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INVESTIGATING THE ATTITUDES TOWARDS LEARNING CALCULUS AMONG SCIENCE AND TECHNOLOGY STUDENTS: A CASE STUDY IN UITM JOHOR, MALAYSIA

Nor Hidayah Hassim[1*], Siti Hasma Hajar Mat Zin[2], Muhammad Yassar Yusri[3]

[1] Mathematical Sciences Studies, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Johor, Kampus Segamat,85000 Segamat, Johor, Malaysia
Email: hidayah@uitm.edu.my
[2] Mathematical Sciences Studies, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Johor, Kampus Segamat,85000 Segamat, Johor, Malaysia
Email: hasmahajar@uitm.edu.my
[3] Mathematical Sciences Studies, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Johor, Kampus Segamat,85000 Segamat, Johor, Malaysia
Email: muham449@uitm.edu.my
[*] Corresponding Author

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Abstract:

Calculus is widely regarded as one of the difficult branches of Mathematics and is considered an intimidating subject even to Science and Technology students. Majority of the students find themselves struggling. This is due to the fact that a student's attitude has an impact on how effectively they learn Calculus and as a result, affecting their performance in course grades in university level. Therefore, this study was conducted to investigate the students' attitude towards Calculus at UiTM Segamat Branch, Johor. This study also aims to determine the differences in attitudes scores between program courses and gender as well as to examine the relationship between students' attitude and their Calculus achievement. The target population of this study is undergraduate students comprising Diploma in Computer Science (CS110) and Diploma in Mathematical Sciences (CS143) students who have enrolled in Calculus subject. Data was collected using an online questionnaire and a cross-sectional research design was used for this study. Descriptive statistics such as mean and standard deviation, independent t-test and correlation analysis were conducted. The findings of this study revealed that students showed a positive moderate attitude towards Calculus. Meanwhile, there is no significant difference in attitudes scores across program courses as well as gender. Also, students with a negative attitude tend to have a low level in terms of Calculus achievement. Students' attitudes towards Calculus may change over time because it could be influenced by other elements but the most important element that influences the students are lecturers. In order to

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encourage the development of a positive attitude towards Calculus, lecturers must constantly monitor students' attitudes toward the subject and offer the necessary support.

Keywords:

Calculus, Attitude, Achievement, Education

Introduction

Mathematics is a fundamental subject that has been taught since the early stages of school. It serves as a foundation of knowledge especially in learning science and technology, particularly at the tertiary level, where Mathematics education helps students comprehend and develop analytical skills (Shamsuddin et al., 2015). A common branch of Mathematics is Calculus. Integral Calculus for instance is used in computer graphics to compute surface properties like curvature and normal vectors, which are essential for rendering and animation tasks (Noeiaghdam, Rahmani & Allahviranloo, 2021).

According to Gerhardt et al. (2006), Calculus themes provide a solid basis for computational abilities, which are crucial in many upper-level computer courses. Additionally, the principles taught in Calculus create the quantitative thinking abilities needed for such an algorithmic and logic-based field, giving computer majors the training they need. Hence, the Calculus subject introduced at the university level and the syllabus is prepared based on the requirement of the market demands.

In Universiti Teknologi MARA (UiTM), there are two compulsory Mathematics subjects which are Pre-Calculus and Calculus I, taught to CS110 (Diploma in Computer Science) and CS143 (Diploma in Mathematical Sciences) students. Many students, especially those majoring in Computer Science, struggled with these two subjects, due to a lack of broad problem-solving abilities. These students struggle to comprehend the nature of the issue at hand or the specifications for an effective solution (Beaubouef, 2002). There are numerous studies related to the factors that cause poor performance in Calculus. According to Ayub et al. (2005), the study suggested that students' poor Calculus performance is correlated with their lack of conceptual understanding and inadequate foundation in the subject. This finding is supported by Dlamini (2017), who found that among the causes of poor performance are the lack of knowledge and skills in algebra, the inability to demonstrate factorization skills and many more.

This problem needs to be treated seriously because when students have a solid foundation of knowledge and understanding of that specific topic, it will help them to foster their achievement. Studies have shown that the attitude of students was related to their academic achievement (Hammoud et al. 2008; Sarwar et al. 2010; Narmadha & Chamundeswari, 2013). In addition, there is a positive association between students' attitudes toward mathematics and mathematics achievement (Bhowmik & Roy, 2016). Students who enjoy Mathematics and engage in math-related activities, think learning Mathematics will be beneficial, and have confidence in their Mathematics skills are more likely to perform better (Hwang & Son, 2021). As a result, it is crucial to address students' weak Calculus skills as well as evaluate their attitudes towards the subject. Therefore, this study is conducted to assess the students' attitudes towards learning Calculus, to determine the differences in attitudes scores between courses and

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gender and to identify the association between students' attitudes towards Calculus and their Calculus achievement.

Literature Review

There are few studies on the opinions about Calculus as a subject. Although much of this research is related to Mathematics in general, it might be worthwhile to look at the study in this area since Calculus is one of the main branches of Mathematics.

Students' Attitude towards Mathematics

According to Sarmah and Puri (2014), attitude is the learned tendency of a person to react favorably or unfavorably to an object, situation, idea, or another person. This aligns with the study from Fisher & Rickard (2008) that describes attitude as a psychological predisposition that can be rated with approval or disapproval by a certain entity. Meanwhile, Wijnen et al. (2023) used three dimensions namely perceptions of behavioral attributes, perceptions of social norms, and perceptions of behavioral control, that together form a person's attitude toward a particular behavior making up attitudes. Based on Brown et al. (2002), three elements that effectively convey the meaning of attitudes are affect, cognition, and behavior.

Depending on the students, their attitude may have a positive or negative impact on how well they succeed in the Mathematics subject. Once a positive attitude is created, it can enhance students' learning (Akinsola & Olowojaiye, 2008; Mutai, 2011). Syyeda (2016) stated that attitudes can change and grow over time. A negative attitude, on the other hand, prevents effective learning and subsequently has an impact on performance (Joseph, 2013). Therefore, attitude is declared an important factor that must be taken into consideration.

Based on previous studies, there are several factors that can influence Mathematics performance, which are attitudes, anxiety, Mathematics background, practice and preparation, assessments, and grades, as well as teachers' characteristics, parental support, and schools (Alibraheim, 2021; Tshabalala & Ncube, 2016; Kupari & Nissinen, 2013). However, students' attitudes are the most significant component in determining whether they perform better or worse in Mathematics (Ngussa & Mbuti, 2017; Kafata & Mbetwa, 2016; Syam & Salim, 2014). According to Awang et al. (2013), students' attitudes in science courses like Mathematics have a direct impact on their ability to access concepts, solve problems, and reach the proper conclusions. The poor performance among students in certain subjects was due to their attitude and preconceived ideas towards the subject. Either a positive or negative feeling might be used to characterize a student's attitude. Those with a positive attitude towards Mathematics see it as a subject with rules and formulas to memorize, but those with a negative attitude always believe they are helpless and incapable of learning the topic (Zan & Martin, 2007).

Numerous studies have already addressed attitudes towards Mathematics, which may provide information about their perception of the subject. In many of these studies, it was found that the students' attitudes were causally influenced by their Mathematical achievement levels (Mazana et al., 2019; 2013; Tang et al., 2013; Huang et al., 2011). For instance, a research conducted by Kafata and Mbetwa (2016) found that most Zambian students believed that their poor performance in Mathematics was caused by their negative attitude towards the subject. Additionally, Syam and Salim (2014) stated that students who are not majoring in Mathematics have a bad attitude towards the subject, which affects how well they do in Mathematics courses. However, a study by Alibraheim (2021) claimed that first-year engineering students have

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positive attitudes towards Mathematics, and these attitudes are more strongly influenced by their parents and teachers. Based on Awang et al. (2013), two criteria, namely the normality of Mathematics and the enjoyment of Mathematics, were found to have an impact on students' attitudes towards Mathematics. According to the findings, attitudes towards Calculus and quantitative studies may generally be expected to change throughout the semester. In terms of the students' attitudes towards Calculus across course codes, there was little difference in the attitudes of the students towards the Calculus course and the Calculus field. Students in Pre-Calculus and Calculus I appeared to view, think, and act in a consistent manner towards the Calculus Course and the Calculus Field (Tang et al., 2013).

Students' attitudes between gender

Numerous studies have shown that, in comparison to males, females lack confidence when performing Mathematical calculations and perceive Mathematics as a male-dominated field (Meelissen & Luyten, 2008). This is supported by the study of Patterson et al. (2003) that male students are more enthusiastic about Mathematics than female students. Arias et al. (2023) discovered that competitive assessments such as Mathematics have a negative impact on female students, particularly high-performing students in the university entrance exam.

Mathematics has historically been seen as a field dominated by men, which may be seen in career choices and occupations (Leaper, Farkas, & Brown, 2012). This gender-math prejudices are regarded to pose a threat to female's mathematical achievement (Xie, Yang & Xiao ,2023). Based on students' perceptions, they also believe that male students are more likely to succeed than female students (Effandi & Normah ,2009). In addition, females were found to have a negative relationship with Mathematics confidence (Pierce, Stacey and Barkatsas,2007).

On the other hand, there are several results that suggest there is no significant difference between attitude towards Mathematics and gender (Kibrislioglu , 2015; Mohd et al, 2011; Köğce et al, 2009; Nicolaidou & Philippou, 2003).

Students' attitudes and academic performance

Academic performance refers to results that demonstrate how far a student has progressed toward specified goals (Diaz, 2023). According to Hashmi et al. (2023), academic performance acts as a basis for knowledge acquisition and skill development.

A relationship between students' attitudes and academic performance has been observed in the study of Akkuzu and Akcay (2011). They proposed that students' favourable tendency to teaching methods may contribute to an improvement in their academic performance. This aligns with the study from Eastman, Iyer, and Eastman (2011) that showed students will complete the task successfully when they have a positive attitude towards something. Therefore, students need to be shown from an early age that Mathematics can be entertaining and fascinating in order to establish a positive attitude towards learning in general and Mathematics in particular (Abuja,2006).

There are several studies that suggest a positive correlation between students' attitude towards Mathematics and its achievement (Papanastasiou, 2000; Shashaani, 1995; Gallagher & De Lisi, 1994). As a result, the probability of students taking more advanced Mathematics subjects such as Calculus in future is increased (Ajzen, 2001). Contradictorily, Hagan et al. (2020) found that students have a negative perception towards Mathematics based on low interest in the study of

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Mathematics results. This is quite overwhelming since students will further develop their understanding of Mathematics using real-life situations (Tong et al., 2022).

Methodology

This is a quantitative study which explores students' attitude towards Calculus at Universiti Teknologi MARA (UiTM) Segamat Branch, Johor. Population under consideration is for CS110 and CS143 students who have enrolled in Calculus subject. Since Roscoe (1975) and Sekaran (2016) established the general guideline that respondents in a survey should be greater than 30 and fewer than 500, thus a minimum sample size of 106 respondents was appropriate for this study. An online questionnaire was used for data collection. The instrument used in this study was adapted from Tapia and Marsh II (2004). The instrument consists of Section A which focuses more on the demographic profiles of respondents such as gender, program courses and CGPA score. Meanwhile, Section B consists of 40 items with a five-item Likert scale ranging from strongly disagree to strongly agree. The instrument was pilot tested on 47 students who were not involved in the actual study. According to Conroy (2016), the sample size must be at least 30 respondents because the scale items have a high degree of association with one another. This is also supported by Hair et al. (2016) that provide the value of reliability analysis with interpretation based on strength using Rule of thumb. Since the Cronbach's alpha for this study is 0.878 which is considered to be very good, the instruments are valid and reliable for further analysis.

Descriptive statistics were used to identify the demographic profiles of the respondents and to assess the students' attitudes towards Calculus. Independent t-test was also applied in order to determine the differences in attitudes scores between courses and gender. Lastly, correlation analysis was conducted to identify whether there is an association between students' attitudes towards Calculus and their Calculus achievement.

Findings

Demographic Profiles

Table 1 represents the demographic profiles of the students according to their gender. The number of students who participated in this study is 106 respondents. The results show that the majority of the respondents (63.2%) are female, while 36.8% are male.

Table 1: Demographic Profiles According to Gender

Gender	N	%
Male	39	36.8
Female	67	63.2
Total	106	100

Table 2 represents the demographic profiles of the students according to their program courses. 69.8% of the respondents were enrolled in Diploma in Computer Sciences course and another 30.2% came from Diploma in Mathematical Sciences.

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Table 2: Demographic Profiles According to Program Courses

Program	N	%
CS110	74	69.8
CS143	32	30.2
Total	106	100

Students' Attitudes Towards Calculus

Table 3 represents the level of students' attitudes towards Calculus. Based on Table 3, items B1, B2, B3, B4, B6, B7, B27, B31 and B39 show a high level; however, items B14, B22 and B25 show a low level and while, the rest of the items were at a moderate level. Overall, the level of students' attitudes towards Calculus subject was moderate.

Table 3: Level of Students' Attitudes Towards Calculus

No	Items	Mean	SD	Interpretation
B1	Calculus is a very worthwhile and necessary subject.	4.04	0.861	High
B2	I want to develop my mathematical skills in Calculus.	4.39	0.811	High
B3	I get a great deal of satisfaction out of solving a mathematics problem in Calculus.	4.22	0.936	High
B4	Calculus helps develop the mind and teaches a person to think.	4.31	0.735	High
B5	Calculus is important in everyday life.	3.38	1.108	Moderate
B6	Calculus is one of the most important subjects for people to study.	3.78	0.956	High
B7	High school mathematics courses would be very helpful no matter what I decide to study.	4.07	0.831	High
B8	I can think of many ways that I use Calculus outside of school.	3.07	1.089	Moderate
B9	Calculus is one of my most dreaded subjects.	3.54	1.148	Moderate
B10	My mind goes blank and I am unable to think clearly when working with Calculus.	3.14	1.215	Moderate
B11	Studying Calculus makes me feel nervous.	3.12	1.322	Moderate
B12	Calculus makes me feel uncomfortable.	2.55	1.180	Moderate
B13	I am always under a terrible strain in a Calculus class.	2.66	1.120	Moderate
B14	When I hear the word Calculus, I have a feeling of dislike.	2.16	1.204	Low
B15	It makes me nervous to even think about having to do a Calculus problem.	2.80	1.268	Moderate
B16	Calculus does not scare me at all.	2.91	1.291	Moderate
B17	I have a lot of self-confidence when it comes to Calculus.	3.11	1.157	Moderate
B18	I am able to solve Calculus problems without too much difficulty.	2.78	1.014	Moderate
B19	I expect to do fairly well in any Calculus class I take.	3.47	0.864	Moderate

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B20	I am always confused in my Calculus class.	3.05	1.018	Moderate
B21	I feel a sense of insecurity when attempting Calculus.	3.30	1.181	Moderate
B22	I learn Calculus easily.	2.37	1.063	Low
B23	I am confident that I could learn advanced Calculus.	3.02	1.078	Moderate
B24	I have usually enjoyed studying Mathematics in school.	3.89	1.045	Moderate
B25	Calculus is dull and boring.	2.19	1.131	Low
B26	I like to solve new problems in Calculus.	3.43	0.966	Moderate
B27	I would prefer to do an assignment in Calculus than to write an essay.	3.80	1.206	High
B28	I would like to avoid using Calculus in college.	2.78	1.187	Moderate
B29	I really like Calculus.	3.50	1.221	Moderate
B30	I am happier in a Calculus class than in any other class.	3.22	1.138	Moderate
B31	Calculus is a very interesting subject.	3.73	0.991	High
B32	I am willing to take more than the required amount of Calculus.	3.15	1.058	Moderate
B33	I plan to take as much Calculus as I can during my education.	3.14	1.082	Moderate
B34	The challenge of Calculus appeals to me.	3.49	0.928	Moderate
B35	I think studying advanced Calculus is useful.	3.63	1.008	Moderate
B36	I believe studying Calculus helps me with problem solving in other areas.	3.58	1.032	Moderate
B37	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in Calculus.	3.41	0.993	Moderate
B38	I am comfortable answering questions in Calculus class.	3.32	1.010	Moderate
B39	A strong Mathematics background could help me in my professional life.	3.84	1.015	High
B40	I believe I am good at solving Mathematics problems.	3.31	1.027	Moderate
	Students' Attitudes	**3.32**	**1.062**	**Moderate**

Students' Attitudes Towards Calculus Based On Program Courses

Table 4 presents the result of the difference in students' attitudes towards learning Calculus based on program courses. The p-value exceeds the significance level ($p = 0.650 > \alpha = 0.05$). Therefore, there was no significant difference between students' attitudes and program courses. The attitudes towards Calculus subject between the students from Diploma in Computer Sciences were the same as the students from Diploma in Mathematical Sciences.

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Table 4: The Difference Between Students' Attitudes and Program Courses

Courses	N	Mean	Standard Deviation	t	P-values
Diploma in Computer Sciences	74	3.3037	0.4560	-0.445	0.650
Diploma in Mathematical Sciences	32	3.3445	0.3374		

Students' Attitudes Towards Calculus Based On Gender

Table 5 presents the result of the difference in the students' attitudes towards learning Calculus based on gender. The p-value exceeds the significance level ($p = 0.402 > \alpha = 0.05$). Therefore, there was no significant difference between attitudes and gender.

Table 5: The Difference Between Students' Attitudes and Gender

Gender	N	Mean	Standard Deviation	t	P-values
Male	39	3.3679	0.5553	0.844	0.402
Female	67	3.2858	0.3225		

Students' Attitudes Towards Calculus And Their Calculus Achievement

Based on Table 6, it shows that the relationship between students' attitudes and Calculus achievement among UiTM students is at -0.315, which indicates that there is a weak negative correlation between these two variables. This means that students with a negative attitude tend to have lower achievement in Calculus.

Table 6: Correlations Between Students' Attitudes and Their Calculus Achievement

Variables	Students' Attitude	Calculus achievement
Students' Attitude	1	-0.315** p-value (0.001)
Calculus achievement	-0.315 p-value (0.001)	1

** Correlation is significant at the 0.05 level

Discussion

The findings of the study have revealed that students have a moderately positive attitude towards Calculus subject. A study done by Ayub et al. (2005) stated that the higher the mean scores, the more positive the respondents' attitudes would be. The findings of this study are similar to Lawsha and Hussain (2011), which found that the students showed a moderate level of attitude towards learning Mathematics. This means that while students are interested in learning Calculus, there are a number of reasons that may prevent them from consistently excelling in this subject. These include the students themselves, the lecturers and the materials and methods they use to teach, as well as the students' problems with their friends and families. This is supported by Huang (2011) who found that students have a moderately positive attitude towards learning Mathematics due to the traditional approach of teaching that caused students to become passive in class. This is especially true since the current generation of students is more familiar with technology and modern learning styles that are simple, interactive, and fun. They simply do not enjoy sitting in class without the use of their smartphone or other gadgets.

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However, the most crucial issue that came into view from this study was indicated by items B14, B22, and B25. Based on these responses, students are more likely to have a feeling of dislike when they hear the word Calculus, they did not think that they can learn Calculus easily and most importantly, they felt Calculus is dull and boring. These findings are consistent with Evans (2000) who observed that students in higher education institutions frequently have negative opinions, beliefs, and attitudes toward Mathematics. The findings from Dietiker et al. (2023) also proved that when asked to characterize their normal experience in Mathematics class, most students said it was uninteresting. Since Calculus requires students to memorize formulas or equations through a lot of exercises, this causes some students to develop phobias about the subject. Because they are required to study and master difficult Mathematical procedures, students may begin to dislike Mathematics as they fail to understand its significance and practical applications (Kei & Intan Raihana, 2020).

On the other hand, items B1, B2, B3, B4, B6, B7, B27, B31 and B39 have a similar mean score that indicates students' positive attitudes towards Calculus. They believe that Calculus is a very worthwhile, necessary, and interesting subject, thus it is one of the most important subjects in their field of study. Since many educators have been encouraged to use online learning platforms to teach because of the global prevalence of COVID-19, the use of software and technology helps students to grasp Mathematical concepts (Cui et al., 2011; Tay & Mensah-Wonkyi, 2018). This makes learning more fun and exciting for some students. Besides that, students also agreed that they want to develop their Mathematical skills and felt great satisfaction when solving the problem. They were also willing to do assignments in Calculus than to write essays. This indicates that enjoyment of the learning experience is one of the key components of student engagement as numerous research has shown that attitudes and self-efficacy beliefs among students are positively correlated with how much students enjoy doing a task (Ahmed et al., 2010; Sakiz et al., 2012).

It seems that students were aware Calculus helps to develop the mind and teaches a person to think. These findings concur with Khilji and Xenofontos (2023) who discovered that students ranked school subjects according to their importance, with an unexpected majority placing Mathematics at the top. The students also noticed that any Mathematics courses would be helpful, and a strong Mathematics background could help them in the near future. This may be because students are aware that Mathematics is used in many non-STEM areas, including social sciences, economics, logistics, and risk analysis (Gravemeijer et al., 2017). This is how Mathematics is regarded as providing transferrable abilities that are found throughout educational institutions, governments, and businesses around the world (Cresswell & Speelman, 2020).

This study also showed that there were no statistical differences between students' attitudes towards Calculus according to gender which agrees with other studies (Casey et al, 2001; Ho, et al., 2000; Tapia & Molavan, 2007). This finding illustrated that male and female students did not differ in their opinions towards Calculus and that both males and females have moderately positive attitudes. This result contradicts the study by Dan'inna (2016) which found that male students are more enthusiastic about learning Mathematics than female students. In addition, there is no significant difference between program courses in terms of their attitude towards Calculus. This result also differs from another study by Karjanto (2017) which found a significant difference between students who specialize in International Relations Economics and Mathematical Physics courses. One of the important factors in these differences

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is that CS110 and CS143 students in this study share the same background and come from the same fields, therefore there is no difference in their opinions toward Calculus across gender and program courses.

Regarding the relationship between students' attitudes and Calculus achievement, it was found to have a significant weak negative relationship. This indicates that students who have a negative attitude typically perform poorly in Calculus. This finding is in accordance with Cho (2019) that revealed students who disliked Mathematics put in less effort to do well in the subject, lost confidence, and eventually lost sight of the importance of Mathematics. On the contrary, this finding has a different magnitude from Mazana et al. (2019) which showed a weak positive correlation in their study. The responses demonstrated that students like Mathematics because they were motivated, confident, and interested in it.

One of the factors that may contribute to students' attitudes towards their Calculus achievement is their level of interest in learning Calculus. According to Fitzmaurice et al. (2021), a lack of understanding and respect for the importance of calculation subjects can have a negative impact on a student's engagement with the subject. The findings from Hussein & Csíkos (2023) proved that a lack of mathematical proficiency does not imply a lack of intelligence or an inability to understand the subject. Instead, this is a result of the fact that students at school are losing interest in STEM areas, particularly those that heavily integrate Mathematics and Science. As a result, students' academic performance is negatively impacted particularly for those entering fields of study involving Calculus in university level. This finding is consistent with Siregar et al. (2023) that observed a potential crisis in the industrial sector on a global scale because of a shortage of trained workers in STEM areas.

Conclusions And Recommendations

This study has identified the attitudes towards Calculus among Science and Technology students at UiTM Segamat. Based on the findings, it can be concluded that the overall mean scores of attitudes towards Calculus for both CS110 and CS143 students are at a positively moderate level. Lecturers should therefore provide students with the same teaching methods and materials in their classroom. The lecturers may ask students for feedback so that they can learn about this subject with a more positive attitude. For instance, collaborative teaching does increase teaching effectiveness and enhances critical thinking among students. The result of the study also suggested that there is no significant difference in terms of attitudes towards Calculus with both gender and program courses. Despite the fact that male and female students show no different attitudes towards Calculus, lecturers need to fully monitor their performance since they might need different kinds of support depending on individual needs. It would be beneficial to select students from a variety of fields outside of science and technology in order to perceive a different perspective from a non-Mathematics background.

As evidenced by this study, there is a low negative correlation between students' attitude and their Calculus achievement. Lecturers need to do some interventions such as preparing a simple and interesting task to engage their students in Calculus and thus, enable them to enjoy Calculus. Students are more likely to perform well in their subject when they truly enjoy, have self-confidence, and are constantly inspired by their lecturers.

In conclusion, students' attitudes towards Calculus may change over time because it could be influenced by other components such as family, teaching strategies, assessment methods, and

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peers, as well as the university environment. However, the most important roles come from the participating lecturers. Successfully supporting students through their Calculus courses would improve students' performance in this subject. Additionally, students need to change how they feel about Calculus. They must perceive it as a valuable subject and have faith in their ability to embrace Calculus.

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