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THE RELATIONSHIP BETWEEN MATHEMATICS ATTITUDE AND CREATIVE THINKING AMONG SECONDARY STUDENTS

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ABSTRACT

Background and Purpose: This study aims to examine the levels of mathematics attitudes and creative thinking among Malaysian secondary school students and to explore the relationship between these two factors. The goal is to provide valuable insights and recommendations to enhance the overall quality of mathematics education in Malaysia.

Methodology: A quantitative research design was adopted, using a survey as the primary method of data collection. Data were collected from 531 secondary school students in Selangor and Kuala Lumpur through a validated instrument that is Mathematics Attitude and Creative Thinking Scale (MACTS). Descriptive and inferential statistical analyses were conducted using SPSS.

Findings: The findings indicate that the overall levels of mathematics attitude ($M = 3.26$, $SD = 0.71$) and creative thinking ($M = 3.28$, $SD = 0.69$) among Malaysian secondary school students were at a middle high level. Additionally, the study revealed a significant positive correlation ($r = 0.70$, $p < 0.001$) between students' attitudes toward mathematics and their creative thinking skills.

Contributions: This study provides significant contributions to both theory and practice in mathematics education. Theoretically, it enriches the existing literature by exploring the relationship between

mathematics attitudes and creative thinking skills within the Malaysian secondary school context. Practically, it provides valuable information for teachers, curriculum developers, and policymakers.

Keywords: Mathematics attitudes, creative thinking, mathematics education, STEM education, secondary school students.

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1.0 INTRODUCTION

Mathematics education is a critical component of the school curriculum, serving as the foundation for logical reasoning, problem-solving, and analytical thinking. Wang et al. (2022) suggest that attitude and subjective norms have effects, directly or indirectly, on intentions, behavioral engagement, and mathematical performance. Positive attitudes toward mathematics are essential for fostering student engagement and academic success. However, many students experience negative emotions such as anxiety or disinterest in mathematics, which can hinder their academic performance and willingness to pursue Science, Technology, Engineering and Mathematics (STEM)-related careers (Hernández de la Hera et al., 2023; Song, 2022).

Mathematics is foundational for STEM (Science, Technology, Engineering, and Mathematics) fields, which are critical for national development. As Malaysia aims to enhance its position in the global economy, improving mathematics education is vital for equipping students with the necessary skills for future careers. The decline in mathematics performance threatens not only individual student outcomes but also the country's economic competitiveness. Therefore, the performance of Malaysian students in mathematics has been a subject of considerable scrutiny, particularly in comparison with their regional counterparts. For example, the Programme for International Student Assessment (PISA) provides further insights into Malaysian students' mathematical abilities. The 2022 PISA results indicated that 41% of Malaysian students attained at least Level 2 proficiency in mathematics, which is significantly lower than the OECD average (OECD, 2023). Moreover, only 1% of Malaysian students were classified as top performers (Level 5 or 6) in mathematics, contrasting sharply with countries like Singapore, where 41% achieved similar levels (OECD, 2023).

This underperformance is compounded by various factors, including inadequate teaching methodologies, negative attitudes towards mathematics, and insufficient emphasis on

creative thinking skills. Research indicates that a positive attitude towards mathematics is crucial for student success. A study found that students with a favorable disposition towards mathematics tend to perform better academically (Hernández de la Hera et al., 2023; Wang et al., 2022). Conversely, negative attitudes can lead to anxiety and disengagement, further exacerbating performance issues. For instance, upper secondary students in Malaysia have reported high levels of mathematics anxiety, which directly correlates with lower achievement levels (Gopal et al., 2020).

To address the challenges faced by Malaysian students in mathematics, it is essential to focus on improving both attitudes toward the subject and the development of creative thinking skills. This is because creative thinking plays a pivotal role in overcoming difficulties, such as mathematics anxiety, lack of interest, and negative perceptions (Gopal et al., 2020). By fostering creativity, students are encouraged to approach problems from multiple perspectives and develop innovative solutions (Khalid et al., 2020). Therefore, by prioritizing the enhancement of both attitudes and creative thinking, it is believed that the trend of underachievement in mathematics can be reversed, thereby better equipping students with the critical thinking and problem-solving abilities necessary for academic and career success.

Mathematics attitude refers to an individual's thoughts, beliefs, and feelings towards mathematics as a subject (Yulia Prawestri et al., 2020). It encompasses their overall attitude, confidence, interest, motivation, and enjoyment in engaging with mathematical concepts, problem-solving, and mathematical activities. Numerous studies have consistently highlighted that mathematics attitude is a critical construct related to learning (Vandecandelaere et al., 2012). Tapia and Marsh (2004) proposed self-confidence, value of mathematics, enjoyment of mathematics and motivation to be the main components of the mathematics attitude and Watt (2000) identified several components, including perceived talent, expected success, effort, difficulty, interest, and utility. Meanwhile, Di Martino and Zan (2010, 2011) presented a three-dimensional model of mathematics attitude, consisting of the student’s vision of mathematics, perceived competence and an emotional dimension.

Students who exhibit higher confidence in their mathematical abilities are more likely to engage in problem-solving and perform well academically. Research by Gjicali and Lipnevich (2021) supports this, emphasizing the direct and indirect effects of positive attitudes on students' behavioural engagement and performance. Their findings resonate with the Malaysian educational goal of creating learners who are not only competent but also resilient and innovative thinkers.

On the other hand, students with high creative thinking abilities in fluency, flexibility, originality, and elaboration are believed to be adaptable, able to perceive opportunities, handle obstacles and take in information from various viewpoints (Ritter & Mostert, 2017; Zakiah & Fajriadi, 2020). Creative thinking in mathematics education involves skills that enable students to approach problems innovatively and effectively (Sahara, 2023). Creative thinking is essential for problem-solving in mathematics. The conventional educational framework often prioritizes rote memorization over conceptual understanding and application. This lack of emphasis on creative problem-solving skills limits students' ability to tackle complex mathematical problems effectively. Enhancing creative thinking can foster deeper understanding and improve performance by encouraging students to approach mathematical challenges from multiple perspectives.

Creative thinking skills are essential in addressing the challenges students face in mathematics education. Analytical thinking, a key component of creative thinking, plays a crucial role in solving complex problems and fostering innovation. According to Adeoye and Jimoh (2023), analytical thinking is closely linked to 21st-century skills such as problem-solving and innovation, which are increasingly emphasized in mathematics education. These skills enable students to think critically, adapt to changes, and find novel solutions to mathematical problems. Additionally, Hebebci and Usta (2022) highlight how perceptions of STEM and attitudes toward technology foster both creative and critical thinking in mathematics. This underscores the importance of interdisciplinary learning, where students apply creative thinking across various subjects. By integrating these skills into mathematics education, teachers can overcome challenges such as mathematics anxiety, lack of interest, and rigid learning environments, ultimately enhancing student engagement and success.

Creative thinking skills, particularly in the context of mathematics, play a transformative role in equipping students with the ability to approach problems from multiple perspectives. These skills are critical for fostering innovation, which is increasingly valued in a rapidly evolving global economy. Khalid et al. (2020) underscore the interplay between attitudes toward mathematics and the development of creative thinking. Their study revealed that fostering positive attitudes significantly enhances students' capacity for creative problem-solving, thereby bridging the gap between theoretical knowledge and practical application.

In the Malaysian context, there has been growing attention to improving students' creative thinking skills and their attitudes toward mathematics. Recent studies emphasize the importance of innovative teaching methods, such as STEAM-based blended learning, which integrates Science, Technology, Engineering, Arts, and Mathematics, in fostering critical and

creative thinking. For instance, a study by Putri et al. (2023) demonstrated that such pedagogical approaches significantly enhance students' ability to think creatively while simultaneously addressing the widespread issue of low engagement in mathematics classes. Additionally, the Malaysia Education Blueprint, as highlighted by Aroff (2014), advocates for strategies that improve students' mathematical competence by aligning it with real-world applications, thereby making learning more relevant and enjoyable.

The significance of this study lies in its ability to inform educators and policymakers about effective strategies to cultivate both mathematics attitudes and creative thinking among secondary students in Malaysia. By understanding the current state of these variables, interventions can be tailored to meet the unique needs of Malaysian students, ensuring that they are equipped with the skills necessary to thrive in a knowledge-based economy. Furthermore, the study contributes to the global discourse on integrating creativity into mathematics education, offering insights that are applicable beyond the Malaysian context.

This research aims to achieve four primary objectives: (1) to identify the level of mathematics attitudes among Malaysian secondary students, (2) to determine the current levels of creative thinking among secondary students, focusing on key dimensions such as fluency, flexibility, originality, and elaboration, (3) to examine the relationship between students' mathematics attitudes and their creative thinking in mathematics, and, (4) to investigate the influence of mathematics attitudes among Malaysian secondary students towards creative.

2.0 LITERATURE REVIEW

2.1 Mathematics Attitudes

Studies about mathematics attitude are not new. For instance, Fennema and Sherman conducted a study in 1976 to determine the underlying factor structure of the Fennema-Sherman Mathematics Attitude Scales (FSMAS) (Fennema & Sherman, 1976). Over the past four decades, the Fennema-Sherman Mathematics Attitudes Scales (FSMAS), developed by Fennema and Sherman in 1976, have been widely utilized to explore students' attitudes toward learning mathematics and the factors related to these attitudes.

Mathematics attitudes encompass several dimensions, including self-confidence, enjoyment, and perceived value. Students who exhibit higher confidence in their mathematical abilities are more likely to engage in problem-solving and perform well academically (Gjicali & Lipnevich, 2021). The study also emphasizing the direct and indirect effects of positive attitudes on students' behavioural engagement and performance.

Previous studies have found that mathematics attitudes significantly influence students' academic engagement and performance (Isa & Ibrahim, 2023). Gjicali and Lipnevich (2021) discovered that positive mathematics attitudes indirectly enhance behavioral engagement and mathematics performance, particularly in the U.S. PISA context. Meanwhile, Hassim et al. (2023) highlighted that strong preparation and positive attitudes synergistically improve calculus performance.

Li (2023) investigated how ICT integration post-pandemic influences mathematics teaching, emphasizing the transformative role of teacher attitudes. On the other hand, Gibeau et al. (2023) explored how spatial and mathematics anxiety interplay, finding that reduced anxiety levels are linked to higher student engagement.

In addition, Scofield et al. (2021) provided insights into clusters of mathematical abilities and their correlation with attitudes, revealing that tailored interventions can target specific weaknesses to improve attitudes. Building on this, Mammarella et al. (2023) highlighted how mathematics anxiety manifests behaviorally and physiologically, emphasizing the need for addressing emotional barriers.

2.2 Barriers to Positive Mathematics Attitudes

While creative thinking is essential, several barriers hinder the development of positive attitudes towards mathematics, with anxiety and disinterest being among the most significant challenges. Mathematics anxiety, widely studied for its adverse effects on performance and attitudes, can have profound behavioral, emotional, and cognitive impacts. Mammarella et al. (2023) emphasized the importance of early interventions to mitigate these effects and foster healthier relationships with mathematics.

Similarly, Gibeau et al. (2023) highlighted the interplay between mathematics and statistics anxiety, suggesting that equipping students with effective cognitive strategies, such as mindfulness techniques and problem-solving frameworks, can help manage these challenges. Low self-efficacy and academic motivation also play a crucial role in shaping mathematics attitudes. Karakose et al. (2023) found that building self-confidence and addressing motivational deficits are essential for creating a more engaging and supportive learning environment.

Socio-cultural and intergenerational influences further compound the issue, as Olivares and Ceglie (2020) observed how familial and societal apprehensions about mathematics can perpetuate cycles of disinterest and anxiety, necessitating comprehensive approaches like family engagement and societal awareness campaigns. Additionally, Geary et al. (2023)

explored gender differences in mathematics attitudes, revealing the importance of gender-sensitive interventions. Gholami (2023) further emphasized the critical role of problem-solving in mathematics learning, noting that gender differences also exist in problem-solving performance. Drawing on TIMSS and PISA findings, Gholami's study highlighted that while Malaysian students face significant challenges in problem-solving, female students outperformed males. Boys and girls often experience and express attitudes toward mathematics differently, and tailored strategies, such as mentoring programs and inclusive practices, can bridge these gaps and promote equitable learning experiences.

Cognitive interventions, such as mindfulness and cognitive-behavioral approaches, have proven effective in reducing mathematics anxiety and promoting emotional stability (Mammarella et al., 2023; Soares et al., 2024). Interactive learning tools, including augmented reality and problem-based simulations, enhance student engagement and critical thinking skills, making mathematics more relatable and enjoyable (Chang et al., 2022). This matter is supported by the results of Ratnah et al. (2022), who concluded that problem-based learning tools assisted by interactive simulations demonstrated a positive impact on students' creative thinking abilities in mathematics. Additionally, personalized e-learning systems and instructional strategies that adapt to individual students need significantly improve learning outcomes, particularly for those experiencing high anxiety or low confidence (Jacobs et al., 2022).

On the other hand, Soboleva et al. (2022) highlighted the potential of interactive novels to create tailored educational pathways, fostering deeper understanding and creativity in mathematics. Similarly, AI-driven personalized tutoring systems address diverse learning requirements, democratizing access to quality education (Alam & Mohanty, 2023). Cultural shifts, such as mindfulness-based teacher training and public campaigns to reduce stigma, further support the development of positive mathematics attitudes and well-being (Henriksen et al., 2022). Collectively, these strategies demonstrate how a multifaceted approach, combining cognitive, technological, and cultural elements, can foster engagement and enhance creative thinking in mathematics education.

2.3 Creative Thinking in Mathematics Education

The term "creativity" and its concept have been extensively used in psychological disciplines for about fifty years, largely influenced by the works of Guilford (1956) and Guilford (1967). Creative thinking skills, characterized by fluency, flexibility, originality, and elaboration, are crucial in navigating complex problem-solving scenarios that mathematics often demands.

(Guilford, 1967; Torrance, 1966). Integrating these dimensions offers a holistic approach to enhancing students' cognitive and emotional connections with mathematics.

Fluency: The ability to produce a large number of ideas. A higher fluency score reflects a capacity for ideation and adaptability.
Flexibility: The ability to think in varied directions or from different perspectives. It reflects openness and adaptability in problem-solving.
Originality: The ability to generate novel and unique ideas, essential for creativity. Originality ensures innovation in thought processes.
Elaboration: The ability to expand, refine, or build upon an idea with detail and depth, which is crucial for refining creative outputs.

Runco and Acar (2012) elaborated on the concept of divergent thinking, highlighting its significance as a metaphor for cognition that fosters originality. While divergent thinking is distinct from creative thinking, it often serves as a precursor to original ideas, which are central to creativity. Divergent thinking contrasts with convergent thinking, which typically leads to conventional and "correct" solutions rather than innovative ones.

Creative thinking in mathematics education involves skills that enable students to approach problems innovatively and effectively (Sahara, 2023). These include fluency, which is the ability to generate numerous ideas or solutions for a mathematical problem and flexibility, the capacity to approach a problem from various perspectives and adapt strategies as needed.

Khalid et al. (2020) noted that students performed better in problem-solving skills and creativity, emphasizing that discussing among peers allowed them to think and express their thoughts. Originality plays a key role, in fostering the creation of novel or unconventional solutions, while elaboration involves expanding on ideas to make them more comprehensive and detailed. Encouraging these skills equips students to tackle complex problems, connect theoretical knowledge to real-world applications, and cultivate a mindset oriented towards innovation and creative problem-solving (Cahya Mulia et al., 2023; Yunita et al., 2020).

Creative thinking in mathematics also interacts with interpersonal skills. Sahara (2023) demonstrated that interpersonal intelligence combined with creative thinking fosters cooperation and engagement in mathematics learning. This finding aligns with Malaysia’s emphasis on collaborative and innovative approaches in classrooms. Further supporting the importance of self-perception, Nugroho et al. (2023) highlighted self-efficacy as a mediator in

the relationship between creative thinking and mathematical problem-solving skills, underscoring the need to nurture confidence alongside skills.

Variables influencing creative thinking in mathematics have been explored by Kozlowski et al. (2019) who identified motivation and cognitive styles as critical factors. These findings are relevant to understanding how attitudes toward mathematics influence creativity and, by extension, performance. Additionally, Karakose et al. (2023) underscored the link between abstract thinking skills and mathematics attitudes, reinforcing the importance of cultivating abstract reasoning to bolster students' attitudes and capabilities.

Finally, studies such as Cahya Mulia et al. (2023) has demonstrated the direct impact of creative thinking on mathematics achievement, affirming the necessity of embedding creativity-focused strategies in the curriculum. These findings underscore the potential for constructivist teaching methods to enhance students' critical and creative thinking abilities, offering actionable insights for educators in Malaysia.

2.4 The Importance of Creative Thinking in Mathematics

Creative thinking in mathematics education is crucial in fostering problem-solving and innovation. It enables students to engage with mathematical concepts in ways that transcend rote learning, promoting a deeper understanding and application of knowledge. According to Khalid et al. (2020) fostering positive attitudes enhances creative problem-solving abilities. Their research highlights how these attitudes not only improve engagement but also act as a bridge between theoretical understanding and practical application. This underscores the importance of cultivating an environment that values creativity and open-minded exploration in mathematics education.

Li (2023) explored into the integration of Information and Communication Technology (ICT) as a transformative tool for encouraging creativity in mathematics classrooms. ICT's ability to make learning more interactive, engaging, and flexible has proven effective in motivating students to approach problems innovatively. This approach aligns with the contemporary educational emphasis on technology-enhanced learning, where creative thinking becomes a natural byproduct of an engaging and adaptive educational experience.

Furthermore, Gibeau et al. (2023) uncovered the correlation between reduced spatial anxiety and enhanced creative engagement in mathematics. When educators focus on minimizing anxiety-related challenges, they empower students to unlock their creative potential, encouraging them to approach mathematical concepts with greater confidence and

originality. These findings emphasize that reducing emotional obstacles is equally as critical as developing cognitive skills in fostering creativity.

Meanwhile, research by Hwang and Son (2021) demonstrated that students with higher levels of creative thinking skills tend to develop more positive attitudes toward mathematics. This is largely because their ability to generate innovative solutions and approach mathematical challenges with confidence fosters a sense of enjoyment and engagement. When students feel capable of thinking creatively, they are more likely to view mathematics as a subject where they can excel, which in turn nurtures their motivation and interest in exploring mathematical concepts further.

This interdependence is particularly evident in problem-solving contexts, where creativity and positive attitudes work together to enhance performance. Attami et al. (2020) highlighted students who are strong in creative thinking tend to approach mathematical problems with more confidence and resilience. This confidence helps them maintain a positive attitude toward the subject, which, in turn, makes them more open to exploring creative ways to solve problems. It is a cycle where each reinforces the other, showing how important it is to encourage both creativity and positive attitudes in the classroom. By combining these two elements into teaching strategies, educators can help students achieve better results in mathematics.

2.5 Theoretical and Conceptual Framework

This study is grounded in two complementary theoretical perspectives namely Social Cognitive Theory (SCT) by Bandura (1986) and Constructivist Learning Theory (CLT) inspired by the works of Piaget (1970), Vygotsky (1978), and Bruner (1961). Both frameworks provide valuable insights into understanding the development of students' mathematics attitudes and creative thinking skills within classroom environments.

Social Cognitive Theory (SCT) emphasizes the dynamic interaction between personal factors, behavioral patterns, and environmental influences in shaping learning outcomes (Bandura, 1986). A central construct of SCT is observational learning, where students acquire knowledge, skills, and attitudes by observing the behaviors of others, such as teachers and peers. This mechanism highlights the role of modeling in promoting positive learning behaviors, including persistence and problem-solving in mathematics.

An essential aspect of SCT is self-efficacy. Self-efficacy is an individual’s belief in their ability to successfully perform a task. Bandura (1986) posited that students with high mathematics self-efficacy are more likely to embrace challenges, engage in problem-solving,

and persist through learning difficulties. Further, Zimmerman (2000) supported the idea that self-efficacy directly influences students' motivation, effort, and emotional regulation in academic settings.

Meanwhile, Constructivist Learning Theory (CLT), rooted in the works of Jean Piaget and Lev Vygotsky, emphasizes that learners actively construct knowledge through experiences and interactions with their environment (Piaget, 1970; Vygotsky, 1978). CLT asserts that learning is a dynamic process where individuals build upon prior knowledge, often in collaboration with others. Piaget's view focuses on the stages of cognitive development, suggesting that learners construct knowledge by interacting with their surroundings in ways that align with their developmental stage. In contrast, Vygotsky emphasizes the social context of learning, proposing the concept of the zone of proximal development (ZPD). ZPD highlights how learners can achieve higher levels of understanding with guidance and support, often through collaborative tasks.

In the context of mathematics education, engaging activities, problem-solving tasks, and real-world applications embody constructivist principles by encouraging students to actively participate in their learning. These methods align with CLT by fostering deeper understanding and practical connections to knowledge, thus enhancing both attitudes and creative thinking. Creative thinking skills are usually characterized by fluency, flexibility, originality, and elaboration (Guilford, 1967; Torrance, 1966). By integrating SCT and CLT, this study positions mathematics attitudes and creative thinking skills as interrelated constructs influenced by both personal beliefs (self-efficacy) and active participation in meaningful learning experiences. These strategies not only enhance students' attitudes but also empower them with creative and analytical thinking skills necessary for academic success and future career readiness.

The relationship between attitudes and skills is supported by research beyond the Malaysian context. Ocak et al. (2021) highlighted the connection between scientific attitudes and inquiry learning skills, revealing that positive attitudes toward a subject significantly enhance cognitive skills. This correlation is mirrored in mathematics education, where fostering positive attitudes can drive improvements in creative and analytical thinking. Meanwhile, Chao et al. (2018) explored how e-learning environments support creative thinking development in mathematics, emphasizing the role of digital tools in enhancing students' fluency and originality in problem-solving tasks.

By integrating SCT and CLT, this study positions mathematics attitudes and creative thinking skills as interrelated constructs influenced by both personal beliefs (self-efficacy) and

active participation in meaningful learning experiences. Zimmerman (2000) supported the idea that self-efficacy directly influences students' motivation, effort, and emotional regulation in academic settings. In the context of this study, students' attitudes toward mathematics, shaped through social interactions, feedback, and learning experiences, are considered a social-cognitive construct that influences their creative thinking skills. Students' positive attitudes toward mathematics (a social-cognitive construct) are linked to their creative thinking skills.

Therefore, the conceptual framework presented in Figure 1 used to guide this study in achieving its objectives is based on Bandura (1986), Guilford (1967), Torrance (1966), Lehmkuhl et al. (2021) and Tapia and Marsh (2002).

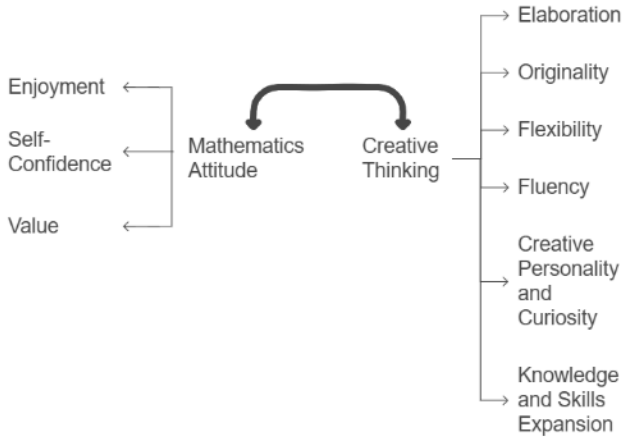

Figure 1: Conceptual framework

3.0 METHODOLOGY

3.1 Research Design

This study employed quantitative research design, utilizing a self-administered survey questionnaire to collect data from secondary school students in Selangor and Kuala Lumpur. The data collection instrument consisted of well-established and validated scales adapted from previous studies to ensure reliability and validity.

3.2 Respondents

A total of 531 secondary school students from Form 1 to Form 5 participated in this study. The sample selection employed a multi-stage random sampling technique. In the first stage, several districts within Selangor and Kuala Lumpur were randomly selected. Subsequently, schools within these selected districts were chosen through random sampling. Table 1 shows the number and percentage of responses from 531 students in the districts of Selangor and Kuala

Lumpur. Of these students, 204 (38.4%) were males, and 327 (61.6%) were females, suggesting a higher representation of females. Based on their level of study, most responses, 168 (31.6%), were from the Form 4 group, followed by the Form 3 group 150 (28.2%). Of the 531 students, 527 (99.2%) are Bumiputras, and 4 (0.8%) are others.

Table 1: Demographic analysis of respondents

Backgrounds	Variables	N	%
Gender	Male	204	38.4
	Female	327	61.6
	Total	**531**	**100**
Race	Malay	484	91.9
	Iban	5	0.9
	Chinese	9	1.7
	Indian	29	5.5
	Others	4	0.8
	Total	**531**	**100**
Form	1 & 2	40	7.5
	2	72	13.6
	3	150	28.2
	4	168	31.6
	5	101	19.0
	Total	**531**	**100**

3.3 Instrument

The survey instrument employed in this study, namely Mathematics Attitude and Creative Thinking Scale (MACTS) consisted of a questionnaire with three sections: (a) Demographic Information, (b) Mathematics Attitude (28-items), and (c) Creative Thinking (30-items).

3.3.1 Mathematics Attitude

The scale used to identify mathematics attitude in this study was adapted and modified from Attitudes Toward Mathematics Inventory (ATMI). ATMI is a widely used and validated instrument developed by Tapia and Marsh (2002) to measure students' attitudes toward mathematics. The ATMI is grounded in the idea that students' attitudes play a crucial role in their engagement, performance, and long-term interest in mathematics. This scale consisted of items measured on a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly

Agree". The instrument assesses students' attitudes across several key dimensions, which reflect both affective and cognitive components of attitude toward mathematics.

3.3.2 Creative Thinking in Mathematics

Meanwhile, students' creative thinking skills were measured using the scale adapted from the SCORE Model developed by Lehmkuhl et al. (2021). The SCORE Model was originally designed to assess creativity within K-12 computing education, providing a systematic and structured approach for students to self-assess their creative abilities. Recognizing the significance of creativity in learning, this model evaluates multiple dimensions of creative thinking relevant to educational settings. For the purpose of this study, the scale was adapted to suit the context of mathematics education among secondary school students. The scale consisted of 30 items measured on a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree." The application of the SCORE Model in this study aims to provide a baseline measurement of students' creative thinking skills, particularly in relation to their learning experiences in mathematics (Lehmkuhl et al., 2021).

3.3.3 Validity and Reliability

To ensure the validity of these instruments, content validity should be considered. Content validity refers to the degree to which the items in the instruments accurately represent the domains they intend to measure. In this study, both the mathematics attitude scale and the creative thinking scale were adapted from well-established models (e.g., ATMI and SCORE model), ensuring that they comprehensively cover the constructs of interest. Additionally, construct validity can be assessed by examining whether the scales effectively measure the underlying theoretical constructs (mathematics attitude and creative thinking) as hypothesized. Correlation analysis between these two instruments would provide preliminary evidence of construct validity, as a significant relationship between students' mathematics attitudes and creative thinking would support the theoretical linkage between the two constructs.

Meanwhile, the reliability score of 0.943 for the mathematics attitude scale indicates excellent internal consistency. This means that the 28 items used to measure aspects of the mathematics attitude are highly cohesive and consistently measure the intended constructs. On addition, the reliability score of 0.923 for the creative thinking scale similarly reflects excellent internal consistency. This score, derived from then 30 items measuring various dimensions of creative thinking (originality, fluency, flexibility, etc.), indicates that the scale is reliable for assessing students' creative thinking capabilities. A Cronbach's alpha value exceeding 0.9

signifies that the items are highly consistent in capturing various facets of creativity, ensuring the instrument's robustness in evaluating students' creative skills. The high reliability supports their use in this study, providing confidence in the consistency and accuracy of the data collected.

4.0 ANALYSIS AND DISCUSSION

4.1 Level of Mathematics Attitude and Creative Thinking in Mathematics

Descriptive analysis was used to explain the results in the form of mean scores and standard deviations to respond to this research question. Considering this, the mean score was measured using the formula of Nunally and Beinstein (1994) (see Table 2).

Table 2: Mean interpretation score

Mean score	Mean interpretation
1.00 – 2.00	Low
2.01 – 3.00	Middle low
3.01 – 4.00	Middle high
4.01 – 5.00	High

Source: Nunnally and Bernstein (1994)

Table 3 displays the student's level of mathematics attitude and creative thinking skills. Based on the findings, the level of mathematics attitude and creative thinking skills were equally high, mean score above 3.0.

Table 3: Level of mathematics attitudes and level of creative thinking skills

No	Sub-dimension	Mean value	Standard deviation	Interpretation
Mathematics Attitude				
1	Self-confidence	2.83	0.69	Middle low
2	Value	3.83	0.70	Middle high
3	Enjoyment	3.13	0.74	Middle high
	Overall	**3.26**	**0.71**	**Middle high**
Creative Thinking Skills				
1	Creative Personality and Curiosity	3.55	0.63	Middle high
2	Knowledge and Skills Expansion	3.81	0.68	Middle high
3	Originality	3.17	0.71	Middle high
4	Fluency	2.67	0.73	Middle low
5	Flexibility	3.08	0.67	Middle high
6	Elaboration	3.39	0.70	Middle high
	Overall	**3.28**	**0.69**	**Middle high**

The findings show that attitudes toward mathematics consists of three sub-dimensions namely self-confidence, Value and Enjoyment. Students exhibit a middle-low level of self-confidence in mathematics (Mean = 2.83, SD = 0.69), suggesting a potential lack of belief in their abilities. This could impact on their willingness to engage with challenging problems. Enjoyment is at a middle-high level (Mean = 3.13, SD = 0.74), indicating that while students generally find mathematics somewhat enjoyable, there is room for improvement to make the subject more engaging. Meanwhile, students place a middle-high value on mathematics (Mean = 3.83, SD = 0.70). They likely recognize its importance in academic and daily life, which can positively influence motivation.

The analysis of creative thinking skills among students reveals six key sub-dimensions. Creative Personality and Curiosity scored a mean of 3.55 (SD = 0.63), reflecting a middle-high level of curiosity and a creative disposition in their thinking. Knowledge and Skills Expansion achieved a mean of 3.81 (SD = 0.68), also at a middle-high level, indicating that students are adept at broadening their knowledge and skills, which is a positive indicator of their creative development. Originality was rated at a mean of 3.17 (SD = 0.71), signifying a middle-high

level of ability to generate unique ideas, though this skill could be further enhanced through targeted encouragement.

In contrast, Fluency scored a mean of 2.67 (SD = 0.73), reflecting a middle-low level, which suggests a relative weakness in generating a variety of ideas. This finding underscores the need for interventions such as brainstorming activities to foster fluency. Flexibility, with a mean of 3.08 (SD = 0.67), and Elaboration, with a mean of 3.39 (SD = 0.70), were both at middle-high levels, indicating the ability to think from different perspectives and elaborate on ideas, respectively, though there remains room for improvement in both areas. Overall, the creative thinking skills of students were rated at a middle-high level. While students demonstrate competence in several aspects of creative thinking, sub-dimensions such as fluency require focused efforts to ensure a more well-rounded creative skill set.

Nasution et al. (2023) claimed that students with high creative thinking abilities often exhibit positive attitudes toward learning mathematics, which in turn boosts their academic achievement. Findings from Laranang and Bondoc (2020) demonstrated that students who value and enjoy mathematics are more likely to demonstrate higher levels of creative thinking, suggesting a cyclical relationship between attitudes and creative problem-solving skills, confirming that the two constructs mutually reinforce each other. Therefore, in order to improve the student's attitude toward mathematics, teachers should focus on fostering creative thinking skills through engaging activities and problem-solving tasks, as these mutually reinforce positive attitudes and enhance students' overall learning experience.

In conclusion, students exhibit a middle-high level of mathematics attitude and creative thinking skills overall, with significant strengths in value, enjoyment, and knowledge and skills expansion. However, areas such as self-confidence in mathematics and fluency in creative thinking may need targeted improvement to achieve higher performance across all dimensions. Contradicted from past studies, Nugroho et al. (2023) argue that students' perceptions of their creative abilities were overwhelmingly negative, particularly in physics and mathematics contexts. The findings underline that significant challenges exist in fostering high creative thinking skills.

4.2 Relationship between Mathematics Attitude and Creative Thinking

To answer the third research question, correlation analysis was conducted to identify the relationship between mathematics attitude and creative thinking skills. If the significant number (p values) was less than 0.05, the two factors are said to be related. But if the significant number was greater than 0.05, it means that the two factors do not have any correlation. Based

on the results shown in Table 6, there is a significant and highly correlated (r = 0.70) relationship between students' mathematics attitude and their creative thinking skills.

Table 4: Correlations between mathematics attitude and creative thinking skills

Variables		**Attitudes towards Mathematics**	**Creative Thinking**
Attitudes towards Mathematics	Pearson Correlation	1	.699**
	Sig. (2-tailed)		<.001
	N	531	531
Creative Thinking	Pearson Correlation	.699**	1
	Sig. (2-tailed)	<.001	
	N	531	531

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

The correlation analysis presented in Table 4 examines the relationship between mathematics attitude and their creative thinking skills. The Pearson correlation coefficient indicates a strong positive relationship between the two variables ($r=0.699$, $p<0.001$). This finding suggests that as students' mathematics attitude improve, their creative thinking skills tend to increase correspondingly. The significance level ($p<0.001$) confirms that this relationship is statistically significant, meaning the observed correlation is unlikely to have occurred by chance. Both variables were measured among 531 students, providing a robust sample size to support the validity of these findings.

Scatter plots are a great way to check the correlation between pairs of continuous data quickly. The scatter plot below displays secondary students' attitudes towards mathematics and creative thinking. Each dot on the graph represents an individual student and their combination of attitudes towards mathematics and creative thinking.

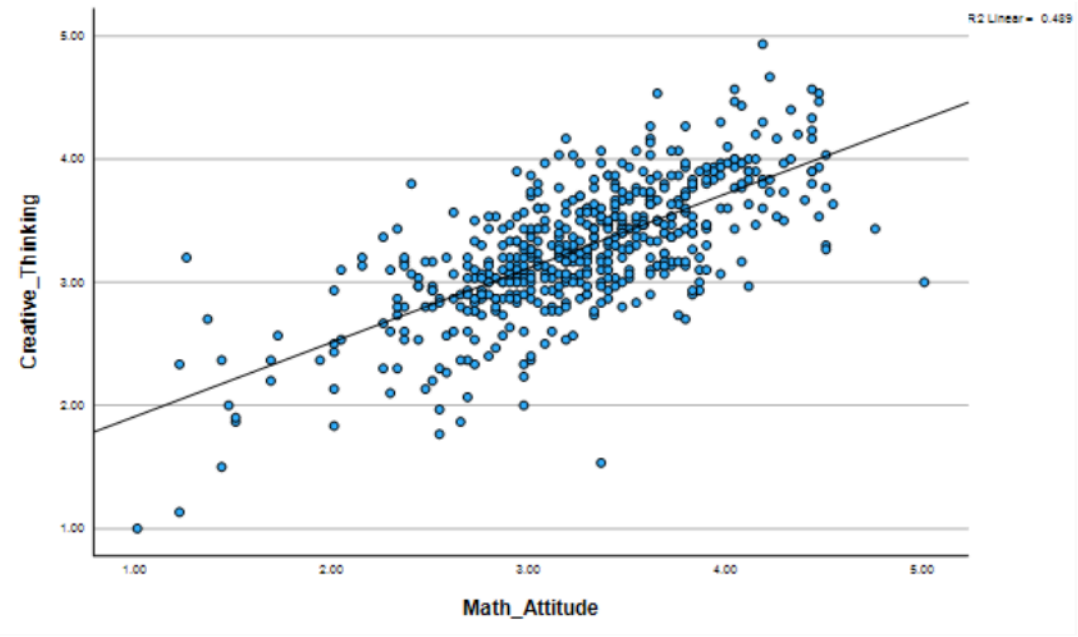

Figure 2: Scatter plot of mathematics attitude and creative thinking

Referring to Figure 2, creative thinking also tends to increase as mathematics attitude increases. A correlation exists because the general tendency that mathematics attitude and creative thinking increase together is unquestionably present.

4.3 Influence of Mathematics Attitude on Creative Thinking Skills

Linear regression was used to determine the influence of mathematics attitude (X) and their creative thinking skills (Y). Based on the data in Table 5, the beta value that has been obtained is 0.60, which explains how mathematics attitude will affect the increase of 0.602 per unit value in creative thinking skills.

Table 5: Influence of mathematics attitude on creative thinking skills

Variable	**Creative thinking skills**		**t**	***p***	**Contributions (%)**
	B	β			
Constant	1.32		14.818		
Attitudes toward Mathematics	0.60	0.70	22.509	<0.001	48.9%

The findings in Table 6 examine the influence of mathematics attitude on their creative thinking skills using a simple linear regression analysis. The results provide significant insights into the predictive relationship between these two variables.

4.3.1 Regression Model Analysis

Based on this analysis, the regression equation derived from the analysis can be constructed below:

$$Y = 1.32 + 0.60\ (X)$$

Y= Creative Thinking Skills

X= Mathematics Attitude

This equation indicates that for every one-unit increase in mathematics attitude, creative thinking skills are predicted to increase by 0.60 units, with a constant value of 1.32 when attitudes are zero. The results suggest that students' attitudes toward mathematics are a strong predictor of their creative thinking skills. A more positive attitude toward mathematics significantly enhances creative thinking abilities, as indicated by the large effect size (β=0.70) and the high proportion of variance explained (R^2=0.49). This finding aligns with the notion that affective engagement in a subject supports cognitive development, particularly in creative domains.

4.4 Discussion

Based on the results, we could conclude that the two variables have a strong relationship. Overall, the findings of the study regarding the relationship between mathematics attitude and creative thinking skills showed a positive correlation. This aligns with the research by Hernández de la Hera et al. (2023) which explored the relationships between attitudes toward mathematics, mathematical anxiety, self-efficacy, and academic performance, highlighting the significant role of positive attitudes in fostering mathematical proficiency. Similarly, Karunarathne and Calma (2024) assessed creative thinking skills in higher education, identifying deficits and proposing improvements, thereby underscoring the importance of nurturing positive attitudes to enhance creativity in academic settings. Teachers should model curiosity and creativity by demonstrating their thought processes when approaching problems and showing students how to think outside the box.

Wang et al. (2023) emphasised that students who see mathematics as valuable and engaging are more inclined to exhibit curiosity and persistence, traits essential for creative problem-solving. When students perceive mathematics as a meaningful and applicable subject, they are encouraged to explore problems from multiple perspectives and devise innovative strategies. This finding aligns with research by Bicer (2021), which showed that instructional approaches targeting creativity in mathematics improve both student attitudes and engagement. Together, these studies underscore the bidirectional relationship between positive attitudes and creativity: enthusiasm for mathematics drives innovation, and creativity deepens students' enjoyment of the subject.

This study establishes a significant positive correlation between students' attitudes toward mathematics and their creative thinking skills, emphasizing the interdependence of these factors in fostering academic and cognitive growth. The findings suggest that positive attitudes toward mathematics substantially contribute to developing creative thinking skills, which are essential for problem-solving, innovation, and overall success in STEM fields (Hernández de la Hera et al., 2023). Students with positive attitudes are more likely to approach mathematics with curiosity and confidence, enabling them to explore diverse problem-solving strategies and develop innovative solutions (Karunarathne & Calma, 2024).

Besides, the findings also highlight that creating an engaging and supportive learning environment can further enhance students' attitudes and creative capabilities. These outcomes underscore the importance of integrating creativity-centred strategies within the mathematics curriculum, aligning with the broader educational goal of equipping students with 21st-century skills necessary for a rapidly evolving global economy (Al Moray, 2024).

We have tinkered with several ways to improve creative thinking, but a more strategic approach would be better than simple curriculum-related fixes. Approaches such as project-based learning, STEAM (Science, Technology, Engineering, Arts, and Mathematics) initiatives, and problem-solving tasks that encourage multiple solutions can be particularly effective (Putri et al., 2023). Linking math to real-world situations and giving positive feedback can boost students' confidence and make the subject more engaging. Making math feel meaningful and maybe even fun. Teachers play a critical role in cultivating curiosity and perseverance, guiding students to perceive challenges not as barriers but as opportunities for innovation and creative development (Rahayu et al., 2023). This study has implications not only for policy and practice by supporting efforts to strengthen STEM education in Malaysia but also provides evidence-based recommendations for developing teacher training programs and classroom practices.

Our finding highlights the importance of giving helpful feedback on student performance, which facilitates students to generate diverse and creative ideas. While much work still needs to be done, academics may begin by prioritizing creating supportive environments that empower teachers to implement innovative instructional practices. This includes providing professional development programs focused on creative teaching methodologies and ensuring access to resources seamlessly integrating creativity into mathematics education (Ruhana et al., 2024). Extracurricular activities, such as math clubs and competitions, can further promote a culture of innovation while boosting students' confidence in applying creative problem-solving skills. Finally, promoting teamwork and a growth mindset can help students see math as a playground for exploration and creativity, all while improving their critical thinking and positive attitudes toward the subject (Idris et al., 2021).

5.0 LIMITATIONS AND RECOMMENDATION

While this study establishes a positive correlation between mathematics attitude and creative thinking skills, several limitations highlight further exploration. The study does not extensively examine the underlying mechanisms driving this relationship, such as the role of emotional intelligence, self-efficacy, or motivational factors (Hernández de la Hera et al., 2023). Moreover, the findings are context-specific and may not fully account for variations across cultural or socio-economic settings. To address these gaps, future research could employ longitudinal designs to assess the long-term sustainability of interventions aimed at improving both attitudes and creativity. Culturally responsive teaching strategies, such as ethnoscience-based project-based learning, have shown potential to enhance creative thinking by integrating local cultural contexts into educational practices (Rahayu et al., 2023). Furthermore, comparative studies across different educational systems could uncover global best practices, while interventions targeting emotional and psychological barriers, like reducing mathematics anxiety and fostering growth mindsets, could provide actionable insights to maximize the benefits of creativity-centred approaches (Putri et al., 2023; Zhang & Ma, 2023). By addressing these limitations and exploring the recommendations for future research, a more comprehensive understanding of the complex interplay between mathematics attitudes and creative thinking can be achieved. This will ultimately contribute to developing more effective educational strategies and interventions that empower students to thrive in mathematics and beyond.

6.0 CONCLUSION

These findings suggest that positive attitudes toward mathematics can significantly enhance creative thinking skills in Malaysian students. This is because when students have a positive attitude toward mathematics, they are more likely to be engaged in learning, be persistent in problem-solving, and see mathematics as a valuable and enjoyable subject. This, in turn, can lead to improved creative thinking skills. The findings of the study underscore the critical relationship between secondary students' attitudes toward mathematics and their creative thinking skills, revealing a significant positive correlation.

With a correlation coefficient of r=0.70 and a variance of 48.9% in creative thinking attributable to positive attitudes, it is evident that fostering a supportive emotional environment is essential for enhancing students' mathematical capabilities. This research highlights the need for educational strategies that not only address content knowledge but also cultivate positive attitudes towards mathematics. By integrating creativity-centered instructional methods, educators can engage students more effectively, thereby reducing anxiety and disinterest in mathematics - a common barrier to academic success.

The findings emphasize the importance of cultivating positive attitudes toward mathematics to support the development of creative thinking skills. Educators should consider implementing teaching strategies that enhance students' enjoyment, confidence, and perceived value of mathematics, such as real-world applications, collaborative learning, and problem-based activities. Simultaneously, promoting creativity through open-ended problem-solving and exploration could contribute to more favorable attitudes toward mathematics, creating a virtuous cycle of improvement in both areas. This interplay offers a promising avenue for holistic student development.

To nurture creative thinking skills, educational interventions should prioritize improving students' attitudes toward mathematics. Strategies such as fostering a growth mindset, creating an engaging learning environment, and emphasizing the relevance of mathematics to real-life contexts may positively impact students' attitudes. By doing so, educators can indirectly enhance creative thinking skills, contributing to holistic student development. The strong predictive relationship identified in this study underscores the need for an integrated approach to teaching those values both affective and cognitive domains.

Moreover, the implications of these findings extend beyond individual student performance to encompass broader educational goals within Malaysia's STEM framework. As the country seeks to prepare its workforce for a competitive global economy, nurturing both creative thinking and positive mathematical attitudes becomes paramount. This dual focus not

only equips students with essential problem-solving skills but also fosters innovation and adaptability - qualities that are increasingly valued in today's rapidly evolving job market. Therefore, educational policymakers and practitioners must prioritize the development of curricula and teaching methodologies that promote creativity alongside mathematical understanding, ensuring that Malaysian students are well-prepared to meet future challenges.

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REFERENCES

Adeoye, M. A., & Jimoh, H. A. (2023). Problem-solving skills among 21st-century learners toward creativity and innovation ideas. *Thinking Skills and Creativity Journal, 6*(1), 52–58.

Al Moray, N. A. (2024). The integration of 21st-century skills in grade eight mathematics curriculum. *Journal of Curriculum and Teaching, 13*(2), 271–282.

Alam, A., & Mohanty, A. (2023). Educational technology: Exploring the convergence of technology and pedagogy through mobility, interactivity, AI, and learning tools. *Cogent Engineering, 10*(2), 1-37.

Aroff, A. R. (2014). Values education and the Malaysia education blueprint. *Journal for Interdisciplinary Research in Education, 4*(1), 59-73.

Attami, D., Budiyono, B., & Indriati, D. (2020). The mathematical problem-solving ability of junior high school students based on their mathematical resilience. *Journal of Physics: Conference Series, 1469*(1), 1-7.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall.

Bicer, A. (2021). A systematic literature review: Discipline-specific and general instructional practices fostering the mathematical creativity of students. *International Journal of Education in Mathematics, Science and Technology, 9*(2), 252–281.

Bruner, J. (1961). The act of discovery. *Harvard Educational Review, 31*(1), 21–32.

Cahya Mulia, T., Rahayu, W., Jakarta, N., Muka, J. R., Gadung, P., & Timur, J. (2023). Creative thinking in mathematics. *Jurnal Pendidikan Matematika, 7*(2), 213–225.

Chang, Y., Lee, S., Wong, S. F., & Jeong, S. P. (2022). AI-powered learning application use and gratification: An integrative model. *Information Technology and People, 35*(7), 2115–2139.

Chao, W.-H., Yang, C.-Y., Hsien, S.-M., & Chang, R.-C. (2018). Using mobile apps to support effective game-based learning in the mathematics classroom. *International Journal of Information and Education Technology, 8*(5), 354–357.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for research in Mathematics Education, 7*(5), 324-326.

Geary, D. C., Hoard, M. K., Nugent, L., Ünal, Z. E., & Greene, N. R. (2023). Sex differences and similarities in relations between mathematics achievement, attitudes, and anxiety: A seventh-to-ninth grade longitudinal study. *Journal of Educational Psychology, 115*(5), 767–782.

Gholami, H. (2023). Performance of Malaysian foundation level students in mathematical problem solving as well as gender comparison. *Mathematics Teaching Research Journal, 15*(2), 104-120.

Gibeau, R. M., Maloney, E. A., Béland, S., Lalande, D., Cantinotti, M., Williot, A., Chanquoy, L., Simon, J., Boislard-Pépin, M. A., & Cousineau, D. (2023). The correlates of statistics anxiety: Relationships with spatial anxiety, mathematics anxiety and gender. *Journal of Numerical Cognition, 9*(1), 16–43.

Gjicali, K., & Lipnevich, A. A. (2021). Got math attitude? (In)direct effects of student mathematics attitudes on intentions, behavioral engagement, and mathematics performance in the U.S. PISA. *Contemporary Educational Psychology, 67*(1), 1–14.

Gopal, K., Salim, N. R., & Ayub. (2020). Study on mathematics self-ecacy and anxiety among Malaysian upper secondary students using fuzzy conjoint analysis. *Malaysian Journal of Mathematical Sciences, 14*(1), 6379.

Guilford, J. P. (1956). The structure of intellect. *Psychological Bulletin, 53*(4), 267–293.

Guilford, J. P. (1967). *The nature of human intelligence.* McGraw-Hill.

Hassim, N. H., Mat Zin, S. H. H., & Yusri, M. Y. (2023). Investigating the attitudes towards learning calculus among science and technology students: A case study in UITM Johor, Malaysia. *International Journal of Modern Education, 5*(18), 75–89.

Hebebci, M. T., & Usta, E. (2022). The effects of integrated STEM education practices on problem solving skills, scientific creativity, and critical thinking dispositions. *Participatory Educational Research, 9*(6), 358–379.

Henriksen, D., Gruber, N., & Woo, L. J. (2022). Looking to the future from the present: A call for well-being and mindfulness in education. *Journal of Technology and Teacher Education, 30*(2), 145-154.

Hernández de la Hera, J. M., Morales-Rodríguez, F. M., Rodríguez-Gobiet, J. P., & Martínez-Ramón, J. P. (2023). Attitudes toward mathematics/statistics, anxiety, self-efficacy and academic performance: An artificial neural network. *Frontiers in Psychology, 14*(1), 1-18.

Hwang, S., & Son, T. (2021). Students' attitude toward mathematics and its relationship with mathematics achievement. *Journal of Education and E-Learning Research, 8*(3), 272–280.

Idris, K., Khazila, K., Agustina, A., & Lisa, L. (2021). High school students' attitudes toward mathematics and its relation to mathematics learning achievement. *Jurnal Riset Pendidikan Matematika, 8*(1), 33–45.

Isa, N., & Ibrahim, H. (2023). The relationship between students' mathematics attitude and their mathematical thinking. *Journal of Islamic, Social, Economics and Development, 8*(56), 664-680.

Jacobs, J., Scornavacco, K., Harty, C., Suresh, A., Lai, V., & Sumner, T. (2022). Promoting rich discussions in mathematics classrooms: Using personalized, automated feedback to support reflection and instructional change. *Teaching and Teacher Education, 112*(1), 1-13.

Karakose, T., Polat, H., Yirci, R., Tülübaş, T., Papadakis, S., Ozdemir, T. Y., & Demirkol, M. (2023). Assessment of the relationships between prospective mathematics teachers' classroom management anxiety, academic self-efficacy beliefs, academic amotivation and attitudes toward the teaching profession using structural equation modelling. *Mathematics, 11*(2), 1-23.

Karunarathne, W., & Calma, A. (2024). Assessing creative thinking skills in higher education: Deficits and improvements. *Studies in Higher Education, 49*(1), 157–177.

Khalid, M., Saad, S., Abdul Hamid, S. R., Ridhuan Abdullah, M., Ibrahim, H., & Shahrill, M. (2020). Enhancing creativity and problem-solving skills through creative problem solving in teaching mathematics. *Creativity Studies, 13*(2), 270–291.

Kozlowski, J. S., Chamberlin, S. A., & Mann, E. (2019). Factors that influence mathematical creativity. *Mathematics Enthusiast, 16*(1–3), 505–540.

Laranang, J. A. I., & Bondoc, J. M. F. (2020). Attitudes and self- efficacy of students toward mathematics. *International Journal of English Literature and Social Sciences, 5*(5), 1392–1423.

Lehmkuhl, G., Von Wangenheim, C. G., Martins-Pacheco, L. H., Borgatto, A. F., & Alves, N. D. C. (2021). SCORE - A model for the self-assessment of creativity skills in the context of computing education in K-12. *Informatics in Education, 20*(2), 1–24.

Li, M. (2023). Chinese mathematics teachers' TPACK and attitudes toward ICT integration in the post-pandemic era. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(7), 1-29.

Mammarella, I. C., Caviola, S., Rossi, S., Patron, E., & Palomba, D. (2023). Multidimensional components of (state) mathematics anxiety: Behavioral, cognitive, emotional, and psychophysiological consequences. *Annals of the New York Academy of Sciences, 1523*(1), 91–103.

Nasution, N. E. A., Al Muhdhar, M. H. I., Sari, M. S., & Balqis. (2023). Relationship between critical and creative thinking skills and learning achievement in biology with reference to educational level and gender. *Journal of Turkish Science Education, 20*(1), 66–83.

Nugroho, P. S., Nasir, M., Syafi'i, M., & Erviyenni, E. (2023). Profile perception of student's collaboration and creative thinking skills in physics. *Jurnal Penelitian Pendidikan IPA, 9*(2), 775–779.

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education, PISA.* OECD Publishing.

Olivares, V., & Ceglie, R. J. (2020). The intergenerational transmission of mathematics attitudes. *International Journal of Education in Mathematics, 8*(2), 76-91.

Piaget, J. (1970). *Science of education and the psychology of the child.* Viking Press.

Putri, A. S., Prasetyo, Z. K., Purwastuti, L. A., Prodjosantoso, A. K., & Putranta, H. (2023). Effectiveness of STEAM-based blended learning on students' critical and creative thinking skills. *International Journal of Evaluation and Research in Education, 12*(1), 44–52.

Rahayu, R., Sutikno, & Indriyanti, D. R. (2023). Ethnosains based project based learning model with flipped classroom on creative thinking skills. *Jurnal Penelitian Pendidikan IPA, 9*(8), 348–355.

Ratnah, R., Wildan, W., & Muntari, M. (2022). The practicality of problem-based learning tools assisted by interactive simulations to improve students' creative thinking ability. *Jurnal Pijar Mipa, 17*(3), 347–352.

Ruhana, F., Rochmah, E. Y., Pada, A., Suryani, Y., & Rizki, A. M. (2024). Developing creativity and innovation in STEM curriculum: Project-based approach in secondary education. *Theory and Practice, 2024*(5), 7188–7195.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal, 24*(1), 66–75.

Sahara, A. (2023). The influence of creative thinking ability and interpersonal intelligence on students' cooperation skills in mathematics learning. *Jurnal Pendidikan Matematika, 14*(2), 383-399.

Scofield, J. E., Hoard, M. K., Nugent, L., LaMendola V, J., & Geary, D. C. (2021). Mathematics clusters reveal strengths and weaknesses in adolescents' mathematical competencies, spatial abilities, and mathematics attitudes. *Journal of Cognition and Development, 22*(5), 695–720.

Soares, F., Lopes, A., Serrão, C., & Ferreira, E. (2024). Fostering humanization in education: A scoping review on mindfulness and teacher education. *Frontiers in Education, 9*(1), 1-13.

Soboleva, E. V., Zhumakulov, K. K., Umurkulov, K. P., Ibragimov, G. I., Kochneva, L. V., & Timofeeva, M. O. (2022). Developing a personalised learning model based on interactive novels to improve the quality of mathematics education. *Eurasia Journal of Mathematics, Science and Technology Education, 18*(2), 1-17.

Tapia, M., & Marsh, G. E. (2002). Confirmatory factor analysis of the attitudes toward mathematics inventory. *International Journal of Advanced and Applied Sciences, 4*(3), 7-12.

Tapia, M., & Marsh, G. E. (2004). The relationship of math anxiety and gender. *Academic Exchange Quarterly, 8*(2), 130-134.

Torrance, E. P. (1966). *The Torrance tests of creative thinking: Norms-technical manual research edition-verbal tests, forms A and B.* Personnel Press.

Vandecandelaere, M., Speybroeck, S., Vanlaar, G., De Fraine, B., & Van Damme, J. (2012). Learning environment and students' mathematics attitude. *Studies in Educational Evaluation, 38*(3-4), 107-120.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Wang, L., Peng, F., & Song, N. (2022). The impact of students' mathematical attitudes on intentions, behavioral engagement, and mathematical performance in the China's context. *Frontier in Psychology, 13*(1), 1-11.

Wang, T., Zhang, L., Xie, Z., & Liu, J. (2023). How does mathematical modeling competency affect the creativity of middle school students? The roles of curiosity and guided inquiry teaching. *Frontiers in Psychology, 13*(1), 1-12.

Yunita, Y., Juandi, D., Tamur, M., Adem, A. M. G., & Pereira, J. (2020). A meta-analysis of the effects of problem-based learning on students' creative thinking in mathematics. *Beta: Jurnal Tadris Matematika, 13*(2), 104–116.

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology, 14*(1), 1-14.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91.