The Role of Self-Perception of Mathematics and Technological Self Confidence in Predicting Mathematical Representations in Secondary Education

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Abstract: The primary objective of this research was to explore the intricate relationships and mediating among self-perception of mathematics, technological self-confidence, and mathematical representations. A cross-sectional study was conducted involving a sample of 322 students from both public and private schools in Bandar Lampung, Indonesia. The data were analyzed using structural equation modeling. The findings of this study are significant and contribute to our understanding of the roles of these variables in secondary education. Firstly, the study revealed that technological self-confidence plays a crucial role in promoting mathematical representation. Secondly, technological self-confidence was found to be positively linked with self-perception of mathematics, suggesting the interconnectedness of these factors. Lastly, self-perception of mathematics was identified as a mediating variable, but it exhibited a negative association between the relationship of technological self-confidence and mathematical representation. This study offers valuable insights into the potential keys to success in the field of mathematics education, particularly in the digital age of mathematics teaching.

Keywords: self-perception of mathematics, technological self-confidence, mathematical representations, gender, structural equation modeling.

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INTRODUCTION

In the realm of contemporary education, particularly in the context of secondary education, understanding the multifaceted interplay of self-perception and technological self-confidence concerning mathematical representations has gained prominence. The role of self-perception, which encompasses students' beliefs about their own mathematical abilities, and technological self-confidence, referring to their confidence in employing digital tools and technologies to represent mathematical concepts, is fundamental in shaping students' experiences and achievements in mathematics.

The acquisition of mathematical skills and the ability to construct mathematical representations are critical objectives within secondary education. Not only do these skills underpin academic achievement, but they also serve as vital foundations for students' analytical and problem-solving competencies that are essential in an increasingly technology-driven world.

The significance of self-perception and self-confidence in relation to mathematical achievements has been a subject of substantial research within the field of education (Kaur & Prendergast, 2022; Panaoura, 2012). Prior studies have established a clear relationship between students' self-perception of their mathematical abilities and their academic performance. A wealth of empirical evidence suggests that students who hold positive self-perceptions about their mathematical competencies tend to outperform their peers who exhibit self-doubt or negative perceptions (Dupeyrat et al., 2011; Reich & Arkin, 2006). Moreover, research has illuminated the vital role of self-confidence when it comes to adopting digital tools for mathematical learning. Students who possess higher technological self-confidence tend to engage more actively with digital resources, ultimately impacting their mathematical performance (Huang & Brainard, 2001).

However, while there is substantial research on self-perception, technological self-confidence, and mathematical achievement separately, the intersection of these constructs, specifically in the context of mathematical representations, remains an underexplored domain. This research gap points to the pressing need for an integrated investigation that considers how students' self-perception of mathematical abilities interacts with their technological self-confidence and influences their ability to create effective mathematical representations.

The research problem at the heart of this study revolves around discerning how self-perception and technological self-confidence interact and contribute to students' mathematical representations in a secondary education context. While previous studies have addressed self-perception's influence on mathematical achievement and technological self-confidence's impact on technology use, a comprehensive examination of their collective impact on the quality and effectiveness of mathematical representations is yet to be accomplished.

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By bridging this research gap, we aim to provide a more holistic perspective, shedding light on the complex web of factors influencing students' mathematical representations. This research delves into the nuanced relationships among self-perception, technological self-confidence, and mathematical representations, thereby contributing to a more comprehensive understanding of the cognitive processes involved in mathematical problem-solving and communication.

The subsequent sections of this article will delve into the pertinent theories, methodologies, empirical findings, and discussions, all in pursuit of a more comprehensive understanding of the roles that self-perception and technological self-confidence play in predicting mathematical representations in secondary education.

LITERATURE REVIEW

Technological Self-confidence and Mathematical Representations

In the realm of modern education, technological self-confidence has emerged as a pivotal factor influencing students' preparedness to effectively engage with digital tools and resources. Within the context of mathematics education, technological self-confidence holds even greater significance as it profoundly impacts students' capacity to navigate mathematical software (Roschelle et al., 2000), employ digital tools (Bolaños et al., 2023), and ultimately, enhance their ability to communicate mathematical ideas (Cretchley, 2007). This is where the concept of mathematical representations enters the equation. Mathematical representations encompass a spectrum of visual, symbolic, and verbal depictions that play a crucial role in conveying mathematical concepts and relationships (Cartwright, 2020). The intriguing intersection of technological self-confidence and mathematical representations prompts us to examine how students' confidence in technology utilization influences their proficiency in generating, interpreting, and employing mathematical representations (Hill & Uribe-Florez, 2020).

Research into the interaction between technological self-confidence and mathematical representations has unveiled intriguing connections. For example, a study by Zeldin et al. (2008). There is a positive relationship between technological self-efficacy and mathematics, science, and technology careers. Students who excel in mathematics, science, and technology fields often exhibit a high level of technology self-efficacy. Their competence and confidence in using technology to solve problems, conduct research, and engage in various technical tasks contribute to their success in these career areas (Attard et al., 2016). At the same time, a study by Ke (2014) conducted in the context of secondary education revealed that students with higher technological self-confidence tend to exhibit an increased tendency for creating visual and symbolic representations. Similarly, a survey by Magen-Nagar & Shonfeld (2018) found that students who reported higher levels of technological self-confidence were more inclined to utilize digital platforms for collaborative

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mathematical modeling, showcasing the link between self-confidence in technology and effective mathematical representations.

Furthermore, the study by Brezavšček et al. (2020) examined various factors that impact mathematics achievement in a higher education context. Although the setting differs from secondary education, their findings could still offer insights into how self-perception of mathematics and technological self-confidence can affect mathematics achievement. Their findings demonstrated that confidence with technology positively affects perceived usefulness of technology in learning mathematics. This aligns with Vygotsky's Zone of Proximal Development (ZPD) theory, suggesting that students' technological self-confidence acts as a catalyst for reaching their full potential in generating meaningful mathematical representations (Vygotsky & Cole, 1978). The existing body of research illuminates the integral connection between technological self-confidence and mathematical representations, emphasizing its pertinence within the modern educational landscape. In this paper we assume technological self-confidence effects mathematical representation.

Self-perception of Mathematics and Mathematical Representations

The self-perception of mathematics and mathematical representations refers to an individual's own assessment and beliefs about their abilities, attitudes, and understanding of mathematical concepts and their graphical or symbolic representations. In the context of education, this self-perception plays a significant role. A student's self-perception of mathematics can influence their motivation (Tully & Jacobs, 2010), learning strategies (Ben-Chaim & Zoller, 2001), and ultimately, their performance in mathematical tasks (Shen & Pedulla, 2000). If a student has a positive self-perception of their mathematical abilities, they are more likely to be motivated to learn, apply problem-solving strategies, and persist in the face of challenges. On the other hand, a negative self-perception may lead to reduced motivation and avoidance of mathematical tasks (S. Skaalvik & Skaalvik, 2004).

The finding from the literature provide some insights into the relationship between self-perception of mathematics and mathematical representations. Self-concept, which is similar to self-perception, is positively associated with mathematics achievement (OECD, 2013). Furthermore, the influence of different mathematical representations and degrees of mathematics self-efficacy on the performance of learners in pattern reasoning and their attitude towards learning mathematics has been investigated (Chen et al., 2015). We assumed that the self-perception of mathematics can lead to mathematical representation.

Self-perception of Mathematics as a Mediator Between Technological Self-confidence and Mathematical Representations

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The studies collectively underscore the intricate interplay between emotional well-being, autonomy in mathematics learning, and self-confidence in shaping students' self-perception of mathematics. These factors contribute to the broader landscape of mathematics education and can guide strategies to enhance students' mathematical self-concepts and overall competence in the subject.

Students who feel secure, relaxed, and emotionally stable while engaging in mathematics activity tend to judge their competence on the mathematics activity very highly (Zakariya, 2022). This demonstrates the strong connection between emotional states and self-perception in mathematics. Moreover, correlations exist between mathematics learning autonomy and mathematics self-concept (Bringula et al., 2021). This research indicates that students who exhibit higher levels of autonomy in their mathematics learning are more likely to develop positive self-concepts in mathematics. Autonomy allows students to take control of their learning, leading to increased confidence in their mathematical abilities. Furthermore, self-confidence in mathematics refers to how students perceive themselves in relation to their own abilities in mathematics (Aguilar, 2021). This self-confidence plays a pivotal role in shaping students' self-perception of mathematics. As students perceive themselves as capable and competent in mathematics, their self-concept in mathematics becomes more positive.

Based on the above points, it can be inferred that self-perception of mathematics, specifically mathematics self-concept and mathematics self-efficacy, can act as a mediator between technological self-confidence and mathematical representations. Students who have high levels of technological self-efficacy and mathematics self-efficacy are more likely to engage in mathematics tasks and perform better in mathematics. Additionally, students who have high levels of mathematics self-concept are more likely to perform well in mathematics. Therefore, it is important to understand how students perceive their abilities related to mathematics and technology to improve their engagement and performance in mathematics tasks.

Gender

The role of gender in the context of self-perception of mathematics and technological self-confidence in predicting mathematical representations among secondary education students is a subject of significant interest and research.

An empirical study by Xie and Liu (2023) reveals that traditional gender stereotypes have a dual impact on mathematical performance: they tend to enhance the performance of male students while undermining that of female students. Notably, the authors observe that, despite prevailing stereotypes, female students do not exhibit the classic symptoms of stereotype threat, a psychological phenomenon that typically impairs performance in male-dominated fields such as mathematics. Instead, although gender role perceptions negatively influence female students' quantitative abilities, they do not trigger the heightened anxiety commonly associated with stereotype threat.

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Moreover, the findings suggest that societal and familial beliefs about gender roles significantly shape students' engagement with mathematics.

Despite gender differences in mathematics achievement narrowing over the last decades, gender differences in self-concept in mathematics remain considerable (Mejía-Rodríguez et al., 2021; Sax, 1994). Furthermore, research has confirmed gender differences, even in secondary education, in mathematics self-concept, self-efficacy, and interest, suggesting that gender differences in mathematics motivation emerge early in life (Mejía-Rodríguez et al., 2021). Moreover, gender stereotypes are believed to play a role in the heightened math anxiety reported by female students (Justicia-Galiano et al., 2023).

Based on the above points, it can be inferred that gender plays a significant role in the self-perception of mathematics and technological self-confidence in predicting mathematical representations among secondary education students. Therefore, it is important to understand the role of gender in the self-perception of mathematics and technological self-confidence to improve students' engagement and performance in mathematics tasks.

Present Study

This study aims to investigate the role of self-perception of mathematics and technological self-confidence in predicting mathematical representations in secondary education in Indonesia. The primary focus of the research is to understand the extent to which these psychological factors influence students' ability to represent mathematical problems. According to Anderson (1949), educational psychology is defined as the science of human learning. These factors include social and psychological resources, psychological risk factors, self-efficacy, beliefs, attitudes, motivations, emotional attachments, and coping responses to life (Thomas et al., 2020). In the context of education and learning, these factors include cognitive processes such as perception, memory, reasoning, and problem-solving, which are crucial for understanding and representing mathematical problems. In Indonesia, students often face challenges in understanding and representing mathematical concepts. Therefore, it is essential to comprehend the factors that affect students' ability to comprehend and represent mathematical problems.

Research has consistently indicated that self-perception of mathematics and technological self-confidence play significant roles in shaping students' capacity to comprehend and address mathematical challenges. As established in the literature review, these psychological factors have been shown to impact students' mathematical problem-solving abilities (Brezavšček et al., 2020; S. Skaalvik & Skaalvik, 2004, 2004; Xie & Liu, 2023). However, this research focuses on the context of secondary education in Indonesia, which has unique cultural and educational characteristics. The uniqueness of this study is that it is one of the first to explore the relationship between self-perception of mathematics, technological self-confidence, and mathematical representation

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abilities in the context of secondary education in Indonesia. This research is expected to provide new insights into the factors influencing students' mathematical abilities and can serve as a basis for the development of more effective educational strategies to enhance students' mathematical representations in Indonesia.

Hypotheses

Based on the theoretical framework, the following hypotheses were formulated:

Hypothesis 1: Technological self-confidence positively affects mathematical representations.
Hypothesis 2: Self-perception of mathematics positively affects mathematical representations
Hypothesis 3: Self-perception of mathematics as expected to mediate the relationship between technological self-confidence and mathematical representations.
Hypothesis 4: There are differences between male and female among variables.

The model illustrating these hypotheses is provided in Figure 1.

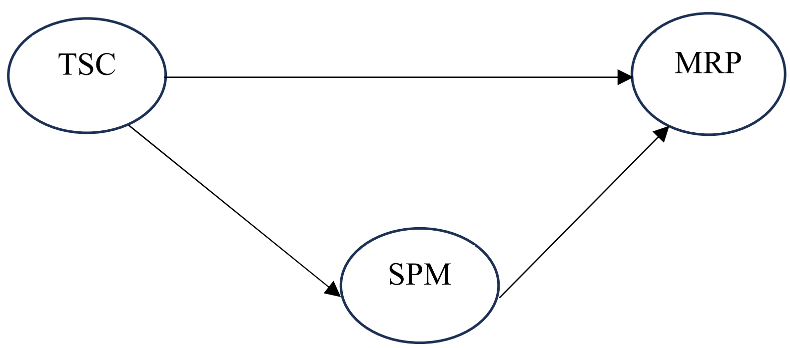

Figure 1: The model of self-perception of mathematics (SPM), technological self-confidence (TSC), and predicting mathematical representation (MRP).

METHOD

Participants

In this cross-sectional research, the participants consisted of 322 secondary education students in Bandar Lampung, Indonesia, through cluster random sampling (Gliner et al., 2016). Among the participants, 192 (59.6%) were female students with an average age of 11.27 years (*SD* = 0.46), and 130 (40.4%) were male students with an average age of 11.17 years (*SD* = 0.38). The research received approval from the Institutional Review Board of Universitas Islam Negeri Raden Intan Lampung, in compliance with the institution's ethical standards. Furthermore, all participants

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provided their informed consent prior to their involvement in the study. Further details regarding the sample characteristics can be found in Table 1.

Demographic Factor		Frequency	Percentage (%)
Gender	Female	192	59.6
	Male	130	40.4
School Type	Private	202	62.7
	Public	120	37.3
Age	11 years	248	77.1
	12 years	74	22.9
Place of Residence	City	127	39.4
	Urban	195	60.6

Table 1: The characteristic of the participants.

Instruments

In our study, students were requested to complete a questionnaire consisting of 12 items related to self-perception of mathematics and technological self-confidence. Additionally, they were presented with 5 test items assessing mathematical representation skills. Background information, including age, gender, place of residence, and school type, was also collected from the participants. Detailed information about the instruments used in the study will be provided.

Self-perception of mathematics. The self-perception of mathematics questionnaire consisted of six items that were adapted from Suherman & Vidákovich (2022a). These items were translated and validated in the Indonesian context. The questionnaire aimed to assess students' feelings and perceptions regarding their mathematical abilities. Sample items included statements such as "Math is very hard for me" and "I can tell if my answers in math make sense." Participants were asked to rate these items using a five-point Likert scale, where 5 indicated "strongly agree" and 1 indicated "strongly disagree." Cronbach's alpha was measured at 0.79, while McDonald's coefficient omega for these statements also registered a value of 0.79. We also evaluated the scale's validity and reliability.

Technological self-confidence. The technological self-confidence questionnaire in this study consisted of six items related to one's belief in their ability to successfully perform technologically sophisticated tasks. These items included statements such as "I am sure I could work with computers" and "I am sure I could learn a computer language." The questionnaire was adapted from Francis et al. (2000). Participants were asked to respond to these items using a 5-point Likert scale, where 5 represented "strongly agree" and 1 represented "strongly disagree." Cronbach's alpha this statement was measured at 0.85. Again, we also measured the validity and reliability of this scale.

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Mathematical representation. The test of mathematical representation employed in this study is designed to gauge how students interpret and express their thoughts when addressing mathematical problems. This test serves as a tool for uncovering their problem-solving skills. An example of a test question is as follows in Table 2. This particular question was adapted from (Suherman & Vidakovich, 2022). Scores are allocated according to categorized responses. Each response is then evaluated for its level and awarded one to five points accordingly. Cronbach's alpha of this instruments was 0.86 and reliability of the person and items was 0.86 and 0.85, respectively. Again, we also evaluated the instruments in this study. We provide one example of these instruments.

Questions	Picture
The pictures are part of Tapis Lampung with geometry motif. 1. Make a list of any flat shapes that you find in the Tapis Lampung motif! 2. Draw any pictures from your findings using at least one flat shape you listed in number 1. You can combine 2 or 3 or more flat shapes to create a unique image. Then name the image you have made.	

Table 2: An Example of the test.

Procedure

The initial phase involved translating the assessment instruments into the Indonesian language. The items of the tests and questionnaires were thoroughly reviewed by one expert and two mathematics teachers prior to their administration. To ensure compliance and gain permission for the research, each school principal was contacted and provided with a formal letter outlining the study's objectives. Subsequently, 7 classes were randomly chosen from five different secondary schools in Bandar Lampung. This process resulted in the participation of a total of 322 students in the current research. Data collection was carried out through the administration of paper-pencil tests.

Data Analysis

In this study, we utilized several software tools for data analysis, including MPlus version 8.3 (Muthén & Muthén, 2017), SPSS version 25 (IBM Corp, 2017), R software, and Winstep. The data analysis consisted of a multi-faceted approach. We conducted confirmatory factor analysis (CFA) using the questionnaire data to assess validity and reliability. Simultaneously, we employed the Winstep software to evaluate the validity and reliability of the test items in the context of Rasch measurement. The reliability of the data was also assessed using Cronbach's Alpha. In addition, we performed descriptive statistical analysis to elucidate the mean and standard deviation (*SD*) of

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the test items and questionnaire. Lastly, structural equation modeling (SEM) was employed to examine the hypothetical model.

We utilized various parameters to assess the model fit. Maximum likelihood was employed as an indicator for loading factors, with a threshold value of approximately 0.30. Additionally, we considered other parameters, including the Tucker-Lewis Index (TLI) and the Comparative Fit Index (CFI), Chi-square, the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Squared Residual (SRMR). Following the criteria proposed by Hu & Bentler (1999), we aimed for CFI and TLI values close to or greater than 0.90, an SRMR value less than 0.80 (Hu & Bentler, 1999), RMSEA value of < 0.05 indicates a close fit, while a value < 0.08 suggests a reasonable model–data fit (Browne, 1993; Jöreskog & Sörbom, 1993; Xia & Yang, 2019). Furthermore, we also conducted Chi-square statistics to evaluate the overall model fit.

RESULTS

Validity, Reliability, and Descriptive Statistic of the Instrument.

Descriptive statistics were employed to examine the distribution of questionnaire and test responses. As indicated in Table 3, this table provides an overview of the dataset. The data reveals that the means for each variable fall within the range of 3.53 to 3.89 on a 5-point Likert scale, while the *SDs* range from 0.69 to 0.99. To assess the internal consistency or reliability of the variables, Cronbach's alpha was calculated. The Cronbach alpha values for self-perception of mathematics, technology self-confidence, and mathematical representation were approximately 0.72, 0.75, and 0.67, respectively, indicating that these variables are consistent and dependable for further analysis.

Variables	M	SD	Cronbach Alpha	McDonald Omega	Skewness	Kurtosis
Self-perception of mathematics	3.89	0.69	0.72	0.72	1.01	0.67
Technology self-confidence	3.54	0.73	0.75	0.76	0.04	0.16
Mathematical representation	3.53	0.99	0.67	0.68	0.65	-0.16

Table 3: Descriptive statistics.

Regarding data normality, Kline (2015) recommended that skewness values should not surpass |3| and kurtosis should be under |10|. In this study, skewness values varied from 0.04 to 1.01, and kurtosis ranged from -0.16 to 0.67. Table 3 presents the correlations between the elements of each variable.

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We conducted a CFA of the questionnaire to evaluate the relationships between the items and their respective latent constructs. The results of this analysis are displayed in Table 4, which provides information on the loading factors for each item in the scale. These loading factors reflect the strength and direction of the relationship between each item and the underlying construct it is intended to measure. This analysis allows us to assess the validity and reliability of the measurement model, confirming that the items effectively capture the intended constructs.

Scale	Items	Loading factor
Self-perception of mathematics	SPM1	0.55
	SPM2	0.66
	SPM3	0.56
	SPM4	0.45
	SPM5	0.48
	SPM6	0.53
Technology self-confidence	TSC1	0.46
	TSC2	0.45
	TSC3	0.45
	TSC4	0.54
	TSC5	0.49
	TSC6	0.45

Table 4: Loading factors of item questionnaire.

Table 4 reveals that the loading factor values for the self-perception of mathematics items fall within the range of 0.45 to 0.55. Similarly, for technology self-confidence, the loading factor values range from 0.45 to 0.54. These values demonstrate the strength of the relationship between each item and its respective construct. The consistency of these loading factor values across the items within each construct contributes to the reliability of the measurement model, ensuring that the items effectively measure the intended constructs.

We conducted a validity assessment of the test items using Rasch analysis. As shown in Table 5, it provides a summary of measurements by person and test items. The Cronbach alpha for assessing

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person ability was found to be 0.96, while the reliability for the test items and person ability was 0.64 and 0.71, respectively.

Object Measured	Measure [Mean (*SD*)]	Separation	Reliability	Cronbach Alpha
Person	0.03 (1.33)	1.55	0.71	0.96
Item	0.07 (0.00)	1.32	0.64	

Table 5: Summary of measured person and item test.

We also assessed the item fit using Rasch analysis, and the results are illustrated in Figure 2. It is evident that each item fits the Rasch model well, indicating the appropriateness of the items for measuring the construct.

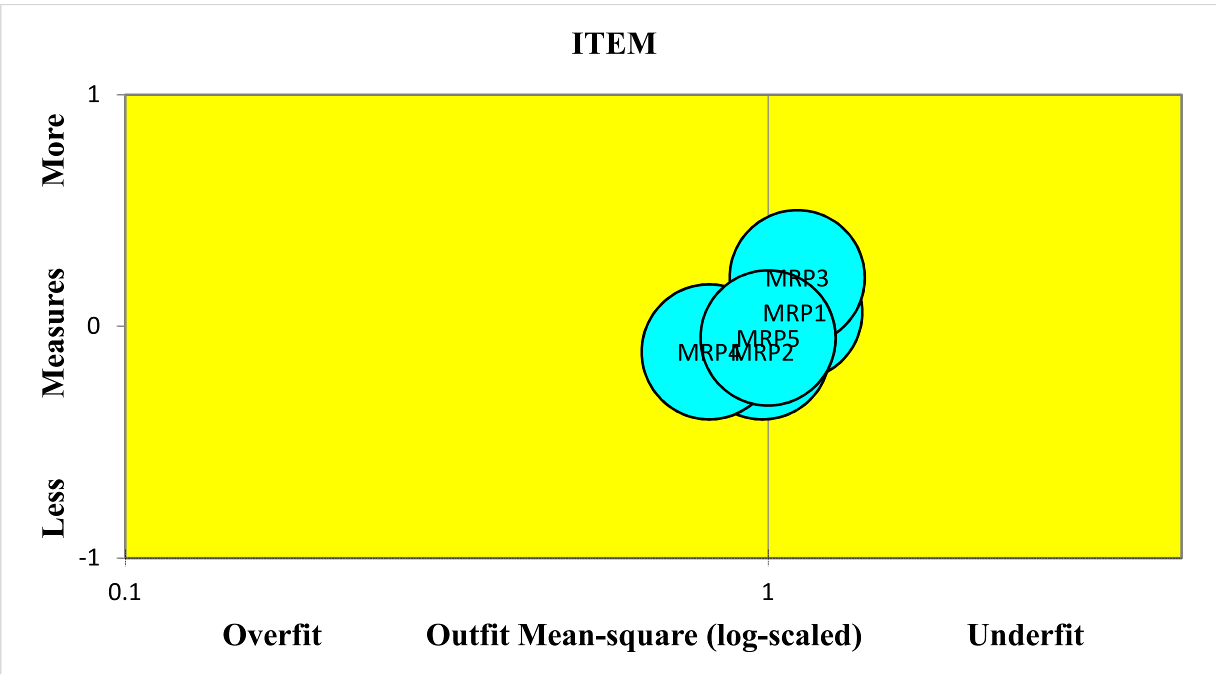

Figure 2: Bubble maps for item fit.

SEM Measurement

In our research, we proposed a hypotheses model in which self-perception of mathematics serves as a mediator between technological self-confidence and mathematical representations. Our initial

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SEM yielded the following fit indices: χ^2 (df = 116) = 411.327, p < 0.001, CFI = 0.75, TLI = 0.70, RMSEA = 0.08, SRMR = 0.05. Unfortunately, the CFI and TLI indicated a poor model fit. To improve the model fit, we made modifications (see Fig 3). The revised model demonstrated improved fit indices with χ^2 (df = 113) = 153.948, p < 0.001, CFI = 0.97, TLI = 0.96, RMSEA = 0.03, SRMR = 0.04, suggesting a much better fit to the data.

In Figure 3, we observe the SEM that provides valuable insights into the relationships between technological self-confidence, self-perception of mathematics, and mathematical representation among secondary education students. The results suggest a positive association between technological self-confidence and mathematical representation (β = 0.11, p = 0.10), although this direct relationship does not reach statistical significance. This indicates that higher levels of technological self-confidence may contribute to better mathematical representation, even though the effect is not strong. Additionally, technological self-confidence has a statistically significant positive association with self-perception of mathematics (β = 0.04, p < .05), highlighting that students with greater confidence in their technological abilities tend to have more positive self-perceptions about their mathematical skills. However, the relationship between self-perception of mathematics and mathematical representation reveals a negative association (β = -0.13, p > 0.05). This suggests that as students' self-perception of their mathematical abilities increases, their mathematical representation decreases, though the effect is not statistically significant. A noteworthy finding is that self-perception of mathematics mediates the relationship between technological self-confidence and mathematical representation with a negative association (β = -0.005, p < 0.05). This mediation suggests that the impact of technological self-confidence on mathematical representation is partially explained by students' self-perception of their mathematical abilities. The model fit for direct and indirect as also performed in table 6.

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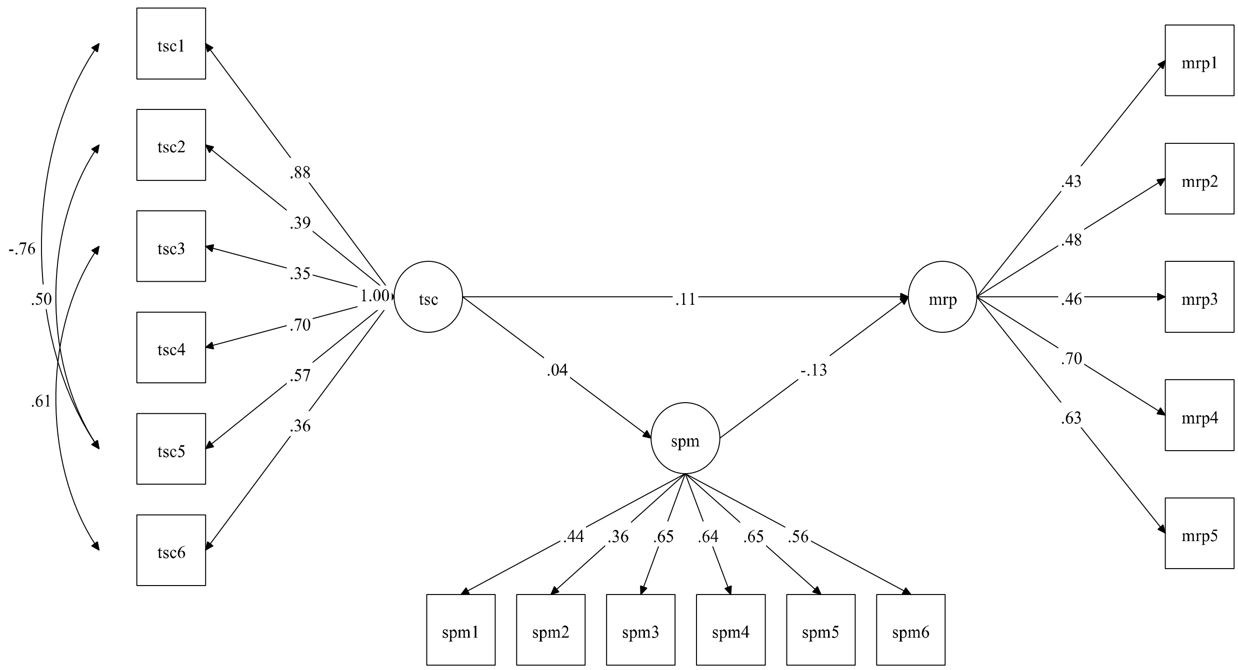

Figure 3: SEM model

Model Path	**Estimate**	***S.E.***	***p***	**Bootstrap 95% Confidence interval**	
				Lower	**Upper**
1. Technological self-confidence → Self-perception of mathematics	0.04	0.06	0.04	-0.07	0.14
2. Self-perception of mathematics → Mathematical representation	-0.13	0.07	0.08	-0.25	-0.03
3. Technological self-confidence → Self-perception of mathematics → Mathematical representation	-0.005	0.01	0.58	-0.03	0.00

Table 6: Path Model summary. Note: S.E. = Standard error.

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To assess the performance differences between male and female students, we analyzed the data using a violin plot. The Figure 4 violin plot visually depicts various variables, including students' mathematical representation. This type of plot, known as a violin plot, serves as an effective tool for comparing and visualizing a wide range of data. It provides insights into several key aspects of the data's distribution, such as its symmetry, the central value's location, and the dispersion of data observations. Essentially, the violin plot offers a comprehensive view of how data values are distributed, offering valuable insights into the dataset's characteristics (Potter et al., 2006). The detail of students' answer can be seen in Figure 5.

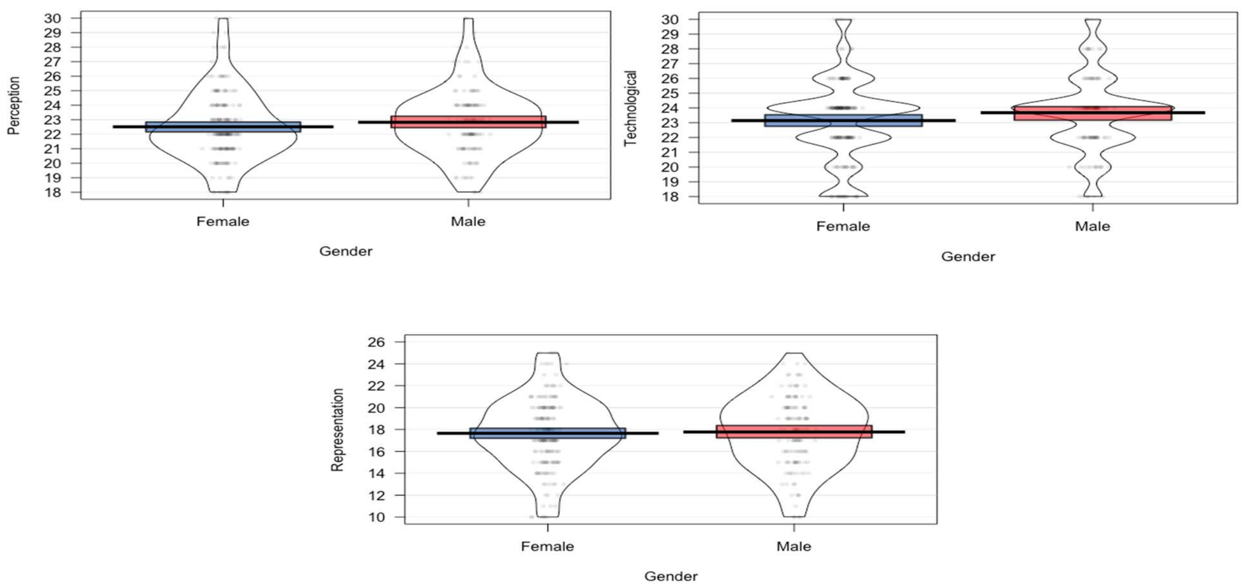

Figure 4: Violin plot of students performance across various variables.

Figure 4 displays the descriptive statistics for the variables in the study. The mean score for self-perception of mathematics was 22.64, with a standard deviation of 2.39. Technology self-confidence and mathematical representation had mean scores of 23.36 (SD = 2.77) and 17.70 (SD = 3.28), respectively. Moreover, we assessed the differences between male and female students in each variable category. The results indicated that there were no statistically significant differences between male and female students. Specifically, for mathematical representation, the t-value was -0.29, with $p > 0.05$, for self-perception of mathematics, the t-value was -1.18, with $p > 0.05$, and for technology self-confidence, the t-value was -1.95, with $p > 0.05$. The results of the statistical analysis indicate that there are no significant differences between male and female students in terms of mathematical representation, self-perception of mathematics, and technology self-confidence. In other words, both male and female students show similar performance and attitudes in these areas.

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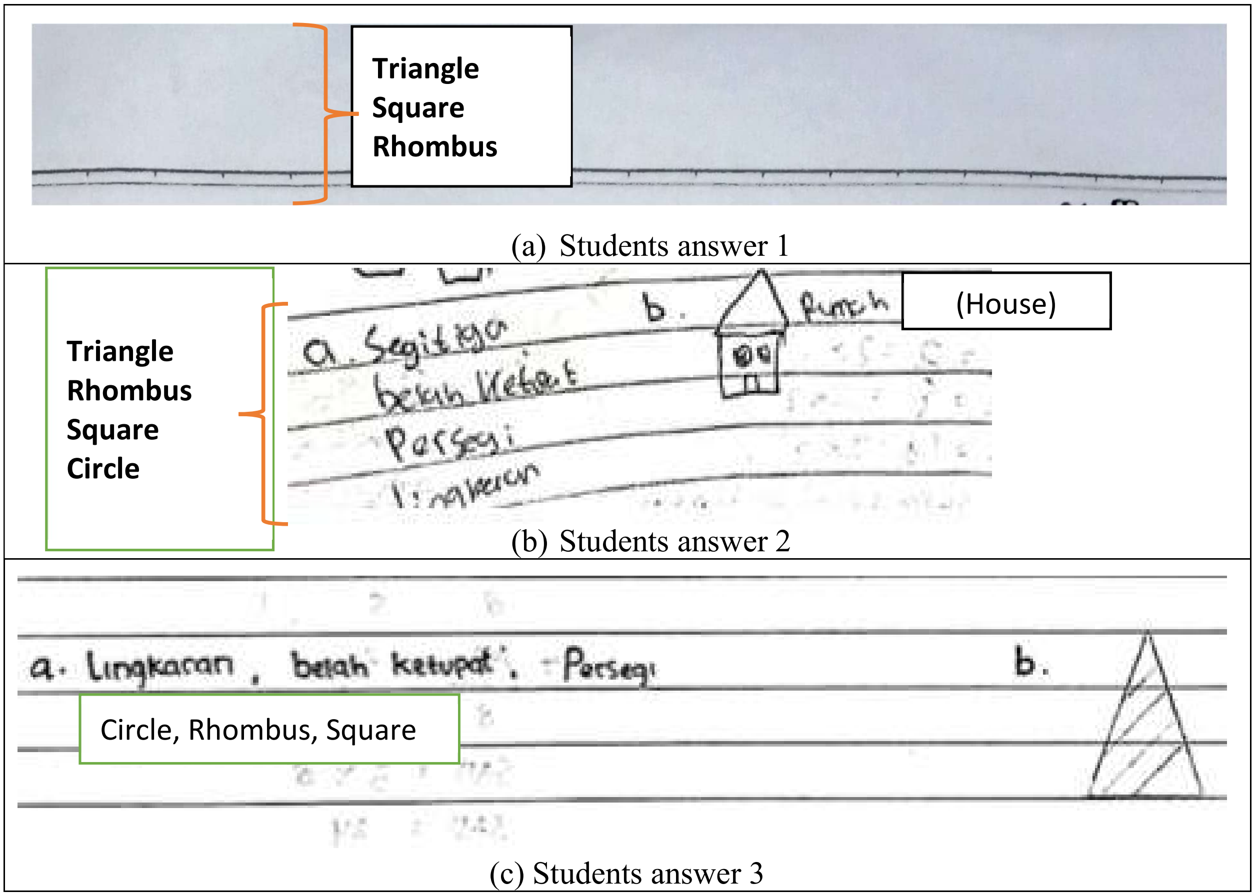

(a) Students answer 1

(b) Students answer 2

(c) Students answer 3

Figure 5: An example of students answer.

DISCUSSION

The main goal of this research was to explore the SEM that examines the relationships between technological self-confidence, self-perception of mathematics, and mathematical representation in secondary education.

The findings of our study revealed a direct association between technological self-confidence and mathematical representation, supporting our first hypothesis. This line was supported by previous research (Attard et al., 2016; Ke, 2014). This implies that fostering technological self-confidence among students may encourage them to engage with digital educational tools and enhance their mathematical representation skills. While the statistical effect may not be particularly robust, it is noteworthy that technological self-confidence could still play a part in improving mathematical representation. Individual variations among students, such as their previous encounters with technology (Byungura et al., 2018), familiarity with particular software or tools (Frowd et al., 2011),

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and preferred learning methods (Wishart, 2005), may all influence the extent to which technological self-confidence influences their mathematical representation abilities (Chen et al., 2015; Hartsell et al., 2010). Students who have good experience and confidence with technology tools can improve their skills and represent mathematical concepts more effectively (Kunhertanti & Santosa, 2018). Therefore, it can be inferred that there may be a direct association between technological self-confidence and mathematical representation, as students who are confident in their technological skills may be better able to represent mathematical concepts effectively. By addressing these points, teachers can help students develop their technological self-confidence and improve their mathematical representation abilities, mathematical creative thinking (Suherman & Vidákovich, 2022b), promote students' skill in solving algebraic problems (Khairunnisak et al., 2021), mastery mathematics (Maskur et al., 2022), and metaphorical thinking (Farida et al., 2022) ultimately enhancing their overall mathematical literacy and problem-solving skills (Supriadi et al., 2024).

The results of this study further revealed a statistically significant positive associated between technological self-confidence and self-perception of mathematics, thereby substantiating our second hypothesis. This discovery aligns with previous research by Chen et al. (2015) and Karatas et al. (2017), which proposed similar relationships. In essence, this finding suggests that students who exhibit higher levels of confidence in their technological skills also tend to hold more positive self-perceptions regarding their mathematical abilities. According to a study by Zander et al. (2020), students who exhibit higher levels of confidence in their technological skills also tend to hold more positive self-perceptions regarding their mathematical abilities. This finding suggests that self-efficacy, or the belief in one's ability to succeed in a particular task, can be transferable across domains. Other studies have also explored the relationship between self-perceived competence in mathematics and positive affect towards mathematics on mathematics achievement (Areepattamannil & Kaur, 2012), as well as the impact of self-efficacy on problem-posing and solving skills in mathematics (Görgün & Tican, 2020). Self-confidence has been observed as the greatest non-cognitive predictor for academic achievement among other self-belief measures such as self-efficacy and self-concept (Kaur & Prendergast, 2022). Therefore, it is important to foster self-efficacy and self-confidence in students to improve their performance in mathematics. Technology's significance in education is paramount, especially considering the foundational role attributed to mathematics as a core subject (Yanuarto et al., 2023). By acknowledging and leveraging this association, educators can create an environment where students feel more confident and capable in both technology and mathematics, ultimately leading to improved academic outcomes and a more positive attitude toward math.

Our study also identified a negative association between self-perception of mathematics and mathematical representation. This research is supported by Boyer & Mailloux (2015). Although there seems to be a general trend of decreasing mathematical representation as self-perception of mathematics increases, the presence of variations among students within the sample may obscure the

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overall effect. This phenomenon suggests that while, on average, higher self-perception of mathematics is linked to decreased mathematical representation (Skaalvik & Rankin, 1994), individual differences play a crucial role in shaping this relationship. Factors such as students' prior experiences, learning styles, and problem-solving approaches can contribute to these variations. Even exploring students' perceptions of mathematics allows us to grasp how the formation of mathematical knowledge unfolds (Rosa et al., 2020). Consequently, the overall effect is not as pronounced as one might expect.

In the context of the mediation analysis, our study has shed light on the intricate relationship among technological self-confidence, self-perception of mathematics, and mathematical representation. Specifically, our findings have revealed that self-perception of mathematics acts as a mediator in the relationship between technological self-confidence and mathematical representation. Importantly, this mediation process is characterized by a negative association, aligning with the hypothesis we initially posited (Hypothesis 3). The negative association observed in this mediation warrants a deeper exploration (Phan, 2009). It can potentially be attributed to several underlying factors that influence how students perceive their mathematical abilities and their actual mathematical representation skills (Helwig et al., 2001). This can lead to errors and difficulties in problem-solving tasks that demand strong mathematical representation skills (Sari & Rosjanuardi, 2018). While students with high technological self-confidence may exhibit a positive self-perception of their mathematical abilities (Ayuso et al., 2020), this may not necessarily translate into superior mathematical representation skills (Mullins et al., 2011). Furthermore, it's conceivable that students with strong technological self-confidence may overestimate their mathematical competencies (Foster, 2016). In light of these findings, it becomes evident that addressing mathematical representation skills among students should encompass a comprehensive approach that considers both their confidence levels and actual competencies. A positive self-perception alone may not be adequate to enhance their mathematical representation abilities. Educators and policymakers should strive to bridge the gap between students' confidence and competence in mathematics, recognizing the multifaceted nature of this relationship and integration technology in the classroom (Suherman et al., 2021).

In our analysis of students' performance, we observed no significant differences between male and female students concerning mathematical representation, self-perception of mathematics, and technology self-confidence (Hypothesis 4). This indicates that both male and female students exhibit similar levels of performance in these domains (Zhan et al., 2015). In other words, gender does not appear to be a significant factor influencing students' abilities (Mejía-Rodríguez et al., 2021) and confidence related to mathematical representation (Carr et al., 2008) and technology use in the context of mathematics (Sáinz & Eccles, 2012). This finding suggests that educational efforts and interventions aimed at improving mathematical representation and technology-related skills should be designed to benefit all students regardless of their gender, as there are no apparent gender-based disparities in this regard.

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LIMITATION AND FUTURE RESEARCH

This study has made significant contributions to our understanding of the intricate connections between technological self-confidence, self-perception of mathematics, and mathematical representation in the context of secondary education. However, it is crucial to acknowledge several limitations that should be considered in future research. First, the sample used in this study consisted of secondary education students from a specific geographic region, which could limit the generalizability of the findings. Future research should endeavour to include a more diverse and representative sample that encompasses a broader spectrum of backgrounds and contexts, such as primary or tertiary education, would provide a broader perspective on these relationships.

Second, the study relied on self-report measures for variables like technological self-confidence, self-perception of mathematics, and mathematical representation. While self-reports offer valuable insights, they may be subject to response bias and may not capture the full complexity of these constructs. Combining self-report measures with objective assessments could enhance the robustness of future research. Third, the cross-sectional design of this study provided a snapshot of the relationships at a particular moment. To gain deeper insights into the dynamics of these relationships, future research should adopt longitudinal designs that track changes over time. Lastly, it's important to note that some of the associations observed in this study did not reach statistical significance. Future research should delve into the factors contributing to these non-significant relationships to uncover the underlying mechanisms at play.

CONCLUSIONS

In summary, the findings of this study revealed several key associations and mediating relationships. First, technological self-confidence was positively associated with both self-perception of mathematics and mathematical representation. However, self-perception of mathematics exhibited a negative association with mathematical representation. Furthermore, our research demonstrated that self-perception of mathematics plays a mediating role in the relationship between technological self-confidence and mathematical representation, and this mediation is characterized by a negative association. Additionally, male and female students exhibit comparable performance in these domains. These results shed light on the intricate interplay between students' confidence in technology, their perceptions of their mathematical abilities, and their mathematical representation skills, offering valuable insights for educators and policymakers seeking to enhance mathematics education, digital literacy, and digital age in secondary education.

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