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THE RELATIONSHIP BETWEEN STUDENTS' MATHEMATICS ATTITUDE AND THEIR MATHEMATICAL THINKING

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Abstract: *This research aims to describe students' mathematical thinking based on their attitude towards mathematics. In addition, this study also aims to investigate the relationship between students' mathematics attitude and their mathematical thinking and to know how much influence mathematics attitude among the students with their mathematical thinking. There are two indicators of students' mathematics attitude which were used in this study, namely Affective Engagement which means emotions or thoughts toward mathematics and Cognitive Engagement which defines as the judgements and beliefs about mathematics. This study employed a descriptive research design and 75 Form Four students from a public school in Segamat, Johor, Malaysia have been chosen as the sample of this study. A Mathematical Thinking Test (MTT) and Mathematics Attitude Questionnaire were used as the instruments in this study to collect the data. Based on the finding of this research, generally, there is a positive correlation between students' mathematics attitude and mathematical thinking skill. However, according to the Pearson Correlation test results, students' attitude towards mathematics has little influence on their mathematical thinking ability.*

Keywords: *Mathematical Thinking, Mathematics Attitude, Mathematics Education, Mathematics Performance*

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Introduction

Mathematics education plays a vital role in schools, aiming to develop students' mathematical thinking skills. This literature review explores the objective of mathematics education in school and the learning activities that can foster students' mathematical thinking skills. By examining relevant studies, including Hui and Mahmud (2023), Ilyas et al. (2022), Calder et al. (2021), and Bakker et al. (2021), we can gain insights into effective instructional practices and strategies to enhance students' mathematical thinking.

The objective of mathematics education in school extends beyond the acquisition of computational skills. It encompasses the development of students' mathematical thinking skills, enabling them to reason, problem-solve, and apply mathematical concepts in real-life situations. Bakker, Cai, and Zenger (2021) highlight the importance of mathematics education research in identifying future themes, with a focus on enhancing students' mathematical thinking and fostering meaningful learning experiences.

Various learning activities have been explored to foster students' mathematical thinking skills. One approach is game-based learning in mathematics education, which is investigated by Hui and Mahmud (2023). Their systematic review examines the influence of game-based learning on students' cognitive and affective domains. The findings indicate that game-based learning has a positive impact on students' mathematical thinking, enhancing their problem-solving abilities, motivation, and engagement.

Another approach is the implementation of the Science, Technology, Engineering, and Mathematics (STEM) approach, as studied by Ilyas et al. (2022). This approach integrates interdisciplinary content, promoting connections between mathematics and other STEM fields. The researchers found that the STEM approach improves students' ability to learn mathematics, as it encourages critical thinking, problem-solving, and the application of mathematical concepts in real-world contexts.

Additionally, Calder, Jafri, and Guo (2021) investigate the experiences of mathematics education students during lockdown and their management of collaboration in e-learning. Although not directly addressing learning activities, their study highlights the importance of collaborative learning in fostering students' mathematical thinking skills. Collaborative activities provide opportunities for students to engage in mathematical discourse, share ideas, and develop their reasoning and communication skills.

The objective of mathematics education in school extends beyond rote learning and computational skills. It aims to foster students' mathematical thinking skills, enabling them to reason, problem-solve, and apply mathematics in real-life contexts. Studies such as Hui and Mahmud (2023), Ilyas et al. (2022), Calder et al. (2021), and Bakker et al. (2021) shed light on effective instructional practices and learning activities that can enhance students' mathematical thinking.

Students' attitudes towards mathematics play a significant role in their learning experiences and academic achievement in the subject. This literature review explores the relationship between students' attitudes towards mathematics and their achievement in mathematics. Relevant studies by Berger, Mackenzie, and Holmes (2020), Capuno et al. (2019), and Mazana, Suero Montero, and Olifage (2019) provide valuable insights into understanding the nature of this relationship and its implications for mathematics education.

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Multiple studies have shown a strong relationship between students' attitudes towards mathematics and their achievement in the subject. Positive attitudes towards mathematics are associated with higher levels of achievement, while negative attitudes are linked to lower levels of achievement. Students with positive attitudes view mathematics as enjoyable, relevant, and

valuable, which fosters their engagement and motivation to learn. This positive disposition towards mathematics contributes to their active participation, persistence, and willingness to invest effort in understanding mathematical concepts, ultimately leading to higher academic achievement.

On the other hand, students with negative attitudes towards mathematics may perceive the subject as difficult, boring, or irrelevant to their lives. These negative perceptions can result in disengagement, lack of motivation, and avoidance of math-related activities. This disengagement and lack of motivation hinder their ability to grasp and apply mathematical concepts, leading to lower achievement levels. Furthermore, studies have also highlighted the reciprocal nature of the relationship between attitudes and achievement. Berger, Mackenzie, and Holmes (2020) conducted a latent profile analysis and found that positive attitudes towards both mathematics and science were mutually beneficial for student achievement. Students who demonstrated positive attitudes towards both subjects tended to achieve higher scores in mathematics assessments. This finding suggests that fostering positive attitudes towards mathematics not only benefits students' motivation and engagement but also positively influences their overall academic performance.

This study has been conducted in which students needed to answer a mathematical thinking test to investigate their ability to understand the mathematical concept by using their mathematical thinking skill, and also a mathematics attitude survey has been disseminated to the respondents to determine the relationship between mathematics attitude among the students and their mathematical thinking skill.

We asked two research questions: (1) what is the relationship between students’ mathematics attitude and MTT score? and (2) how does the mathematics attitude affect their MTT score? With these questions this study contributes two interrelated objectives, understanding the relationship between students’ mathematics attitude and their mathematical thinking skill and how students’ mathematics attitude differs in the ability to comprehend the mathematical thinking skill that can be explored through their score in mathematical thinking test.

Research Objectives

In supporting the above quest, the objectives of this research are:
1. To study the level of mathematics attitude among the students.
2. To investigate the level of mathematical thinking test.
3. To determine the relationship between students’ mathematics attitude and their mathematical thinking skill.

Literature Review

The Importance of Mathematical Thinking

Mathematical thinking is a critical aspect of mathematics education, facilitating problem-solving, reasoning, and conceptual understanding. This literature review explores the definition of mathematical thinking and highlights its significance for students. To provide a

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comprehensive understanding, relevant studies by Xu et al. (2020), Rizki and Priatna (2019), and Genc and Erbas (2019) are examined, shedding light on the nature and importance of mathematical thinking.

Mathematical thinking involves the ability to reason logically, analyse patterns, make connections, and apply mathematical concepts and procedures to solve problems. It encompasses skills such as critical thinking, problem-solving, and mathematical modelling. Xu et al. (2020) focus on teachers' predictions of students' mathematical thinking related to problem posing. Their study highlights the importance of students' ability to generate and pose their own mathematical problems, which requires higher-order thinking skills and deep conceptual understanding. Mathematical thinking holds immense importance for students, both within the domain of mathematics and beyond. It equips students with essential skills and competencies that are valuable in various aspects of life, including academia, careers, and everyday situations.

Firstly, mathematical thinking fosters problem-solving skills. The ability to analyse problems, break them down into manageable parts, and develop effective strategies to solve them is crucial not only in mathematics but also in other disciplines and real-world contexts. Mathematical thinking enables students to approach complex problems with confidence and creativity, seeking viable solutions.

Secondly, mathematical thinking promotes critical thinking and logical reasoning. It encourages students to question assumptions, evaluate evidence, and construct well-reasoned arguments. By engaging in mathematical thinking, students learn to analyse information, identify patterns, and make connections, enhancing their ability to think critically and make informed decisions. Furthermore, mathematical thinking nurtures conceptual understanding. It goes beyond memorization and procedural knowledge, focusing on deep comprehension and the ability to apply mathematical concepts flexibly. Mathematical thinking helps students develop a solid foundation of mathematical knowledge and build connections between different mathematical ideas, leading to a more profound and enduring understanding of the subject.

Additionally, mathematical thinking cultivates mathematical literacy, as explored by Rizki and Priatna (2019). Mathematical literacy refers to the ability to use and apply mathematical knowledge effectively in real-life situations. It empowers students to interpret and critically analyse quantitative information, make informed decisions, and solve everyday problems that involve mathematical reasoning. Mathematical literacy is recognized as a crucial 21st-century skill, enabling individuals to navigate an increasingly data-driven and technologically advanced world.

Mathematical thinking plays a fundamental role in mathematics education and holds significant importance for students. It encompasses problem-solving skills, critical thinking, logical reasoning, conceptual understanding, and mathematical literacy. Studies conducted by Xu et al. (2020), Rizki and Priatna (2019), and Genc and Erbas (2019) provide valuable insights into the nature and significance of mathematical thinking. By fostering mathematical thinking, educators can equip students with essential skills and competencies that extend beyond the realm of mathematics, preparing them for success in academic, professional, and everyday life contexts. Understanding the nature of mathematical thinking and its importance allows educators to design effective instructional strategies that nurture students' mathematical thinking abilities.

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The Four Elements of Mathematical Thinking

Mathematical thinking is a crucial aspect of mathematics education that encompasses various cognitive processes. This literature review focuses on the four elements of mathematical thinking: generalizing, convincing, conjecturing, and specializing. Generalizing is an essential element of mathematical thinking that involves identifying patterns, structures, and relationships within mathematical concepts. Drijvers et al. (2019) emphasize that generalizing allows students to move beyond specific instances and recognize broader mathematical principles. It involves identifying commonalities and extending mathematical ideas to a wider context. Students engage in generalizing when they observe recurring patterns, make connections, and develop rules or formulas that apply to a range of situations. Generalizing enables students to develop a deeper understanding of mathematical concepts and enhance their problem-solving abilities.

Convincing is another critical element of mathematical thinking that involves providing valid reasoning and evidence to support mathematical claims or arguments. It requires students to justify their solutions, explain their thought processes, and provide logical and coherent explanations. Shari, Leatham, and Van Zoest (2022) emphasize that convincing promotes mathematical communication and critical thinking skills. Students engage in convincing when they construct convincing arguments, use mathematical evidence, and employ logical reasoning to justify their mathematical claims. This element of mathematical thinking develops students' ability to critically evaluate mathematical ideas and effectively communicate their reasoning to others.

Conjecturing is the process of making informed guesses or hypotheses based on observations and patterns. It involves formulating predictions or conjectures about mathematical relationships, properties, or outcomes. Jawad et al. (2021) highlight that conjecturing encourages students to explore and investigate mathematical concepts. Students engage in conjecturing when they make initial guesses, test their hypotheses, and refine their understanding based on evidence and logical reasoning. Conjecturing fosters curiosity, creativity, and an exploratory mindset, allowing students to develop and refine their mathematical thinking as they explore different possibilities.

Specializing is the process of applying mathematical concepts and principles to specific cases or situations. It involves adapting and narrowing down general mathematical ideas to contexts or problems. Drijvers et al. (2019) emphasize that specializing helps students understand the limitations and variations of mathematical concepts. Students engage in specializing when they apply general rules, strategies, or formulas to specific scenarios, making appropriate adjustments based on contextual factors. Specializing allows students to connect abstract mathematical concepts to real-world contexts, promoting meaningful and applicable learning experiences.

Mathematical thinking encompasses various elements that contribute to students' deep understanding and proficiency in mathematics. The four elements discussed in this literature review—generalizing, convincing, conjecturing, and specializing—play crucial roles in fostering mathematical thinking. Generalizing helps students identify patterns and relationships, convincing develops their reasoning and communication skills, conjecturing fosters exploration and hypothesis generation, and specializing facilitates the application of mathematical concepts to specific contexts. By understanding these elements and their

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significance, educators can design instructional strategies that nurture students' mathematical thinking abilities and promote a deeper understanding of mathematical concepts.

Students' Attitudes Towards Mathematics and Differences between Positive and Negative Math Attitudes

Students' attitudes towards mathematics play a crucial role in their engagement, motivation, and achievement in the subject. This literature review explores the concept of students' attitudes towards mathematics and highlights the differences between students with positive and negative math attitudes. Students' attitudes towards mathematics refer to their thoughts, beliefs, and emotional responses towards the subject. It encompasses their overall feelings, perceptions, and self-perceptions related to mathematics. Positive math attitudes involve a favourable disposition towards mathematics, including enjoyment, confidence, and interest in learning and engaging with mathematical concepts. On the other hand, negative math attitudes encompass negative emotions, anxiety, and a lack of confidence or interest in mathematics.

There are many differences between students who have positive math attitudes and those who have negative math attitudes. One notable difference is in terms of engagement and motivation. Students with positive math attitudes approach math tasks with enthusiasm and actively participate in class. They view math as an interesting and relevant subject, seeking opportunities to explore and understand mathematical concepts. Their motivation drives them to actively engage with math problems and persevere through challenges. In contrast, students with negative math attitudes often lack motivation and may experience math anxiety. They may perceive math as difficult or irrelevant to their lives, leading to disengagement and avoidance behaviours. This lack of motivation and disengagement can hinder their learning and achievement in mathematics.

Students with positive math attitudes tend to exhibit greater persistence and resilience in the face of challenges or setbacks. They approach difficult math problems with a growth mindset, believing that their abilities can be developed through effort and practice. When encountering obstacles, they are more likely to seek help, learn from their mistakes, and persist in finding solutions. On the other hand, students with negative math attitudes may give up easily and become discouraged by mistakes. They may possess a fixed mindset, perceiving their math abilities as unchangeable. This fixed mindset can hinder their willingness to tackle challenging math tasks and their ability to overcome obstacles, impeding their progress in the subject.

Positive math attitudes have been linked to higher levels of achievement and performance in mathematics. Students with positive attitudes tend to have higher math self-efficacy, believing in their own abilities to succeed in math. This self-belief positively influences their academic outcomes. They are more likely to set higher goals, put in effort, and persist in their pursuit of success. As a result, they tend to achieve better results in math assessments. Conversely, negative math attitudes can have a detrimental effect on performance and achievement. Students with negative attitudes may doubt their abilities, experience math anxiety, and underperform due to a lack of confidence or interest in the subject. Their negative perceptions of their own math abilities can limit their academic achievements.

Students' attitudes towards mathematics significantly impact their engagement, motivation, persistence, resilience, and academic achievement in the subject. Positive math attitudes are associated with greater engagement, motivation, persistence, and higher levels of achievement. In contrast, negative math attitudes can lead to disengagement, low motivation, math anxiety, and lower levels of achievement. The studies by Purba and Surya (2020) and Cvencek et al. (2021) contribute to our understanding of students' math attitudes and their influence on mathematics learning experiences.

Capuno et al. (2019) investigated the attitudes, study habits, and academic performance of junior high school students in mathematics. They found that students with positive attitudes towards mathematics tended to exhibit better study habits, such as consistent effort, effective time management, and active engagement in learning. These positive study habits, in turn, contributed to higher academic performance in mathematics. The literature consistently demonstrates a strong relationship between students' attitudes towards mathematics and their achievement in the subject. Positive attitudes towards mathematics, characterized by enjoyment, relevance, and value, are associated with higher levels of engagement, motivation, and persistence, ultimately leading to higher academic achievement. Conversely, negative attitudes hinder students' engagement, motivation, and effort in mathematics, resulting in lower levels of achievement.

Understanding the relationship between attitudes and achievement is crucial for educators and policymakers in mathematics education. Fostering positive attitudes towards mathematics through engaging instructional practices, creating a supportive learning environment, and highlighting the relevance of mathematics can enhance students' motivation, engagement, and ultimately their achievement in the subject. By recognizing the reciprocal relationship between attitudes and achievement, educators can design effective strategies to cultivate positive attitudes, promote academic success, and ensure that all students have the opportunity to excel in mathematics.

Methodology

Research Design

A descriptive research design has been chosen as a method for this study. According to Suphat (2005) quantitative research is the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect. Meanwhile, according to Atmowardoyo (2018), descriptive research is defined as a research method used to describe existing phenomena as accurately as possible with the main objective of descriptive research is to systematically describe the existing phenomena being studied. Since this study is focusing on investigating the relationship between students' mathematics attitude and their mathematical thinking skill, therefore, quantitative descriptive by using a mathematics attitude survey and mathematics test are appropriate to answer the research question.

Sample of Study

Form Four students from a school in Segamat, Johor were selected using a purposive sampling method to achieve the study's objectives. Characteristics of the sample are; (i) the majority of the students are of average abilities, (ii) students are from a semi-urban school, and (iii) there is a mix of male and female students to achieve the objectives of the study. Students with average abilities were selected as this study aims to observe the effect of the interventions on the majority of students in the school and not only for high or low-ability students. During the study, the rubric creativity observation checklist was administered to the observers. A total of 75 survey and test were distributed. And all of them were returned completely. The results were

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analysed quantitatively to assess the students' creativity during the interventions. The Cronbach's Alpha reliability index for overall items (N=10) is 0.890.

Instrumentation

Mathematics Attitude Survey Questionnaire

This study was part of a project to determine the relationship between students' attitude towards mathematics and their mathematical thinking skill. To achieve the objectives of the study, a set of survey questionnaires will be administered to the students at the beginning stage of the research design. The scale for mathematics attitude scale is initially adapted from the previous study, which is, Re-Designing A Measure of Student's Attitudes Toward Science: A Longitudinal Psychometric Approach (H. Tai et al., 2022) and referred and adapted the instruments from previous research which are: 1) Mathematics and Technology Attitudes Scale (MTAS) by Pierce et al., (2005); 2) Attitudes Towards Mathematics Inventory (ATMI) by Abdul Majeed et al., (2015); and 3) Ibrahim (2021). Hence, for mathematics attitude, the researcher selected two elements which are cognitive engagement and affective engagement.

This study used content validation method to ascertain that the content of the instruments measure what they are intended to measure.

Reliability indicates the trustworthiness or dependability of the validity. It is the extent to which it constantly measures what it is meant to measure, or it consistently produces the same results whenever it is repeatedly administered. Similarly, reliability of a scale implies its freedom from error (De Vaus & de Vaus, 2013; Pallant, 2011). The reliability of a measurement signifies stability and consistency with which the instrument measures the concept and aids in assessing the 'goodness' of a measure (Sekaran, 2003; Swerdlik & Cohen, 2005).

To obtain further evidence on reliability, the internal consistency test on reliability through Cronbach's Alpha was adopted as it has been the generally used technique in any pilot study of the survey instrument. This was employed through statistical inter-item of Cronbach's Alpha result (Abdullah et al., 2008).

The reliability of the constructs and subconstructs were examined in the previous study that the researchers selected to employ in this study, which used the approach of internal consistency, utilising Cronbach's alpha to assess how well the items reflect a common underlying construct. Cronbach's alpha is regularly adopted in studies in science education as a measure of reliability (Taber, 2018).

Table 1: Cronbach's Alpha Value for overall questionnaire

Cronbach's Alpha	N of Items
.890	10

Table 1 displays the overall Cronbach's Alpha value and the number of items for the questionnaire under consideration. The overall Cronbach's Alpha value is calculated to be 0.890, and the questionnaire consists of a total of 10 items. The Cronbach's Alpha value of 0.890 indicates a high level of internal consistency and reliability for the entire questionnaire. This value suggests that the 10 items collectively measure a common underlying construct (mathematics attitude in this case) with a high degree of reliability. It implies that the

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questionnaire items are cohesive and effectively capture the intended concept, making it a robust tool for assessing individuals' attitudes towards mathematics. A Cronbach's Alpha value of 0.890 is well above the commonly accepted threshold of 0.7, further affirming the questionnaire's strong internal consistency. This indicates that the items within the questionnaire are highly correlated with each other, which is essential for drawing accurate and dependable conclusions from the collected data.

Mathematical Thinking Test

To test the respondents' mathematical thinking ability, a Mathematical Thinking Test that contains 10 questions with a total score of 43 was in this study. Following an analysis of the contents of the school's curriculum, we chose to adapt the 2012 PISA questions. Assessment items in the PISA are assigned to mathematical reasoning and problem solving in accordance with the PISA 2021 Mathematics Framework. It emphasises formulating and interpreting mathematical problems to address practical difficulties, which encourages students to work on mathematically formulated problems. In order to describe, explain, and forecast events, students must solve issues using mathematical concepts, methods, data, and resources. The components of mathematical reasoning in this study are matched with the PISA 2021 Mathematics Framework. As a result, we will continue to configure the PISA question items.

Reliability Analysis of MTT Score Data

Table 2: Reliability Analysis Based on Rasch Model

Statistics	Results	Interpretation
Cronbach's Alpha (MTT Score)	0.60	Good
Person Reliability	0.55	Sufficient
Item Reliability	0.97	Excellent
Person Separation	1.10	Good
Item Separation	5.96	Excellent

The table presents the results of a reliability analysis based on the Rasch model for the MTT Score (Mathematical Thinking) data. The Rasch model is a widely used measurement model that assesses the reliability and validity of a set of items or test scores. In this analysis, several reliability statistics are calculated to evaluate the consistency and accuracy of the MTT Score measurements.

The first statistic reported is Cronbach's Alpha for the MTT Score, which is calculated as 0.60. Cronbach's Alpha is a measure of internal consistency and indicates how well the items in the MTT Score scale correlate with each other. A Cronbach's Alpha value of 0.60 is considered "Good" and suggests that the items in the MTT Score scale are somewhat consistent in measuring the same underlying construct of mathematical thinking. While a higher Cronbach's Alpha value is desirable for better reliability, a value of 0.60 indicates an acceptable level of consistency among the items.

Next, the Person Reliability is reported as 0.55. Person Reliability in the Rasch model refers to the reliability of the scores for the individuals (participants) in the study. A Person Reliability value of 0.55 is categorized as "Sufficient." This indicates that the MTT Score scale is

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somewhat reliable in distinguishing between individuals with different levels of mathematical thinking. However, it suggests that there is room for improvement in terms of precision and accuracy in measuring individuals' mathematical thinking abilities.

On the other hand, the Item Reliability is reported as 0.97, which is labelled as "Excellent." Item Reliability in the Rasch model refers to the reliability of the items in the scale in measuring the underlying construct. A high Item Reliability value of 0.97 indicates that the items in the MTT Score scale are highly consistent in measuring mathematical thinking. This means that the items are effectively distinguishing between individuals with varying levels of mathematical thinking abilities and contribute significantly to the overall reliability of the scale.

The Person Separation value is reported as 1.10, categorized as "Good." Person Separation is a measure of how well the MTT Score scale distinguishes between different levels of mathematical thinking in individuals. A value of 1.10 suggests that the MTT Score scale has a moderate ability to differentiate between individuals with different levels of mathematical thinking. While a higher Person Separation value would indicate better discriminative power, a value of 1.10 still suggests that the scale is somewhat effective in classifying individuals into distinct groups based on their mathematical thinking abilities.

Lastly, the Item Separation is reported as 5.96, labelled as "Excellent." Item Separation measures how well the MTT Score scale differentiates between the difficulty levels of the items in the scale. A high Item Separation value of 5.96 indicates that the items in the MTT Score scale are highly effective in discriminating between different levels of mathematical thinking difficulty. This suggests that the items are well-designed and cover a wide range of difficulty levels, contributing significantly to the overall reliability of the scale.

In conclusion, the reliability analysis based on the Rasch model provides valuable insights into the consistency and accuracy of the MTT Score measurements. While Cronbach's Alpha and Person Reliability indicate some room for improvement in internal consistency and precision in distinguishing between individuals, the high Item Reliability and Item Separation values reflect the excellent performance of the items in measuring mathematical thinking and differentiating between difficulty levels. Overall, the MTT Score scale demonstrates good to excellent reliability, suggesting that it is a reliable and valid tool for assessing mathematical thinking abilities in individuals.

Mathematics Attitude Survey Questionnaire

The following table shows that the mean value for the items of Cognitive Engagement is below moderate of 3.0. It could be seen from the table that most of the respondents did not have positive confidence in mathematics. The majority of the respondents (40.0%) revealed that they were seldom or almost never believed that they were capable on answering difficult mathematics questions. Meanwhile, 57.3% of the respondents also perceived that they were seldom or almost never having less trouble in learning mathematics compared to other subjects.

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Table 3: Level of Cognitive Engagement

	N	Mean	Std. Deviation
I have a mathematical mind.	75	2.92	.912
I know I can handle difficulties in mathematics.	75	2.72	.879
I can answer difficult mathematics questions.	75	2.47	.859
I have less trouble learning mathematics compared to other subject.	75	2.36	1.022
I learn mathematics easily.	75	2.64	.895
Valid N (listwise)	75		

The Level of Affective Engagement

Table 4 presents the mean and the standard deviation of responses on Affective Engagement. There are five items and the mean score for all of the items was above moderate 3.0 with a range from 3.00 to 4.13. The highest score is the item 'I get sense of satisfaction when I solve mathematics problems.' while the lowest are the items 'I feel good in doing mathematics exercises'.

Table 4: Level of Cognitive Engagement

	N	Mean	Std. Deviation
I am interested to learn new things in mathematics.	75	3.20	1.115
In mathematics, I feel rewarded for my effort.	75	3.39	1.012
Learning mathematics is enjoyable.	75	3.28	1.214
I feel good in doing mathematics exercises.	75	3.00	1.219
I get sense of satisfaction when I solve mathematics problems.	75	4.13	.949
Valid N (listwise)	75		

Level of Mathematical Thinking Test

Table 4: Level of Cognitive Engagement

MTT Score		
N	Valid	75
	Missing	0
Mean		13.1667
Median		12.0000
Std. Deviation		5.01372

To describe how students think mathematically, the researcher analysed the students' answer scripts quantitatively according to the elements of mathematical thinking. Total score of the Mathematical Thinking Test used in this study is 43 marks (100%). However, most of the respondents did not perform well with the Mean Score of the respondents was only 13.17 (SD = 5.01) and the Median was 12.00. The highest score was 25.5 marks, and the lowest score was 2. Detailed distributions of the respondents based on their marks and percentage of the frequency is shown in the following figure. The x-axis shows the mark from the minimum 0 to maximum 25.5, while the y-axis shows the frequency of the scores in percent.

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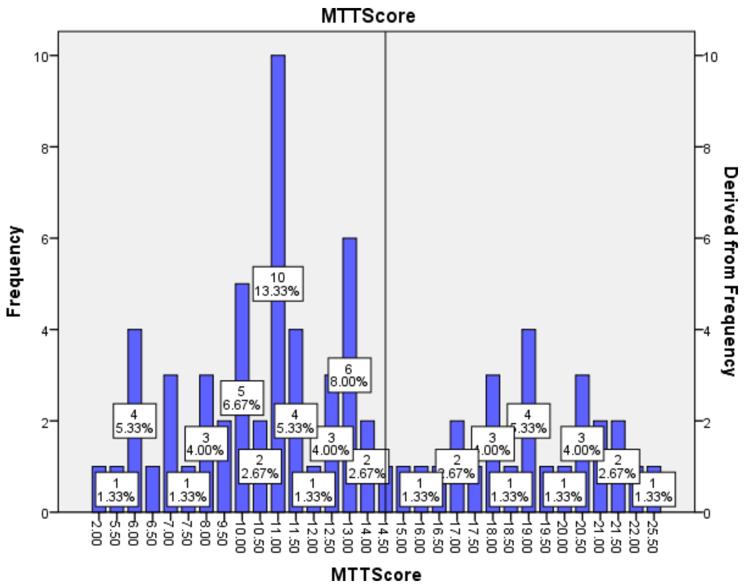

Figure 1: The Distribution of the MTT Score and the Percentage of the Frequency

Referring to the Figure 1, 1.33% of the respondents scored the lowest two marks and 1.33% of the respondents scored the highest 25.5 marks. The students were then categorized into 3 categories of low, average, and high, based on the mean (Mean = 13.17) and standard deviations (SD = 5.01). Students with scores below 1 standard deviation away from the mean will be categorized into the low group. Those between ± 1 standard deviation from the mean will be categorized as average and those who scored higher than 1 standard deviation away will be categorized as high scorers.

Table 6: Students' Performance by Levels

Levels	Explanation	Score Range
Low	Those who scored below (13.17 - 5.01) = 8.16	0 to 8
Average	Those who scored between 5.50 and (13.17 + 5.01) = 18.18	9 to 19.5
High	Those who scored more than (13.17 + 5.01) = 18.18	20 to 25.5

Later, based on the range of categories, the respondents were grouped into three levels namely, 1 = Low (0 to 8), 2 = Average (9 to 19.5) and 3 = High (20 to 25.5). Table 7 shows the respondents' distribution according to the score levels.

Table 7: Percentage of Students' Performance by Levels

Levels	Percent	Cumulative Percent
Low	18.7	18.7
Average	68	86.7
High	13.3	100

Table 7 shows the percentage of the respondents according to the levels. 18.7% of the respondents are at the Low level, 68% at the Average level and only 13.3% of them are at the High level.

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Correlation of Each Attitude Items with MTT Score

Table 8: Correlation Analysis of Mathematical Attitude Items and MTT Score

Mathematical Attitude Item	Pearson Correlation	Sig. (2-tailed)	N
I have a mathematical mind.	1	0	75
I know I can handle difficulties in mathematics.	.646**	0	75
I can answer difficult mathematics questions.	.548**	0	75
I have less trouble learning mathematics compared to other subjects.	.379**	0.001	75
I learn mathematics easily.	.610**	0	75
I am interested to learn new things in mathematics.	.494**	0	75
In mathematics, I feel rewarded for my effort.	.371**	0.001	75
Learning mathematics is enjoyable.	.509**	0	75
I feel good in doing mathematics exercises.	.462**	0	75
I get sense of satisfaction when I solve mathematics problems.	.247*	0.033	75
MTT Score	.299**	0.009	75

The table above presents a comprehensive correlation analysis, examining the relationship between various mathematical attitude items and the MTT Score. These attitude items aim to gauge individuals' beliefs, emotions, and perceptions related to mathematics. Understanding how these attitudes correlate with actual performance on a mathematics test can shed light on the potential impact of attitudes on academic achievement.

The first item, "I have a mathematical mind," shows a perfect positive correlation with a Pearson correlation coefficient of 1. This indicates a strong association between self-perceived mathematical attitude and the MTT Score. However, it is important to note that a correlation of 1 might suggest potential response bias, as it is uncommon for self-perceived abilities to perfectly align with actual performance.

The subsequent attitude items, such as "I know I can handle difficulties in mathematics" ($r = 0.646$, $p < 0.001$) and "I can answer difficult mathematics questions" ($r = 0.548$, $p < 0.001$), also exhibit positive and moderately strong correlations with the MTT Score. These findings suggest that individuals who have higher confidence in tackling challenging math problems tend to perform better on mathematics tests. This correlation aligns with the concept of self-efficacy, where individuals' belief in their capabilities positively influences their actual performance.

Similarly, the attitude item "I learn mathematics easily" demonstrates a significant positive correlation with the MTT Score ($r = 0.610$, $p < 0.001$). Individuals who perceive mathematics as easy to grasp are more likely to exhibit higher mathematical proficiency, possibly due to increased motivation and engagement with the subject. The item "I have less trouble learning mathematics compared to other subjects" also displays a positive correlation with the MTT Score ($r = 0.379$, $p = 0.001$), albeit somewhat weaker compared to the previous items. This suggests that individuals who find mathematics relatively easier in comparison to other subjects tend to perform better on mathematics tests.

Attitudes related to enjoyment and interest in mathematics also show significant positive correlations with the MTT Score. The items "Learning mathematics is enjoyable" ($r = 0.509$, $p < 0.001$) and "I am interested to learn new things in mathematics" ($r = 0.494$, $p < 0.001$) both indicate that individuals who derive pleasure from learning mathematics and have a keen interest in exploring new concepts are more likely to excel in mathematics assessments. Moreover, attitudes connected to emotional rewards are also positively associated with the MTT Score. The item "In mathematics, I feel rewarded for my effort" exhibits a significant positive correlation ($r = 0.371$, $p = 0.001$), indicating that individuals who feel a sense of reward or recognition for their efforts in mathematics tend to perform better in related assessments.

However, one attitude item shows a relatively weaker correlation with the MTT Score. The item "I get a sense of satisfaction when I solve mathematics problems" has a Pearson correlation coefficient of 0.247 ($p = 0.033$). While this correlation is still statistically significant, it suggests that the relationship between a sense of satisfaction in problem-solving and actual mathematical performance might be less pronounced compared to other attitudes measured in the study. Based on the table provided, the item with the highest correlation with the MTT Score is "I learn mathematics easily" ($r = 0.610$, $p < 0.001$). This attitude item demonstrates the strongest positive correlation with the MTT Score among all the items listed in the table. This suggests that individuals who perceive mathematics as easy to learn are more likely to perform better on the mathematics test (MTT Score).

Discussion

According to a thorough investigation of the link between several attitude components and the MTT Score, Attitude has a significant influence in determining Mathematical Thinking (MTT) Scores. The results of the correlation study show that people's attitudes towards mathematics—their beliefs, feelings, and perceptions about it—have a big impact on how well they actually perform mathematical tasks.

First, opinions concerning one's own estimation of one's mathematical prowess show a substantial correlation with the MTT Score. The statement "I have a mathematical mind" had a 100% positive association with the MTT Score, indicating that people who think they naturally excel at math typically perform well on math tests. The overall pattern suggests that one's self-confidence in one's mathematical talents positively improves mathematical performance, notwithstanding the possibility of response bias in the case of a perfect correlation.

It has also been discovered that attitudes that represent self-efficacy beliefs significantly affect the MTT Score. Both the statement "I know I can handle difficulties in mathematics" and the statement "I can answer difficult mathematics questions" showed moderate to high positive relationships with the MTT Score. This suggests that people who are more comfortable solving difficult mathematical problems tend to perform better in maths tests. In the context of mathematical reasoning, the idea of self-efficacy, where people's beliefs in their skills influence their actual performance, remains true.

On top of that, beliefs about how simple it is to learn maths have a big impact on the MTT Score. Among all the attitude factors, the statement "I learn mathematics easily" had the strongest association with the MTT Score, suggesting that those who believe mathematics is simple to learn are more likely to score higher on the mathematics test. This shows that higher mathematical thinking and problem-solving skills are influenced by a good opinion of mathematics as an approachable and understandable topic.

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The MTT Score is also significantly impacted by Attitudes Related to Emotional Engagement. Both the statement "Learning mathematics is enjoyable" and the statement "I am interested to learn new things in mathematics" showed statistically significant positive relationships with the MTT Score. This shows that people who enjoy learning mathematics and have a strong desire to understand new mathematical ideas are more likely to perform well on mathematical tests. The emotional component of mathematics appears to be a key factor in improving mathematical performance and thought.

Additionally, the MTT Score is impacted by attitudes connected to emotional rewards. The response "In mathematics, I feel rewarded for my effort" showed a strong positive association, showing that those who feel appreciated or rewarded for their work tend to perform higher in related tests. This shows that favourable effects on mathematical thinking and performance can result from sentiments of accomplishment and recognition in the setting of mathematics.

The analysis as a whole show how the MTT Score, which measures attitude, is a key indicator of mathematical thinking. Better mathematical thinking and performance are influenced by positive attitudes, such as self-perceived abilities, self-efficacy beliefs, enjoyment, curiosity, and emotional engagement with mathematics. These findings highlight the significance of establishing mathematically positive attitudes, self-confidence, and emotional engagement in order to improve people's mathematical talents and accomplishments.

Table 9: Correlation between Attitude and MTT Score

Variable	Pearson Correlation	Sig. (2-tailed)	N
MTT Score	1.000	.000	75
Attitude Score	.239*	.039	75

The table above presents the results of a correlation analysis conducted to explore the relationship between the MTT Score (Mathematical Thinking) and the Attitude Score towards mathematics. The dataset used in the analysis consists of data from 75 respondents.

The Pearson correlation coefficient (r) between the MTT Score and Attitude Score is reported as 0.239 with a two-tailed significance level of 0.039. The significance level, denoted as "Sig. (2-tailed)," indicates whether the correlation observed is statistically significant or likely due to random chance. The correlation coefficient of 0.239 suggests a positive but relatively weak relationship between the MTT Score and the Attitude Score. A positive correlation indicates that as one variable increases, the other tends to increase as well. However, the value of 0.239 suggests that the relationship is not particularly strong, meaning that the variation in the MTT Score is only moderately associated with variations in the Attitude Score.

The statistical significance of the correlation is determined by the p-value (Sig. 2-tailed), which is reported as 0.039. In this case, the p-value is less than 0.05 (typically chosen as the threshold for significance), indicating that the correlation observed is statistically significant at the 0.05 level. This means that the association between the MTT Score and Attitude Score is unlikely to have occurred by chance, supporting the conclusion that there is a genuine relationship between these two variables. The correlation analysis also includes the sample size (N = 75) for both the MTT Score and the Attitude Score, which represents the number of participants in the study for whom data on both variables were available.

Conclusion and Recommendation

The correlation analysis in this table reveals a statistically significant, albeit relatively weak, positive relationship between the MTT Score and the Attitude Score. While the strength of the correlation is not particularly high, it suggests that there is some connection between individuals' mathematical thinking and their attitudes towards mathematics. The findings highlight the potential importance of attitudes in shaping mathematical thinking abilities and performance. A positive attitude towards mathematics may contribute to better engagement, motivation, and interest in the subject, which, in turn, could positively influence individuals' mathematical thinking skills. However, it is essential to acknowledge that the correlation coefficient of 0.239 indicates that attitudes are just one of the several factors influencing mathematical thinking. It is highly recommended for further researchers to other factors such as prior knowledge, educational experiences, and problem-solving strategies that also play critical roles in fostering students' mathematical thinking.

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