paper, Opstad (2024) showed there was no longer any significant correlation between choices regarding mathematics in upper secondary school and achievement in business mathematics; however, neither gender nor high school grade point average had any significant effect.

A study conducted among Chemistry undergraduate' students by Garner-O'Neale and Cumberbatch (2015) to determine the attitudes toward Mathematics at the University of the West Indies revealed that overall Chemistry undergraduates' attitudes toward Mathematics were moderate; however, there were no statistically significant differences based on their sex or level of study. In their study, most students had a good level of value for mathematics throughout the four areas, but the majority moderately enjoyed mathematics, were motivated, and had moderate self-confidence.

Accordingly Opstad and Årethun (2019) at a study conducted among economics and business students in Norway was revealed that there is a significant difference in attitudes toward mathematics among males and females, with females having substantially lower values compared to males. Research by Karjanto (2017) analyzed students' attitudes toward mathematics at Nazarbayev University Foundation Year Programme among Mathematical-Physics (MP), Biology-Chemistry (BC), and International Relations-Economics (IRE) students, where it was reported no significant difference among males and females and a very significant difference between students who specialize in IRE and MP in terms of their attitude toward mathematics.

In a study conducted by Hernández de la Hera et al. (2023) among 276 Spanish students, 255 from the University of Granada and 19 from a secondary school in Granada, Spain, revealed a significant difference in mathematics attitudes between males and females, with males displaying slightly higher levels of mathematical attitudes than females. When comparing STEM (engineering) and non-STEM (nursing) fields among first-year undergraduates, Duggan et al. (2017) reveal that in examining gender and attitudes toward mathematics, a statistically significant relationship exists only for the value factor. In "Attitudes towards mathematics, achievement, and drop-out intentions among STEM and non-STEM students in Norway," Óturai et al. (2023) revealed that while STEM and non-STEM students did not differ in terms of mathematics self-efficacy or attitudes toward mathematics, field of study was significantly related only to students' subjective value of mathematics.

Research on students' attitudes toward mathematics in our country provide valuable data mostly on secondary education level (OECD (2023), Garo (2008), Braho (2024)). Additionally, few studies have explored how these attitudes differ among higher education students. Building on this work, the present research tend to fulfill this gap of limited data and fragmented literature that exist related to attitudes toward mathematics among higher education level in the Albanian context.

Research purpose

The research purpose is to obtain an estimation of attitudes toward mathematics and how they differ across disciplines, gender, and STEM by controlling if there exist any statistically significant difference between and comparing means for every item.

Research questions

This research study has the objective of responding to the following questions, since its goal is to give an estimation of factors that affect student's attitudes toward mathematics:

RQ1. What do university students' short ATMI scores indicate about their attitudes toward math?

RQ2. Is there a statistically significant difference in Motivation (MO) across disciplines and how do the Motivation components differ?

RQ3. Is there a statistically significant difference in Enjoyment (EN) across disciplines and how do the Enjoyment components differ?

RQ4. Is there a statistically significant difference in Value (VA) across disciplines and how do the Enjoyment components differ?

RQ5. Is there a statistically significant difference in Self-Confidence (SC) across disciplines and how do the Enjoyment components differ?

RQ6. Do STEM and non-STEM students differ statistically significantly in their attitudes?

RQ7. In attitudes, is there a statistically significant difference in overall and in STEM disciplines among males and females?

METHODOLOGY

Researcher conducted a quantitative research study among students from an Albanian public university, with a total of 391 participants, according to the purposes stated above. The instrument used is an adapted version made by Klanderman et al. (2019) of a survey originally developed by Tapia (1996) and later shortened by Lim and Chapman (2013). The survey focuses on four subscales: the enjoyment of mathematics, motivation to do mathematics, self-confidence in mathematics, and value of mathematics. This instrument contains 20 items; for each item, a 5-point Likert scale, starting from strongly disagree (1) to strongly agree (5), was used. The research was conducted among higher education students varying from undergraduate freshmen to graduates related to their level of education and formed a sample of 391 students (n = 264 (67.52%) females; 127 (32.48%) males). Students were from different math levels and different disciplines, such as Math Education (ME) (15.3%), Economics (EC) (23.5%), Nursing (NU) (25.1%), Social Sciences (SS) (11.3%), Education Science (ES) (2.8%), Information Technology (IT) (17.9%), and Biology-Chemistry (BC) (4.1%).

DATA ANALYTICS AND FINDINGS

The data were collected through questionnaires and were analyzed with SPSS version 20, while bar charts were constructed in Excel 2016. As shown in Table I, a Cronbach's Alpha of .94 was revealed, which is a high internal reliability for the instrument. Descriptive statistics were also computed to analyse the mean and standard deviation for each factor.

Table I. Descriptive Statistics and Reliabilities for short ATMI factors

Factor	No. of items	Mean	SD	α
Self-Confidence	5	3.1	1.01601	.911
Value	5	3.7	.082090	.872
Enjoyment	5	3.2	.87465	.830
Motivation	5	3.3	.83325	.793
All 20 items				.94

A. Findings for students' short ATMI scores

Researchers computed the mean score (Table I) for each of the four factors in response to research question 1. Data suggested that university students in general display a moderate level of attitudes toward math in three of the factors and a high level on the value of mathematics. In the self-confidence factor (M = 3.1, SD = 1.01601), students have revealed a moderate level of confidence and self-concept in their mathematics performance. For the value factor (M=3.7, SD=0.82090), students have shown a high level of credence in the utility, relevancy, and value of mathematics in today's life and in the future. For the factor of enjoyment (M=3.2, SD=0.87465), students reported a moderate level of enjoyment when working with mathematics, as well as a moderate level of interest in mathematics at the factor of motivation (M=3.3, SD=0.83325).

B. Findings for Motivation factor among Disciplines

To give a response to research question 2, the answer will be pointed out in two parts: at first, Kruskal-Wallis test outcomes and post hoc results, and at second, conclusions from the mean comparison of items of the motivation factor.

1) Findings for Kruskal-Wallis Test and Post Hoc Test

The outcomes from the Kruskal-Wallis test applied confirm the significant difference with $\chi^2(6) = 101.377$, p<0.001 in the motivation factor among disciplines, where Math Education scored the highest (Mean = 4.1333, Std. dev. = .40449), while other disciplines showed lower means, and the lowest mean was for Social Science (Mean = 2.8818, Std. dev. = .77917).

Table II. Kruskal Wallis Test for MO factor

Factor	Disciplines	Mean	SD	Mean Rank	Chi square	Sig.
	Economics	3.1870	.89335	182.91		
	Math Education	4.1333	.40449	317.63		
	Social Science	2.8818	.77917	132.22		
MO	Nursing	3.0918	.82245	165.74	101.377	.000
	Information Technology	3.2371	.61318	180.66		
	Biology-Chemistry	3.8250	.56510	268.47		
	Education Science	3.0364	.776325	158.91		

Post hoc results (Table III) revealed that a significant difference exists between math education (with higher mean rank) and other disciplines such as nursing, social science, education science, information technology, and economics. Additionally, a significant difference is also between social science and biology-chemistry, which has the higher mean rank between these two disciplines. The biology-chemistry and nursing pairs also differ significantly, with the biology-chemistry pair showing a higher mean rank.

Table III. Results for pair comparison with significant differences on Motivation

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
NU-ME	151.894	18.475	8.221	.000	.000
SS-ME	185.417	22.370	8.289	.000	.000
ES-ME	158.724	36.976	4.294	.000	.000
IT-ME	136.969	19.829	6.907	.000	.000
EC-ME	-134.720	18.703	-7.203	.000	.000
SS-BC	-136.253	32.904	-4.141	.000	.001
UN-BC	-102.729	30.390	-3.380	.001	.015

2) Comparing means for MO items

We present in this paragraph the comparison of mean scores on the five items that compound the motivation factor related to each discipline. As seen in Fig. 1 in items "I am motivated by how difficult math is," "Having mathematics connect to other content areas and the world around motivates me to learn mathematics," and "I really like mathematics," students of math education show the highest mean (respectively 3.75, 4.05, 4.73) compared to students of other disciplines. Social science students have shown the lowest mean for the first and third items with a mean of 2.41 and 2.55, respectively; education science students have shown the lowest mean for the first and second items with a mean of 2.64 and 2.55, respectively. In the items "The people around me motivate me to do better at mathematics" and "Getting good grades motivates me to do better in mathematics," students of biology-chemistry showed the highest mean (respectively 3.88, 4.69) compared to students of other disciplines, while social science students showed the lowest means (2.91 and 3.4, respectively).
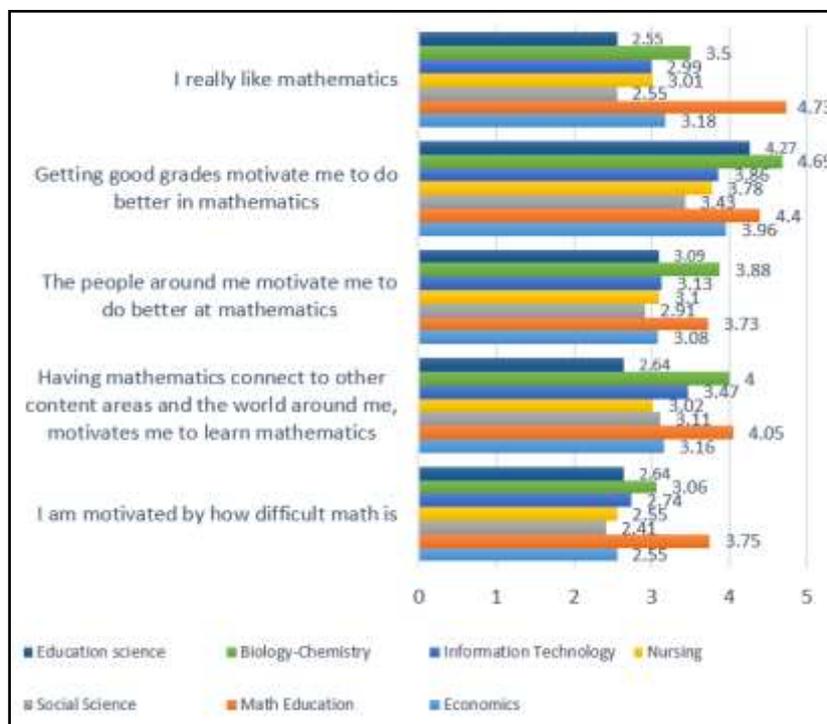

Figure 1. Means for MO items of each discipline

C. Findings for Enjoyment Factor among Disciplines

To give a response to research question 3, the answer will be pointed out in two parts: at first, Kruskal-Wallis test outcomes and post hoc results, and at second, conclusions from the mean comparison of items of the Enjoyment factor.

1) *Findings for Kruskal-Wallis Test and Post Hoc Test*

The outcomes from the Kruskal-Wallis test applied confirm the significant difference with $\chi^2(6) = 117.361$, p<0.001 in the enjoyment factor among disciplines, where Math Education scored the highest (Mean = 4.2967, Std. dev. = .42064), while other disciplines showed lower means, and the lowest mean was for Social Science (Mean = 2.7955, Std. dev. = .78294) (Table IV).

Table IV. Kruskal Wallis Test for EN factor

Factor	Disciplines	Mean	SD	Mean Rank	Chi square	Sig.
	Economics	3.1457	.88460	186.05		
	Math Education	4.2967	.42064	333.18		
	Social Science	2.7955	.78294	137.42		
EN	Nursing	3.0041	.78016	162.49	117.361	.000
	Information Technology	3.0629	.67976	170.04		
	Biology-Chemistry	3.5875	.67909	241.53		
	Education Science	3.0364	.77366	162.73		

Post hoc results revealed that a significant difference exists between math education (with higher mean rank) and other disciplines such as social science, nursing, education science, information technology, and economics. Also, a significant difference exists between social science and biology-chemistry, where biology-chemistry has the higher mean rank between these two disciplines (Table V).

Table V. Results for pair comparison with significant differences on Enjoyment

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
NU-ME	170.680	18.480	9.236	.000	.000
SS-ME	195.755	22.376	8.748	.000	.000
ES-ME	170.448	36.976	4.610	.000	.000
IT-ME	163.132	19.834	8.225	.000	.000
EC-ME	-147.121	18.708	-7.864	.000	.000
SS-BC	-104.111	32.912	-3.163	.002	.033

2) *Comparing means for EN items*

We present in this paragraph the comparison of item mean scores of 5 items composing enjoyment, pointing out the mean scores of each discipline. As seen in Fig. 2, in the five items of enjoyment, students of math education show the highest mean (respectively 3.48, 4.62, 4.58, 4.5, and 4.3) compared to students of other disciplines. The lowest mean for the item "I enjoy reading about mathematics (non-textbook reading)" is shown by education science students (mean 2.09). And for items "Mathematics is a very interesting subject," "I am happier in mathematics class than in any other class," "I like to solve new problems in mathematics," and "I have usually enjoyed studying mathematics in school," students of social sciences show the lowest mean (respectively 3.23, 1.95, 3, and 3.11) compared to students of other disciplines.
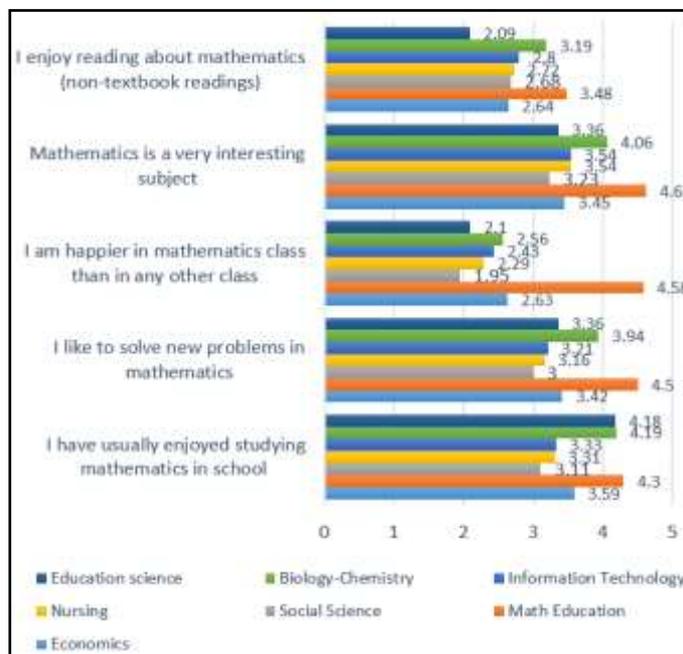
Figure 2. Means for EN items of each discipline

D. Findings for Value Factor among Disciplines

To give a response to research question 4, the answer will be pointed out in two parts: at first, Kruskal-Wallis test outcomes and post hoc results, and at second, conclusions from the mean comparison of items of the Value factor.

1) Findings for Kruskal-Wallis Test and Post hoc test

The outcomes from the Kruskal-Wallis test applied confirm the significant difference with $\chi^2(6) = 77.795$, p<0.001, in the value factor among disciplines, where math education scored the highest mean (Mean = 4.4667, Std. dev. = .46090), while other disciplines showed lower means, and the lowest mean was for nursing (Mean = 3.4204, Std. dev. = .80025) (Table VI).

Table VI. Kruskal Wallis Test for VA factor

Factor	Disciplines	Mean	SD	Mean Rank	Chi square	Sig.
	Economics	3.6957	.83940	189.45		
	Math Education	4.4667	.46090	299.16		
	Social Science	3.4591	.89086	155.95		
VA	Nursing	3.4204	.80025	150.62	77.795	.000
	Information Technology	3.7000	.69678	185.89		
	Biology-Chemistry	4.1125	.47871	248.06		
	Education Science	4.0727	.64045	241.18		

Post hoc results revealed a significant difference exists between Math Education (with higher mean rank) and other disciplines such as Nursing, Social Science, Information Technology, and Economics. A significant difference is also between Nursing and Biology-Chemistry, where Biology-Chemistry has the higher mean rank between these two disciplines (Table VII).

Table VII. Results for pair comparison with significant differences on Value

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
NU-ME	148.536	18.471	8.041	.000	.000
SS-ME	143.204	22.365	6.403	.000	.000
IT-ME	113.273	19.824	5.714	.000	.000
EC-ME	-109.707	18.699	-5.867	.000	.000
NU-BC	-97.440	30.383	-3.207	.001	.028

2) Comparing means for VA items

We present in this paragraph the comparison of item mean scores of 5 items composing value, pointing out the mean scores of each discipline. As seen in Fig. 3 in items "A strong mathematics background could help me in my life," "Mathematics lessons would be very helpful no matter what I decide to study in the future," and "Mathematics is important in everyday life," students of Nursing show the lowest means (3.31, 3.02, and 3.67, respectively) compared to students of other disciplines, while in item "Mathematics is one of the most important subjects for people to study," students of Social Science (mean 3.23). In all these four items, students of Math Education show the highest means (respectively 4.47, 4.62, 4.38, and 4.32) compared to students of other disciplines. And, in the last item, "Mathematics is a very worthwhile and necessary subject," students of Biology-Chemistry show the highest mean (4.63), while the students of Social Science have the lowest mean (3.73).
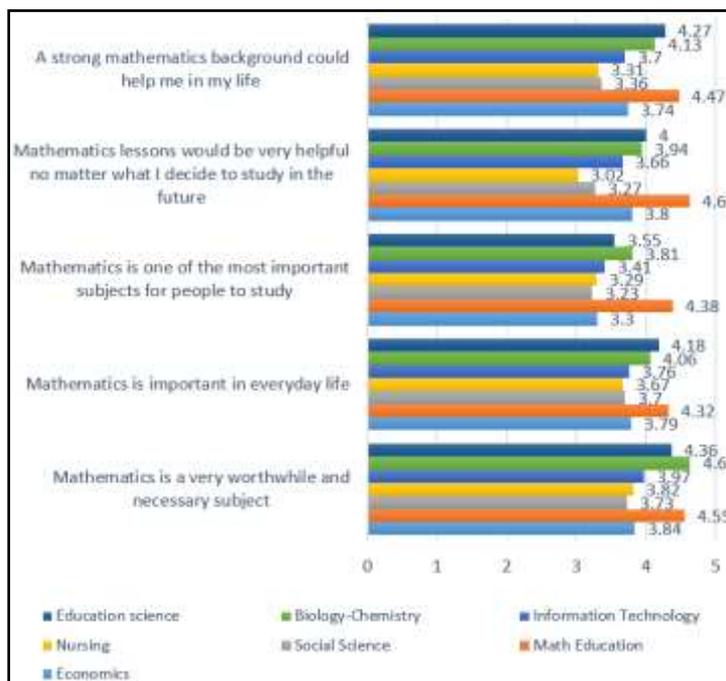

Figure 3. Means for VA items of each discipline

E. Findings for Self-Confidence Factor among Disciplines

To give a response to research question 5, the answer will be pointed out in two parts: at first, Kruskal-Wallis test outcomes and post hoc results, and at second, conclusions from the mean comparison of items of Self-Confidence factor.

1) Findings for Kruskal-Wallis Test and Post Hoc test

The outcomes from the Kruskal-Wallis test applied confirm the significant difference with $\chi^2(6) = 80.095$, p<0.001 in Self-Confidence factor among disciplines, where Math Education scored the highest (Mean = 4.0300, Std. dev. = .62363), while other disciplines showed lower means, and the lowest mean was for Social Science (Mean = 2.5500, Std. dev. = 1.03531) (Table VIII).

Table VIII. Kruskal Wallis Test for SC factor

Factor	Disciplines	Mean	SD	Mean Rank	Chi square	Sig.
SC	Economics	2.8870	1.00299	171.18		
	Math Education	4.0300	.62363	302.03		
	Social Science	2.5500	1.0353	131.13		
	Nursing	2.9327	1.0282	176.25	80.095	.000
	Information Technology	3.0943	.79398	191.46		
	Biology-Chemistry	3.6625	.75443	258.78		
	Education Science	3.0909	1.01337	198.27		

Post hoc results revealed a significant difference exist between Math Education (with higher mean rank) and other disciplines such as: Nursing, Social Science, Information Technology and Economics. A significant difference were also between Social Science and Biology-Chemistry which has the higher mean rank between this two disciplines.

Table IX. Results for pair comparison with significant differences on Self-Confidence

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
NU-ME	125.775	18.490	6.802	.000	.000
SS-ME	170.900	22.388	7.633	.000	.000
IT-ME	110.568	19.845	5.572	.000	.000
EC-ME	-130.840	18.718	-6.990	.000	.000
SS-BC	-127.656	32.930	-3.877	.000	.002

2) Comparing means for SC items

We present at this paragraph the comparing of item mean scores of 5 items compounding Self-confidence pointing out the mean scores of each discipline. As seen in Fig. 4 students of Math Education have the highest mean in four of five items of Self-confidence which are: "Studying mathematics makes me feel nervous", "It makes me nervous to even think about having to do a mathematics problem", "I always feel confused in mathematics class" and "I feel a sense of insecurity when attempting mathematics" (3.62, 4, 4.2, 4.22 respectively) compared to other disciplines, while in item "I am always under a terrible strain in mathematics class" students of Biology-Chemistry has the highest mean (4.19) compared to others. In all five items the lowest mean is shown by students of Social Science.
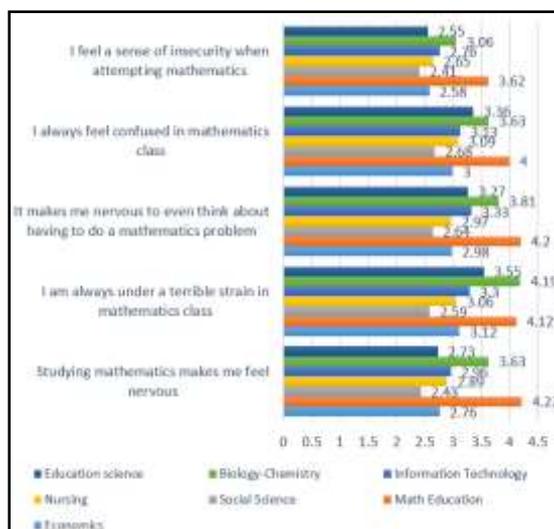

Figure 4. Means for SC items of each discipline

F. Findings related to significant differences between STEM and non-STEM students

Findings related to Self-confidence, between students in STEM (Median=3.6 n=157) and non-STEM (Median=2.8, n=234), U=11296, Z=-6.469, p=0, reveal significant difference with a medium effect size r=0.327. This result indicate that STEM students have a higher self-confidence in mathematics. Also findings reveal significant difference in Value of mathematics between students in STEM (Median=4.2 n=157) and non-STEM (Median=3.6, n=234), U=11557.5, Z=-6.236, p=0, with a medium effect size r=0.315 and Enjoyment between students in STEM (Median=3.6, n=157) and non-STEM (Median=3, n=234), U=11593, Z=-6.201, p=0, with a medium effect size r=0.314. These results indicate that STEM students place a greater value on mathematics and enjoy mathematics more than non-STEM students. A significant difference was revealed in factor of Motivation between students in STEM (Median=3.6, n=157) and non-STEM (Median=3.2, n=234), U=11593, Z=-6.201, p=0, with a medium effect size r=0.32. Indicating that STEM students have stronger motivation related to mathematics compared to non-STEM peers.

Table X. Mann-Whitney Test results for each factor related to STEM and non-STEM

Factor	Gender	N	Mean Rank	Z	Sig.
SC	STEM	157	241.05	-6.469	.000
	Non STEM	234	165.77		
VA	STEM	157	239.39	-6.236	.000
	Non STEM	234	166.89		
EN	STEM	157	239.16	-6.201	.000
	Non STEM	234	167.04		
MO	STEM	157	240.43	-6.385	.000
	Non STEM	234	166.19		

The findings reveal that in our case we have a significant difference between STEM and non-STEM students in attitudes toward mathematics, and overall, STEM students seem to have more positive attitudes.

G. Findings related to gender significant differences

Performing the Mann-Whitney Test since the sample sizes were not equal, in order to answer the question about the significant differences related to gender in each of the factors, findings (results at Table 11) revealed that there is no significant difference between male and female students.

Table XI. Mann-Whitney Test results for each factor related to gender

Factor	Gender	N	Mean Rank	Z	Sig.
SC	Male	127	208.90	-1.568	0.117
	Female	264	189.80		
VA	Male	127	200.07	-0.496	0.620
	Female	264	194.04		
EN	Male	127	199.38	-0.411	0.681
	Female	264	194.37		
MO	Male	127	204.52	-1.037	0.300
	Female	264	191.90		

Between males and females in STEM study programs, a significant difference is found in all four factors. The Mann-Whitney Test results for self-confidence between male students in STEM (Median=3.4, n=82) and female students in STEM (Median=3.8, n=75), confirmed a significant statistical difference with Z=-2.477, p=0.013, at Value between male students in STEM (Median=4, n=82)

and female students in STEM (Median=4.2, n=75), with Z=-3.628, p=0, Motivation between male students in STEM (Median=3.4, n=82) and female students in STEM (Median=3.8, n=75), with Z=-2.600, p=0.009, and Enjoyment between male students in STEM (Median=3.4, n=82) and female students in STEM (Median=4, n=75), with Z=-3.991, p=0.

CONCLUSIONS

Within the framework of this study, it was investigated the students' attitudes towards mathematics across different disciplines, gender and related to STEM and non-STEM studies. Leded by this, seven research questions were raised. The findings show that students in general have positive attitudes toward mathematics in all four factors examined, ranging from a moderate level in motivation, self-confidence, and enjoyment factors to a high level in the value factor. These results indicate the need for improvement in their beliefs in their own abilities as well as to increase the enjoyment and enhance motivation. Even while students still recognize the value of math, there could be opportunities to increase their awareness about how math can be used in the real world.

Analyzing the factors related to study field findings revealed a significant difference in each of four factors. Unsurprising were the results regarding questions 2, 3, 4, and 5 post hoc findings, where it is revealed that between Math Education and other disciplines in all factors exists a significant difference. This result aligns with the results of the study carried out by Karjanto (2017). Furthermore, post hoc findings revealed a significant difference in self-confidence, motivation, and enjoyment between Social Sciences and Biology-Chemistry, and also between Nursing and Biology-Chemistry in motivation and value factors, while the contrary was reported by Yonos (2022). Some of the individual items also have intriguing results that merit discussion. The findings showed that Math Education and Biology-Chemistry had the highest mean scores for "I really like mathematics," followed by the other disciplines, with Social Science scoring the lowest mean, indicating that for them mathematics is not particularly enjoyable. The mean scores for "Getting good grades motivates me to do better in mathematics" and "Mathematics is a worthwhile and necessary subject" were higher among Biology-Chemistry students, followed by Math Education peers. Biology-Chemistry students showed a high mean also for "I am always under terrible strain in mathematics class," indicating that when it comes to math, they experience significant strain and stress, followed by Math Education mates. Furthermore, students of Math Education showed a higher mean score for "Studying mathematics makes me feel nervous," compared to others, indicating that even those who study math education can have discomfort around it.

Students in STEM disciplines seem to have a more positive attitude toward mathematics than students in non-STEM disciplines. Findings revealed a significant difference with a medium effect size between STEM and non-STEM students. In the factors of motivation, self-confidence, value, and enjoyment, STEM students have a higher mean rank than non-STEM peers. This is a similar result with previews researches from Karjanto (2017) and contrary to Óturai et al. (2023) wherein their results, STEM and non-STEM do not differ.

Results regarding gender disparity suggest that between males and females, there is no significant difference in all four factors, which is a similar result to other studies developed before (Karjanto (2017), Abosalem (2015), Yunos et al. (2022), Moussa & Saali (2022)) and contrary to the results of Opstad and Årethun (2019) and Galende et al. (2020)). In STEM disciplines, findings reveal a significant difference between males and females. Among STEM students, females seem to have less pessimistic attitudes toward mathematics than males.

Since these results are linked with gender, STEM and different disciplines give us a view of the situation among university students, but for a deep understanding of the field, further research is needed related to other factors such as mathematical achievement, the background in mathematics, or goal achievement to understand how those can affect their attitudes and to have a broad view.

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