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Correlation between Civil Engineering Student's Performance in Mathematics and Academic Success

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ABSTRACT: This research aims to examine the widely accepted paradigm that proficiency in mathematics significantly influences the academic success of Civil Engineering students. Using data from 119 students of the 2018 and 2019 cohorts at Universitas Mercu Buana, the study analyzes the correlation between their performance in Mathematics courses (Mathematics 1, 2, and 3) and their academic success, as measured by timely graduation and GPA. The data were processed using the Spearman correlation method, given its non-normal distribution as determined by Kolmogorov-Smirnov and Shapiro-Wilk tests. The results indicate a significant positive correlation ($r = 0.313$, $p = 0.001$) between mathematical performance and academic success, with students achieving higher mathematics scores more likely to graduate on time. These findings suggest that while mathematical ability is a critical factor in academic success, other elements such as motivation, teaching methods, and external support should also be considered in improving student outcomes.

KEYWORDS: mathematics, civil engineering, academic success, higher education, correlation

I. INTRODUCTION

Mathematics is known as the queen of science or in Latin it is Regina Scientarium. Mathematics is part of basic science or the basis of knowledge that brings humans to the technology that exists today. Various fields of science and technology have developed due to the influence of developments in mathematics.

Mathematics is actually a thinking process, not a counting process. Learning mathematics is learning to think logically and systematically. With mathematics, people are also made accustomed to solving problems by looking at the available facts and solving the problem with a systematic solution. Mathematics has a very important role in life. With mathematical abilities, a person can develop careful, wise, creative and innovative ways of thinking, reasoning, guessing and decision making.

Engineering can be defined as "the application of mathematics and science to the construction and design of projects for public use"(Kirschenman, 2010). In Civil Engineering, mathematics has a very important role and is the basis for engineering, surveying and planning various concrete mix designs.

In the Civil Engineering study program at Mercu Buana University, mathematics is part of basic science where students are required to get a passing grade for this subject. In the Civil Engineering study program at Mercu Buana University, various assessments of learning outcomes, both from assignment scores, quizzes and final exams, are ultimately expressed with the letters (value) A (4), B+ (3,5), B (3), C+ (2,5), C (2), D (1) and E (0).

Mathematics has long been known to be a problem for engineering students and their lecturers (Scanlan, 1985). While some researchers confirm that how students behave or evaluate mathematics plays an important role in their academic performance, concerns regarding the low mathematics test scores of engineering students have emerged (Alibraheim, 2021). The paradigm that is developing in society regarding the relationship between mathematics scores and students' ability to study in the Civil Engineering Study Program is that if students have high abilities in the Mathematics study field, it is certain that the student will be able to study in the Civil Engineering Study Program.

Furthermore, student engagement in mathematics has been identified as a critical factor influencing academic achievement and long-term participation in STEM courses and careers (Fung et al., 2018). Studies have also delved into the impact of math attitudes and self-efficacy on students' pursuit of STEM careers, suggesting that fostering positive attitudes towards math could encourage more students, including females and non-native English speakers, to enter STEM fields (Dang & Nylund-Gibson, 2017).

This research aims to examine the paradigm in society that to successfully study Civil Engineering, students must have high abilities in mathematics. The indicator of success in studying in the Civil Engineering study program in this

research is that students graduate on time with a minimum GPA of 3.00.

The majority of researchers at universities research related to their field, for example lecturers who teach construction management courses, tend to be motivated to carry out research regarding cost efficiency, quality, time, lecturers who teach transportation courses research on optimizing the performance of transportation, both modes and facilities and infrastructure. A few lecturers research teaching, learning effectiveness, the influence of students' abilities in a field on the success of their studies and so on. In fact, the lecturer's task is not only to find new things or solve problems that occur which are related to the field they master, but as educators the lecturer also needs to improve and create an effective teaching system. This can only be done if the various factors are known that can boost student achievement.

Abroad academics and researchers occasionally pay attention to topics regarding teaching as their research, such as one from Mississippi State University's Industrial Engineering Study, Nagahi, in collaboration with Nagahisarchoghaei from the University of North Carolina and Goerger from the US Army Engineer Research and Development Center researching students' thinking skills and proactive attitudes towards the success of his education as an Engineering student (Nagahi et.al,, 2020). In the Philippines, three assistant professors from the Physical Science Study Program studied the correlation between chemistry skills and engineering students' performance in class and lab (Atienza., et.al, 2020). In Malaysia, Rosmida Binti Ab Ghani and Najah Binti Mohd Nawi, lecturers at the Sultan Mizan Zainal Abidin Polytechnic, researched the factors that influence the performance of engineering students (Ghani & Nawi, 2020). Dr. Gunter Bischof and Prof. Andreas Zw¨olfer from Joanneum University of Applied Sciences in 2015 conducted research that was almost the same as this proposal, namely examining the correlation between mathematical ability and the performance of engineering students (Bischof & Rubesa, 2015).

II. RESEARCH METHODS

DATA ANALYSIS TECHNIQUES

To answer the problem formulation that is the focus of this research, the data was tested for Correlation Analysis using SPSS 23. There are two types of correlation coefficients that are commonly used in correlation tests: the first, the Pearson correlation coefficient and the second, the Spearman correlation coefficient. The Pearson correlation coefficient is used to measure the relationship between two variables that are normally distributed, while the Spearman correlation coefficient is used to measure the relationship between two variables that are not normally distributed or have ordinal data.

Therefore, in this research a normality test was first carried out to determine whether the data was normally distributed or not. Normality test was carried out using Shapiro-Wilk and Kolmogorov-Smirnov.

Research Subject

The data used in this research include: data on mathematics 1, mathematics 2, mathematics 3 scores from 60 Civil Engineering students from the class of 2018, and from the class of 2019 as many as 59 people; their GPA at graduation, study period until graduation or dropping out.

All data in this research is secondary data collected from the Mercu Buana University academic information system.

Objective

Based on the Big Indonesian Dictionary (Kamus Besar Bahasa Indonesia/KBBI), science is a combination of several pieces of knowledge that are arranged logically and systematically by taking into account cause and effect. Based on the definition of science above, it can be stated that the contribution of this research to science is that this research will reveal proven facts (where tested facts are of course part of some knowledge obtained using logical and systematic methods) from the paradigm that develops in society regarding the relationship between mathematical abilities and success in pursuing education in the Civil Engineering Study Program, so that strategic policy makers can use the results of this research as a reference.

III.RESULTS AND DISCUSSION

The results of this study provide insight into the academic characteristics of Civil Engineering students in relation to their performance in mathematics courses and on-time graduation. As shown in Table 1, demographic and academic data, such as gender distribution, on-time graduation rates, and average scores in Mathematics 1 to 3, were collected from 119 students. The following table presents these characteristics, highlighting that the majority of students were male and that most completed their studies within the expected 8 semesters. The distribution of mathematics scores reveals that while a small percentage of students struggled, a significant portion excelled, achieving high average scores.

Table 1. Respondent characteristic

		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Woman	36	30.3	30.3	30.3
	Man	83	69.7	69.7	100
Ontime graduation	>8Semester	18	15.1	15.1	15.1
	8Semester	88	73.9	73.9	89.1

		Frequency	Percent	Valid Percent	Cumulative Percent
	<8Semester	13	10.9	10.9	100
Math1-3 Average	2.67	1	0.8	0.8	0.8
	3.00	1	0.8	0.8	1.7
	3.17	6	5	5	6.7
	3.33	14	11.8	11.8	18.5
	3.50	19	16	16	34.5
	3.67	40	33.6	33.6	68.1
	3.83	24	20.2	20.2	88.2
	4.00	14	11.8	11.8	100

Source: data

As in most Engineering majors, in this study men dominated as much as 69.7%, the majority of students (73.9%) managed to complete their studies on time for 8 semesters, only 10.9% could finish in less than 8 semesters, and only 15.1% who completed more than 9 semesters of college.

Seen in the table 1, the average mathematics score of Mathematics 1 to Mathematics 3 varies from 2.67 to 4.00, the majority of students (33.6%) achieved an average score 3.67 of Math 1 to Math 3, only 0.8% of students obtained the lowest average score which is 2.67 and there were 11.8% of students who achieved a perfect score of 4.00.

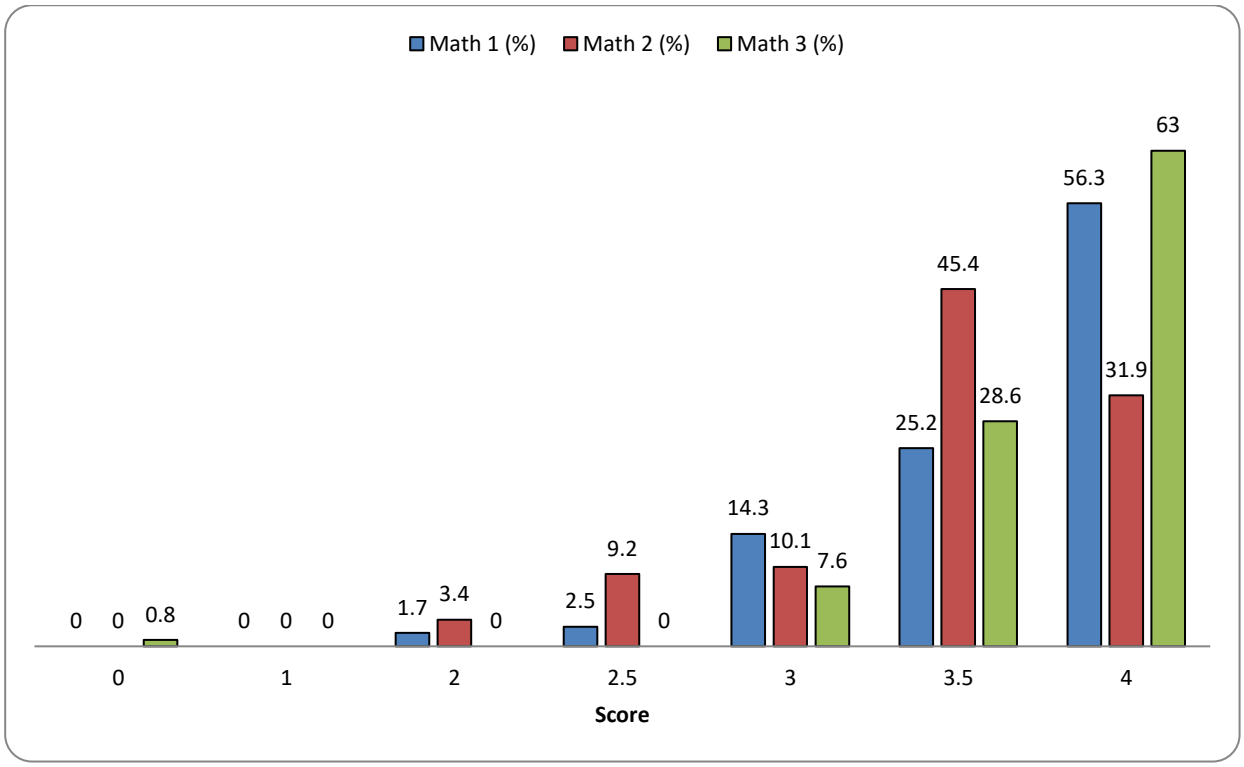

Figure 1. Average mathematics score distribution

The average Mathematics score, from Mathematics 1 to Mathematics 3, was 3.63. It was recorded that there were 34% of students whose average score in mathematics 1 to mathematics 3 was less than 3.63, and there were 66% of students whose average score was 3.63. the average is above or equal to 3.63.

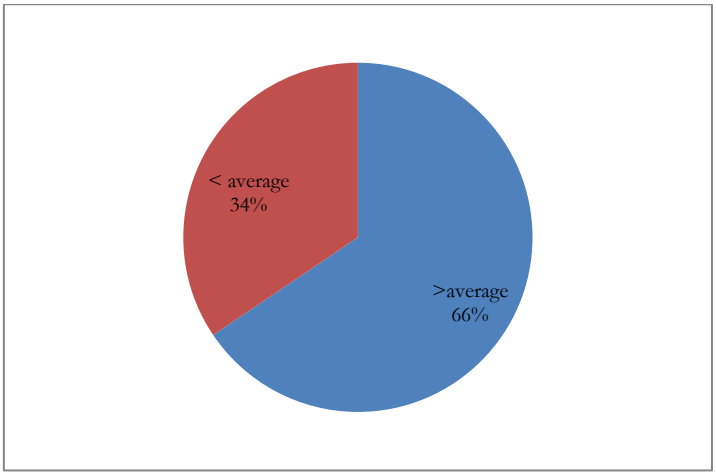

Figure 2. Prosentation distribution of below and above average Math score

The table 2 is a crosstab between the time taken (semester) until graduation or dropping out and their average score for Mathematics 1 to Mathematics 3. It can be seen that only 13 students completed less than 8 semesters of study, 88 students completed their studies in exactly 8 semesters, and 18 people need more than 8 semesters to graduate.

Students who succed to completed their studies in less than 8 semesters had better mathematics skills than others, their average mathematics score was 3.82, students who completed their studies in exactly 8 semesters had an average mathematics score of 3.61, meanwhile students who completing more than 8 semesters of study has an average mathematics score of 3.46. In this study, there was 1 student, referred to as respondent number 28, who failed (dropped out) from the Civil Engineering Study Program, his mathematics 1 score was 3 (B), his math 2 score was 4 (A), and his math 3 score was D (1) or failed, so his average score for mathematics 1-3 is 2.33. The mathematics score of respondent no. 28 is the lowest score of all respondents, the second lowest score is respondent no. 88 with mathematics scores of 1 to 3 in sequence, was A, C+, B+ with an average of 3.05, respondent 88 was able to complete the study in exactly 8 semesters.

Table 2. Crosstab Between Time Taken to Graduate and Math Average Score

		Time taken to graduate			Total			
		>8Semester	8Semester	<8Semester		>8Semester	8Semester	<8Semester
Math1-Math3 Average Score	2.67	1	1	0	2	2.67	2.67	0
	3	0	3	0	3	0	9	0
	3.17	5	8	0	13	15.85	25.36	0
	3.33	2	5	1	8	6.66	16.65	3.33
	3.5	1	13	1	15	3.5	45.5	3.5
	3.67	6	33	1	40	22.02	121.11	3.67
	3.83	2	17	5	24	7.66	65.11	19.15
	4	1	8	5	14	4	32	20
Total		18	88	13	119	62.36	317.4	49.65
Math score average						3.46	3.63	3.82

Source: output SPSS

Table 2 shows further characteristics of the students who were late in completing their study. Students who needed more than 8 semesters to complete their study had an average score of 3.46, with the highest frequency was 6 people who had a mean of 3.67 and in second highest place was mean score of 3.17 was 5 people, while only 1 person managed to get a perfect mean score (4).

Moving on to the normality test of the data. It was revealed that the data was not normally distributed, this was seen from the histogram, Normal Q-Q Plot, Detrended Q-Q Plot,

Boxplot and Kolmogorov-Smirnov and Shapiro-Wilk significance figures.

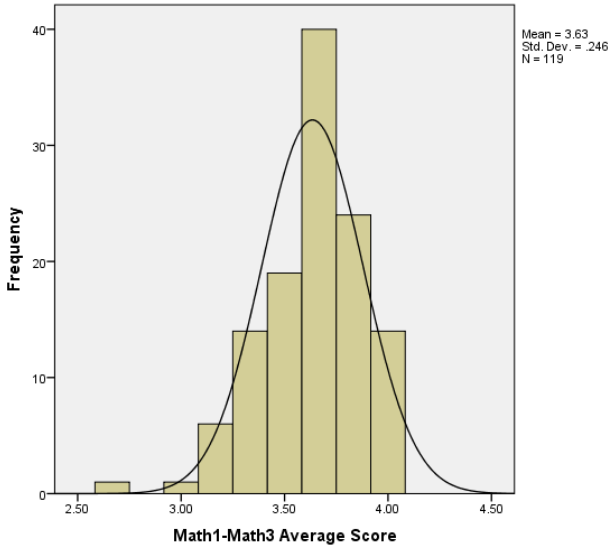

Figure 3. Histogram of Mathematics Average Score

The average value for mathematics 1 to mathematics 3 is 3.63, the histogram shows the average mathematics value has a "skewed to the left of the normal distribution" because the value has negative skewness, which the score was -0.773 and the shape is sharp because the kurtosis value is positive, which the score was 1.165 as shown in the table 3.

Table 3. Descriptive statistic

		Statistic	Std. Error
Mean		3.6345	0.02253
95% Confidence Interval for Mean	Lower Bound	3.5898	
	Upper Bound	3.6791	
5% Trimmed Mean		3.6464	
Median		3.6667	
Variance		0.06	
Std. Deviation		0.24575	
Minimum		2.67	
Maximum		4	
Range		1.33	
Interquartile Range		0.33	
Skewness		-0.773	0.222
Kurtosis		1.165	0.44

Source: SPSS Output

As show in the Normal Q-Q Plot graph (Figure 3) for the average mathematics score variable on study success in the Civil Engineering Study Program, the straight line from left to top right is the z score (z score), it can be seen that the majority of the data is spread around the line, but there are outliers. Next, from the Detrended Normal Q-Q graph, to detect patterns of points that are not part of the normal curve. It can be seen that the data of average mathematics scores on success in studying in the Civil Engineering Study Program is mostly patterned around the line, but there is data that is far in the lower left corner.

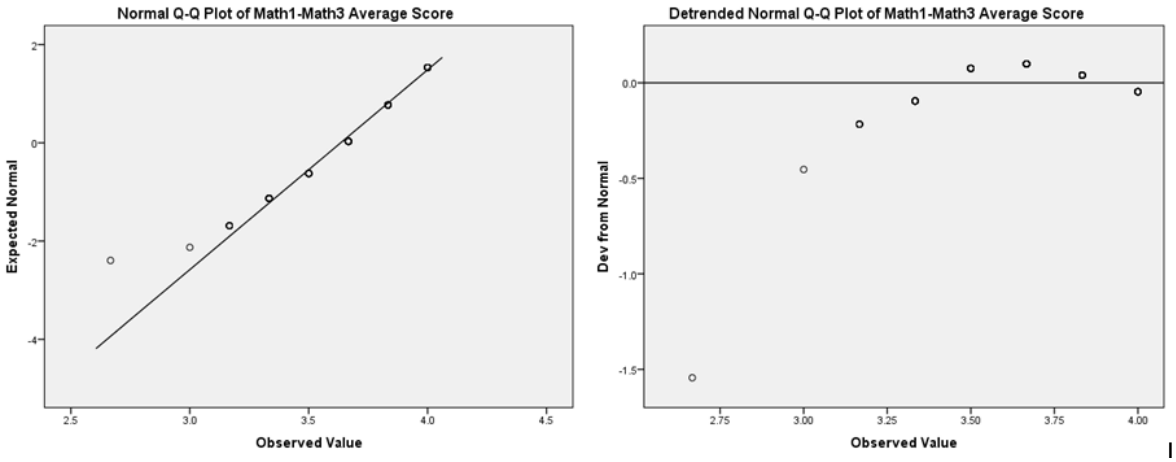

Figure 4. Q-Q plot graph

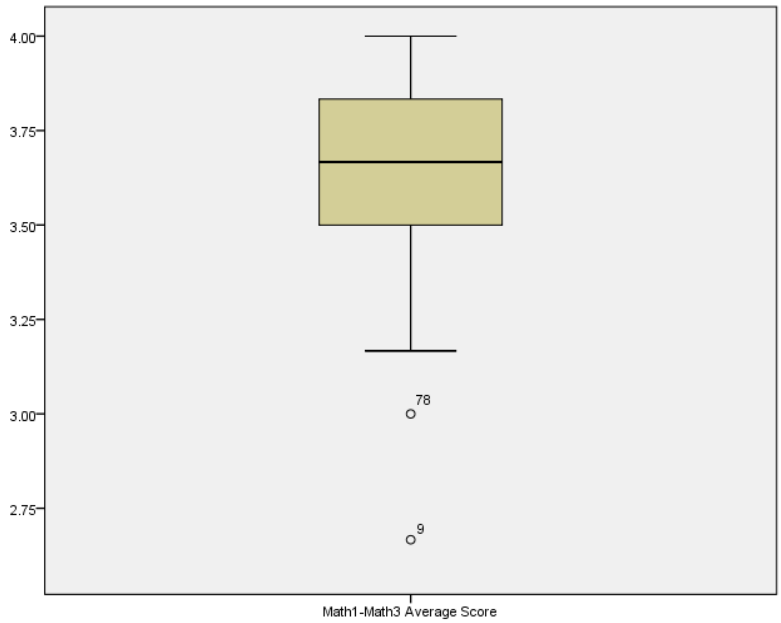

Figure 5. Boxplot

From the boxplot on figure 5, the median value is in the middle of the box, the whisker values are evenly distributed up and down, but there are extreme values or outliers, so the data included in the abnormally distributed category. For further ensure the data distribution, then look at the Kolmogorov-Smirnov and Shapiro-Wilk significance values in the table 4.

Sig value. which can be seen in the Kolmogorov-Smirnov column is 0.000 < 0.05, so the data is not normally distributed, likewise in the Shapiro-Wilk column, the Sig value. is 0,000. Because the data is not normally distributed, the correlation test used Spearman correlation method.

Table 4. Normality test output

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Math1-Math3 Average Score	.208	119	.000	.921	119	.000

a. Lilliefors Significance Correction

Source: SPSS Output

Table 5 shows the results of the Spearman correlation test. From the output, a correlation coefficient figure of 0.313** is obtained, meaning that the level of strength of the relationship (correlation) between the average mathematics score and on time graduation, which is a parameter of success in studying in the Civil Engineering Study Program in this study, is 0.313, included in the moderate correlation category. An asterisk (**) means that the correlation is significant at a significance

score of 0.01. The correlation coefficient score is positive, 0.313, so the relationship between the two variables is unidirectional, thus it can be interpreted that the higher someone's mathematical ability, the chance of success in studying in the Civil Engineering Study Program will increase. From the output, the significance value or Sig. (2-tailed) is 0.001 < 0.05, meaning there is a significant relationship between the two variables.

Table 5. Correlation test output

			Average	On Time Graduate
Spearman's rho	Average	Correlation Coefficient	1.000	.313**
		Sig. (2-tailed)	.	.001
		N	119	119
	On Time Graduate	Correlation Coefficient	.313**	1.000
		Sig. (2-tailed)	.001	.
		N	119	119

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS Output

The sufficient level of closeness resulting from this research is slightly in contrast to Inkelas (2021) where the academic outcomes of engineering students have been closely associated with the calculus courses they enroll in, with research exploring the link between course selection and prior mathematics achievement. The results revealed in this research are actually in line with Wilkins et al. (2021) which conclusions of his study helps to dispel the myth that beginning with higher-level mathematics courses is the optimal course-taking strategy when pursuing an engineering degree, because their findings revealed that overall, students who take Calculus I or a more advanced mathematics course as their first mathematic course and who are more successful in their first mathematics course are more likely to graduate with a degree in engineering. However, considering grade and course together, some groups of students who are more successful in lower-level mathematics courses are as likely to graduate as students who are less successful in upper-level mathematics courses.

The role of mathematics in equipping civil engineering students with the necessary skills to solve engineering problems has been emphasized, emphasizing the fundamental nature of mathematics in civil engineering education (Kwan, 2017), but most students have difficulty facing mathematics courses, as stated by (Harris, Black, Martinez, Pepin, & Williams, 2015) mathematics in engineering remains a central problem, and argue that mathematics should be a fundamental concern in the design and practice of first year engineering. Many of the students consider mathematics and the math professors' teaching style to be an academic problem, especially during their freshman year (Eng, Li, & Julaihi, 2010; Goold, 2012; Harris et al., 2015; Prakash, Jerlin & Fernandes, 2014; Prakash, Kannan, & Jerlin, 2014).

Prakash et al. (2014) investigated the reasons for the failure of engineering students in mathematics. The researchers studied engineering students enrolled in 570 engineering colleges in India. They found that one of the important causes for the failure of engineering students in mathematics is the fact that they considered mathematics a difficult subject since childhood. Relate to Alibraheim, E. A. (2021) revealed the factors that affect freshman engineering students' attitudes toward mathematics using a qualitative research design. Interviews with 26 participants enrolled at Imam Abdulrahman Bin Faisal University (IAU) in Saudi Arabia provided insight into the students' experiences through survey questions. The results of the interview indicate that the freshman engineering students' attitudes are most affected by their fathers and their teachers. The causes that form students' attitudes toward mathematics can be divided into two parts: internal and external. The internal causes result from the students themselves, which include practice and preparation, assessments and grades, effect of English proficiency, and time management. The external causes include teachers' characteristics and parental support. Studies have also delved into the impact of math attitudes and self-efficacy on students' pursuit of STEM careers, suggesting that fostering positive attitudes towards math could encourage more students, including females and non-native English speakers, to enter STEM fields (Dang & Nylund-Gibson, 2017).

Ghani and Nawi (2020) identify factors that influence student's performance in the Engineering Science Course, the result shows that environment was the main driving force being the highest score compared to existing knowledge factors, interests, attitudes, lecturers and peers, also found that there was a significant relationship between attitude and gender differences. Found that the relationship between lecturers and interests was average and significant. While peers, environment and interest were strongly related, and significant.

Despite all that, Williams & Goos say in new situations, engineering requires problem solving and modeling, not just 'applying' mathematics (Williams & Goos).

IV. CONCLUSIONS

This study has established a significant, moderate positive correlation between students' mathematical abilities and their success in the Civil Engineering program, as measured by on-time graduation and academic performance (GPA). The

results indicate that students with higher average scores in Mathematics 1 to 3 are more likely to complete their studies on time, underscoring the importance of mathematical proficiency in the academic success of engineering students.

However, while strong mathematical skills contribute to success, other factors such as student motivation, teaching methods, and support systems from families and faculty also play a crucial role. Therefore, improving student outcomes in Civil Engineering education requires a holistic approach, including enhancing mathematics education, fostering student engagement, and providing support beyond the classroom.

Future research could further explore the influence of non-cognitive factors such as attitudes toward mathematics, self-efficacy, and external support, which may also contribute to academic success. Additionally, implementing targeted interventions to improve mathematical skills in the early stages of study may help increase the graduation rate and academic performance of students in engineering programs.

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