Universidad de Oviedo

Aula Abierta

Volumen 54, número 4, octubre-diciembre, 2025/págs. 399-411

The relationship between technological self-confidence and mathematical creative thinking in primary education: The mediating role of self-perception of mathematics

Meriyati Meriyati
Universitas Islam Negeri Raden Intan Lampung
Mail: meriyati@radenintan.ac.id • ORCID: https://orcid.org/0009-0008-1670-8843

Suherman Suherman*
University of Szeged. Universitas Islam Negeri Raden Intan Lampung
Mail: suherman@radenintan.ac.id • ORCID: https://orcid.org/0000-0002-1700-4177

Vigih Hery Kristanto
Politeknik Pelayaran Surabaya
Mail: vigih.hery@poltekpel-sby.ac.id • ORCID: https://orcid.org/0009-0000-8302-2253

Hidayatulloh Hidayatulloh
Universitas Muhammadiyah Pringsewu
Mail: hidayatulloh@umpri.ac.id • ORCID: https://orcid.org/0000-0002-8958-6276

Mardiyana Mardiyana
Universitas Sebelas Maret
Mail: mardiyana@staff.uns.ac.id • ORCID: https://orcid.org/0000-0002-8329-5355

Erny Untari
Universitas PGRI Madiun
Mail: erny.untari@unipma.ac.id • ORCID: https://orcid.org/0000-0002-8519-5884

Kristóf Lakatos
Eötvös Loránd University
Mail: lakatos.kristof@ppk.elte.hu • ORCID: https://orcid.org/0000-0002-1769-8535

Mujib Mujib
Universitas Islam Negeri Raden Intan Lampung
Mail: mujib@radenintan.ac.id • ORCID: https://orcid.org/0000-0003-3634-1790

ABSTRACT

In the digital era, mathematical creative thinking, technological self-confidence, and self-perception of mathematics were essential skills for success in a world driven by innovation and problem-solving. However, these variables had not been thoroughly investigated. This study invesitigated how self-perception of mathematics acted as a mediator between technological self-confidence and mathematical creative thinking. Data were collected from 502 primary school students (56.6% female), with an average age of 10.86 ± .77 year, using online questionnaires and tests. Structural equation modeling was employed to validate the constructs and measurement tools. The results revealed that technological self-confidence had a positive impact on mathematical creative thinking, while self-perception of mathematics also positively influenced mathematical creative thinking. Furthermore, self-perception of mathematics played a significant mediating role in the relationship between technological self-confidence and mathematical creative

*Autora de correspondencia: suherman@radenintan.ac.id

Recibido: 01/11/2025 – Aceptado: 03/14/2025

ISSN: 0210-2773
DOI: https://doi.org/10.17811/rifie.21914

thinking. This study highlighted the importance of incorporating technology and confidence-building strategies into mathematics curricula to better equip students for real-world problem-solving in a digital society.

Keywords: mathematical creative thinking, primary school students', self-perception of mathematics, structural equation modelling, technological self-confidence.

La relación entre la confianza tecnológica y el pensamiento creativo matemático en la educación primaria: El papel mediador de la autopercepción de las matemáticas

RESUMEN

En la era digital, el pensamiento creativo matemático, la confianza tecnológica y la autopercepción de las matemáticas fueron habilidades esenciales para el éxito en un mundo impulsado por la innovación y la resolución de problemas. Sin embargo, estas variables no habían sido investigadas a fondo. Este estudio investigó cómo la autopercepción de las matemáticas actuaba como mediador entre la confianza tecnológica y el pensamiento creativo matemático. Los datos fueron recogidos de 502 estudiantes de primaria (56,6% mujeres), con una edad promedio de 10,86 ± 0,77 años, utilizando cuestionarios y pruebas en línea. Se utilizó el modelado de ecuaciones estructurales para validar los constructos y las herramientas de medición. Los resultados revelaron que la confianza tecnológica tenía un impacto positivo en el pensamiento creativo matemático, mientras que la autopercepción de las matemáticas también influía positivamente en el pensamiento creativo matemático. Además, la autopercepción de las matemáticas desempeñó un papel mediador significativo en la relación entre la confianza tecnológica y el pensamiento creativo matemático. El estudio destaca la importancia de incorporar la tecnología y estrategias de auto-confianza en los planes de estudio de matemáticas, para preparar mejor a los estudiantes para la resolución de problemas del mundo real en una sociedad digital.

Palabras clave: pensamiento creativo matemático, estudiantes de educación primaria, autopercepción en matemáticas, modelado de ecuaciones estructurales, auto-confianza tecnológica.

1. Introduction

In the 21st century, the need for skills that promote innovation and problem-solving is more vital than ever (Cobo, 2013). As technology increasingly becomes an essential part of daily life (Owsley & Greenwood, 2024) and the workplace, it demands not only basic technical skills (Huang & Gursoy, 2024) but also the confidence to tackle complex technological tasks (Alieto *et al.*, 2024). This technological self-confidence (TSC) is crucial for students, empowering them to navigate new and ever-evolving challenges (Lucas *et al.*, 2009). At the same time, creative thinking in mathematics (MCT)—a skill that goes beyond traditional problem-solving—plays a vital role (Suherman & Vidákovich, 2024b). MCT includes elements such as fluency, flexibility, originality, and elaboration, enabling students to approach mathematical problems with innovative solutions (Suherman & Vidákovich, 2024a). Research consistently highlights the impact of self-perception and self-confidence on mathematical success education (Kaur & Prendergast, 2022). Self-perception of mathematics (SPM), or students' belief in their math capabilities, strongly correlates with academic performance, as students who view themselves as proficient in math tend to achieve better results (Passiatore *et al.*, 2024). This self-perception not only reflects their actual abilities but also influences their attitude and motivation toward learning math (Shih *et al.*, 2019). TSC, which reflects confidence in one's ability to use technology effectively, supports this goal (An *et al.*, 2022). A key challenge remains in guiding students to build both strong mathematical self-perception and technological confidence for a creative and rapidly advancing future.

The study by Ventrella and Cotnam-Kappel (2024) emphasized that the unequal distribution of technology devices (student-to-device; 1:1), with a gap between usage at school and at home, creates disparities in students' ability to effectively interact with digital technologies. This imbalance in access, along with the variation in device types, plays a significant role in shaping students' technological self-confidence, as their familiarity and comfort with technology depend heavily on the resources available to them. Furthermore, students with learning difficulties exhibited a significantly lower self-perception of their abilities (d = .70–1.3) compared to their peers without learning difficulties, across Grades 4 through 8 (Ragnarsdottir *et al.*, 2024). This reduced self-perception extends to their self-concept in mathematics, highlighting the added challenges that students with learning difficulties may face in both their mathematical performance and their confidence in the subject. Despite the importance of creative thinking skills, there are still many instances indicating that students often struggle to develop proficiency in this area. Research has shown that the creative thinking abilities of elementary and middle school students in mathematics remain at a low level, with 46.67% of students falling into this category (Nufus *et al.*, 2024). This suggests that improving creative thinking, particularly in the context of mathematics, is crucial for fostering students' overall academic development and confidence in their abilities.

Previous studies have clearly demonstrated a link between students' self-perception of their math abilities and their academic success. Numerous studies indicate that students who overestimate their math competence tend to have stronger performance approach goals and are more likely to endorse an entity theory of intelligence. These students also experience greater self-doubt and make more stable and generalized attributions based on their mathematics perceptions (Dupeyrat *et al.*, 2011; Reich & Arkin, 2006). Additionally, research highlights the importance of self-confidence in the adoption of digital tools for math learning. Students with greater technological self-confidence are more likely to engage with digital resources, positively affecting their math performance (Huang & Brainard, 2001). This study aims to explore how self-perception and technological self-confidence interact to influence students' MCT in primary education. While past research has examined the impact of self-perception on math achievement and technological self-confidence on tech usage, the combined effect on MCT quality and effectiveness has not been thoroughly investigated. Further research is needed to understand the role of these factors in shaping primary students' MCT, an area that remains underexplored.

This study aims to fill this gap by offering a comprehensive perspective on the complex factors affecting students' MCT. It examines the intricate relationships between SPM, TSC, and MCT, shedding light on the cognitive processes involved in mathematical problem-solving and communication. The subsequent sections of this article will cover relevant theories, methodologies, empirical findings, and discussions, all focused on improving our understanding of how self-perception and technological self-confidence influence MCT.

2. Theoretical framework

2.1. Technological self-confidence and MCT

Technological self-confidence refers to an individual's belief in their ability to effectively use and navigate digital tools and technologies (Ajisebutu *et al.*, 2024). It encompasses a sense of competence and assurance in navigating digital environments, solving technical challenges, and leveraging technology to achieve personal or professional goals (Wei, 2023). This construct is increasingly relevant in the digital age, as it successfully completing online or computer-based courses builds self-confidence and encourages students to take responsibility for their learning in the face of rapid technological change (Malureanu *et al.*, 2021; Ozuorcun & Tabak, 2012). Meanwhile MCT refers to an individual's ability to explore novel approaches when solving mathematical problems (Rahayuningsih *et al.*, 2021). It includes the skills required to generate solutions, analyze mathematical concepts, and assess students' understanding of these concepts (Suherman & Vidákovich, 2022b).

TSC is essential in modern education, especially in mathematics, where it influences students' ability to engage with software, use digital tools, and communicate mathematical ideas (Bolaños *et al.*, 2023; Cretchley, 2007; Roschelle *et al.*, 2000). TSC is closely linked to MCT, which involves generating multiple representations and innovative problem-solving approaches (Kharisudin, 2022; Sriraman, 2009). Research has shown a positive relationship between TSC and MCT, with high technological self-efficacy contributing to success in STEM fields and enhancing students' ability to use technology creatively (Attard *et al.*, 2016; Suherman *et al.*, 2021; Zeldin *et al.*, 2008). Additionally, studies suggest that students' self-perception of their technological abilities boosts creativity (Poon *et al.*, 2014), and emerging technologies foster creative confidence Liu *et al.* (2023). Design thinking approaches also promote creativity by encouraging exploration and idea generation through digital tools.

2.2. Self-perception of mathematics and MCT

SPM refers to an individual's belief in their ability to successfully solve mathematical problems (Tully & Jacobs, 2010). According to Marsh *et al.* (1991), there is a reciprocal relationship between self-perception of ability and academic achievement, where increased confidence in mathematical skills enhances performance, and vice versa. In other words, SPM encompasses affective, cognitive, and behavioral components, including emotional attitudes toward mathematics, personal beliefs about one's abilities, and tendencies to engage with or avoid the subject (Fernández-Andújar *et al.*, 2022; Herman & Kerby-Helm, 2022).

Self-perception in mathematics plays a crucial role in fostering students' MCT. When students have a positive view of their mathematical abilities (Tully & Jacobs, 2010), they approach problems with confidence and openness to exploring unconventional solutions (Krummheuer *et al.*, 2013). This mindset encourages flexible, original problem-solving (Schoevers *et al.*, 2019) and supports academic success in mathematics. Research shows that students with strong SPM engage more deeply with mathematical concepts, enhancing their creative problem-solving skills (Makri-Botsari & Psycharis, 2008). For example, Suherman & Vidákovich (2024b) found that high SPM is linked to better performance on tasks requiring creative mathematical thinking. Self-efficacy, closely tied to SPM, tt is a critical component of self-perception in mathematics, which also includes math self-concept—general feelings about one's competence in math (Sakellariou, 2022), also impacts problem-solving approaches, with students who have higher SPM displaying greater mathematical creativity (Voica *et al.*, 2020). The connection between mathematics self-concept and achievement was reinforced in PISA 2012, showing a positive relationship between a strong self-perception and improved performance in mathematics (Ding *et al.*, 2024). Thus, nurturing positive SPM is essential for boosting students' creative thinking abilities (Khalil & Prahmana, 2024; Nufus *et al.*, 2024).

2.3. Mediating role of SPM

The mediating role of SPM in the connection between TSC and MCT is based on the concept that self-perception affects both how students approach mathematical tasks and their use of technological tools (Kim, 2008; Montague & Van Garderen, 2003). Research supports this notion, indicating that students with high TSC are more inclined to use technology creatively in math (Psycharis & Kotzampasaki, 2019), and this relationship is stronger when they also have a positive self-perception of their mathematical abilities (Park *et al.*, 2012). Zeldin *et al.* (2008) found that technological self-efficacy is positively linked to engagement in STEM fields, particularly when students have a strong self-view of their mathematical skills. Additionally, the TSC also influences SPM (Rosales-Márquez *et al.*, 2025). Students with high self-confidence in technology are generally more motivated to develop digital skills, as they view the use of technologies as a challenge to overcome, similar to mathematics. Thus, SPM acts as a mediator, influencing how students' technological confidence translates into creative problem-solving in mathematics. This idea is consistent with Bandura (1997) work on self-efficacy and creativity.

2.4. The present study

The present study explores the relationship between TSC and MCT in primary education, with a particular focus on the mediating role of SPM. As technology becomes increasingly integrated into education (Szymkowiak *et al.*, 2021), students' confidence in using digital tools may influence their ability to approach mathematical problems creatively ideas (Bolaños *et al.*, 2023; Cretchley, 2007; Roschelle *et al.*, 2000). Self-perception in mathematics, which reflects students' beliefs about their own abilities (Shen & Pedulla, 2000), is expected to play a crucial role in shaping this relationship. Using data from primary school students, this study employs structural equation modeling to examine how TSC impacts MCT both directly and indirectly through SPM. Therefore, we predict significant interconnections among these factors in primary school students. Accordingly, we formulated four hypotheses (H1-H4), which are outlined below

H1: TSC positively affects MCT.

H2: SPM positively predict students' MCT.

H3: TSC positively correlated with the SPM of the students'.

H4: SPM positively mediates the association between TSC and MCT.

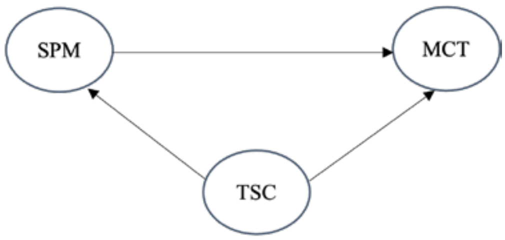

Figure 1. *Conceptual model.* Own elaboration

3. Methods

3.1. Participants

The study employed a cross-sectional design, involving 502 primary school students from Bandar Lampung, Indonesia. We randomly selected 15 classes from a total of five schools, focusing on grades 4 through 6. Data were collected online using a *Google Form*. The sample included 284 females (56.6%) and 218 males (43.4%), with a mean age of 10.86 years (*SD* = .77). Ethical approval was granted by the Institutional Review Board of Universitas Islam Negeri Raden Intan Lampung, ensuring compliance with ethical guidelines. Informed consent was obtained from all participants before their involvement in the study. Detailed sample characteristics can be found in Table 1.

Table 1
Detailed characteristic of the participants. Own elaboration

Characteristic	Category	Frequency	Percentage (%)
Gender	Female	284	56.6
	Male	218	43.4
School-type	Public	43	8.6
	Private	459	91.4
Grade	4th	322	64.1
	5th	61	12.2
	6th	119	23.7
Age	10 years	191	38.0
	11 years	192	38.2
	12 years	119	23.7
Place of residence	City	176	35.1
	Suburban	326	64.9

3.2. Instruments

In our study, participants completed a questionnaire with 10 items. They also answered four test items aimed at measuring their mathematical creative thinking skills. Additionally, demographic information such as age, gender, place of residence, and school type was collected. Further details regarding the instruments used in the study will be shared.

The SPM questionnaire consisted of five items, adapted from Suherman & Vidákovich (2022a), and was translated and validated for the Indonesian context to assess students' views and feelings about their mathematical abilities. Example items included «I am really good at math. (S1), I understand math. (S2), I can solve difficult math problems (S3), Math is very hard for me (S4), and I can tell if my answers in maths make sense (S5).» Participants responded to these statements using a six-point Likert scale, where 6 indicated *strongly agree* and 1 indicated *strongly disagree*. The questionnaire demonstrated a Cronbach's alpha of .79, with McDonald's coefficient omega also yielding a value of .79. The scale's validity and reliability were thoroughly evaluated in the study.

The TSC questionnaire used in this study consisted of five items designed to assess participants' confidence in their ability to perform technologically advanced tasks. Example items included «I have a lot of self-confidence when it comes to working with computers (T1), I am sure I could do work with computers (T2), I could get good grades in computer courses (T3), Generally I would feel OK about trying a new problem on the computer (T4), and I am sure I could learn a computer language (T5).» This questionnaire was adapted from Francis *et al.* (2000). Participants rated their agreement with the statements on a six-point Likert scale, where 6 represented *strongly agree* and 1 represented *strongly disagree*. The reliability of the questionnaire, as indicated by Cronbach's alpha, was .85. The validity and reliability of this scale were also evaluated in the study.

The MCT test in this study assessed students' problem-solving abilities in terms of fluency, flexibility, elaboration, and originality, adapted from Suherman and Vidakovich (2022c). Responses were scored on predefined criteria, with fluency and flexibility scored up to 6, and originality based on percentages (0 for scores above 3%, 1 for 2-3%, 2 for 1-2%, and 3 for below 1%). An example of the instrumen is in Table 2. The reliability and validity of the instrument were evaluated, and all students were required to complete the test.

Table 2
MCT test (M1)

Picture	Questions
	The pictures are part of Tapis Lampung with geometry motifs. a. Make a list of flat shapes you find in the Tapis Lampung motifs! b. Draw a picture using at least one flat shape from your list. You can combine two, three, or more flat shapes to create a unique image. Finally, give your drawing a name!

Note. Elaborate from Suherman and Vidakovich (2022c)

3.3. Procedure and data analysis

In the first phase of the study, the assessment instruments were translated into Indonesian and reviewed by an expert and two mathematics teachers to ensure clarity and relevance. Each school principal was contacted and provided with a formal letter outlining the study's objectives. Seven classes were randomly selected from five primary schools in Bandar Lampung, Indonesia, resulting in 602 students participating in the study. Data collection was conducted using paper-pencil tests.

For data analysis, several software tools were utilized, including Smart PLS version 4, SPSS version 29, R software, and Winstep. Confirmatory factor analysis (CFA) was performed on questionnaire data to assess validity and reliability, while Winstep software was used to evaluate the test items within the Rasch measurement framework. Reliability was measured using Cronbach's Alpha, composite reliability (CR), and average variance extracted (AVE), while discriminant validity was assessed through the heterotrait-monotrait (HTMT) criterion. Descriptive statistics, such as mean (*M*) and standard deviation (*SD*), were calculated. Structural equation modeling (SEM) was used to test the hypothetical model, with model fit assessed using various indices, including CFI, TLI, RMSEA, and SRMR. Criteria proposed by Hu & Bentler (1999) were followed to evaluate fit, with visual representations of relationships created in R software to provide insights into students' performances.

4. Results

4.1. Validity and reliability of the item questionnaires

Table 3 illustrates the validity and reliability of the data. For MCT, the items showed factor loadings ranging from .653 to .782. The reliability of MCT was evaluated using Cronbach's Alpha (α = .678), Composite Reliability (CR = .804), and AVE = .507, indicating acceptable internal consistency and convergent validity. The SPM variable was measured using five items, with factor loadings ranging from .743 to .800. The reliability values for SPM were strong, with Cronbach's Alpha of .836, CR of .884, and AVE of .605. Similarly, TSC was measured using five items, with factor loadings ranging from .749 to .798. The reliability for TSC was also robust, with Cronbach's Alpha of .831, CR of .881, and AVE of .597. These results indicate reliable and valid measures for all three variables.

Table 3
Loading factors, reliability, and validity among variables. Own elaboration

Variable	Item No.	Loading factors	Cronbach Alpha	CR	AVE
MCT	M1	.689	.678	.804	.507
	M2	.782			
	M3	.717			
	M4	.653			
SPM	S1	.800	.836	.884	.605
	S2	.743			
	S3	.798			
	S4	.787			
	S5	.759			
TSC	T1	.798	.831	.881	.597
	T2	.753			
	T3	.781			
	T4	.780			
	T5	.749			

4.2. Discriminant Validity

Table 3 shows the discriminant validity of the constructs in this study, evaluated using the HTMT criterion (Henseler *et al.*, 2015). The values in Table 4 range from .447 to 1.066, indicating that the constructs are adequately separated. This suggests that each construct is more closely related to its own indicators than to those of other constructs, thus reinforcing the validity of the measurement model in this study.

Table 4

Discriminant validity using Fornell-Larcker Criterion. Own elaboration

	1	2	3
1. MCT	.712		
2. SPM	.347	.778	
3. TSC	.349	.891	.773

4.3. Descriptive statistics and correlations among items

Table 5 presents the descriptive statistics and correlations for the three primary variables in this study. Descriptive statistics (see Table 5) showed that all variables had skewness and kurtosis values within acceptable limits, suggesting no severe deviations from normality.

Correlational analysis revealed notable relationships between the variables. The strongest correlation was observed between TSC and SPM, with a $r = .88$, indicating that students with higher confidence in technology also tended to have a more positive self-perception of their mathematical abilities. Additionally, moderate positive correlations were found between MCT and both TSC ($r = .33$, $p < .01$) and SPM ($r = .34$, $p < .01$), suggesting that higher self-confidence in technology and a more positive self-perception of mathematics are associated with higher levels of mathematical creative thinking.

Table 5

Descriptive statistics and correlations. Own elaboration

Variables	M	SD	Skewness	Kurtosis	1	2	3
1. TSC	3.75	.87	.06	-.42	—		
2. SPM	3.83	.88	-.03	-.76	.88**	—	
3. MCT	4.01	.66	-.27	.98	.33**	.34**	—

**$p < .01$

4.4. SEM evaluation

In our study, we proposed a hypothesis model (see Fig. 1), which demonstrated improved fit indices: ($df = 74$) = 23.614, $p < .001$, CFI = .90, TLI = .90, RMSEA = .02, SRMR = .04, indicating a strong fit to the data. The results (see Fig. 2) showed a positive correlation between TSC and MCT (= .194, $p = < .001$), suggesting that higher levels of TSC enhance MCT. Additionally, TSC was strongly associated with SPM (= .891, $p = < .001$), implying that students with greater TSC also tend to have a more positive view of their mathematical abilities. Furthermore, SPM positively influenced MCT (= .174, $p > .05$), indicating that an improved SPM skills leads to greater creative thinking in mathematics. Table 6 outlines the direct and indirect effects of these variables. To explore how SPM mediates the relationship between TSC and MCT, bootstrapping with 5,000 iterations was used. The results confirm that SPM plays a significant mediating role, with a positive mediation effect between TSC and MCT (= .155, $p < .001$).

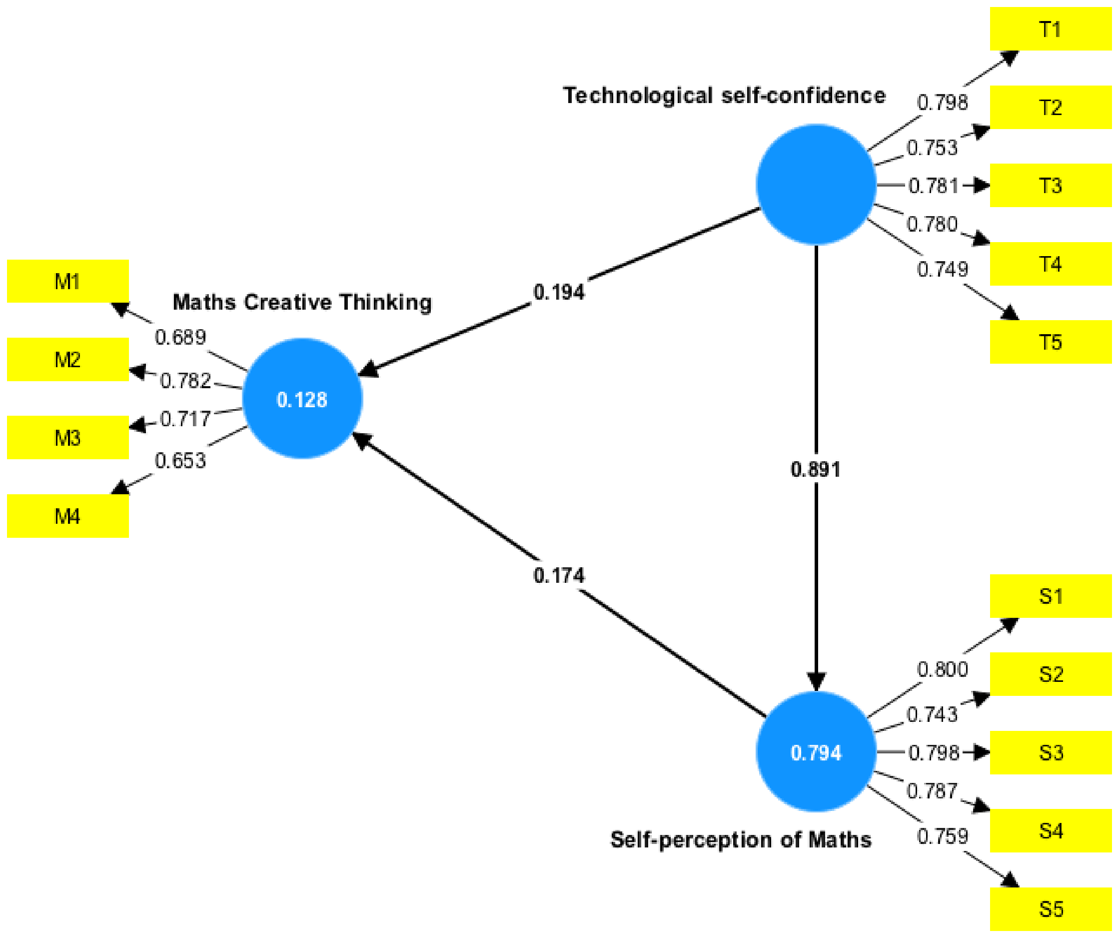

Figure 2. *SEM model data. Smart PLS software outcome elaboration*

Table 6
Bootstrapping of the variables outcome. Own elaboration

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*p* values
SPM -> MCT	0.174	0.183	0.121	1.433	> .05
TSC -> MCT	0.349	0.353	0.042	8.370	< .001
TSC -> SPM	0.891	0.891	0.019	47.550	< .001
TSC -> SPM -> MCT	0.155	0.164	0.110	1.416	< .05

5. Discussion

This studs was to examined the mediating role of SPM in relationship bewteen TSC and MCT. Our study found a direct link between TSC and MCT, supporting the first hypothesis (H1). This result is consistent with previous studies emphasizing the role of technology in enhancing cognitive abilities and creative problem-solving in mathematics (Attard *et al.*, 2016; Liu *et al.*, 2023; Poon *et al.*, 2014; Zeldin *et al.*, 2008) noted that self-perception in technology can boost creativity, and our findings suggest that TSC is a core factor driving creative thinking in mathematics. This aligns with research on technology-enhanced learning, which indicates that technological confidence encourages risk-taking, experimentation, and higher-order thinking, all essential for mathematical creativity (Kirkwood & Price, 2014). Moreover, variations in students' technological experiences, familiarity with specific tools (Byungura *et al.*, 2018), and attitude (Barkatsas *et al.*, 2009) can influence how TSC impacts creativity (Tang *et al.*, 2022). Those with strong technology skills are better equipped to represent mathematical concepts effectively (Kunhertanti & Santosa, 2018). These factors suggest that fostering technological self-confidence in students can enhance their creative thinking and overall mathematical abilities (Farida *et al.*, 2022; Supriadi *et al.*, 2024).

The results of this study revealed a significant positive relationship between SPM and MCT, confirming the second hypothesis (H2). This finding aligns with prior research (Cai *et al.*, 2024; Khalil & Prahmana, 2024; Krummheuer *et al.*, 2013; Nufus *et al.*, 2024; Schoevers *et al.*, 2019; Voica *et al.*, 2020), suggesting that students who view themselves as competent in mathematics are more likely to engage in MCT. This supports the idea that self-perception plays a key role in influencing cognitive and creative processes in academic settings. For example, Suherman and Vidakovich (2024b) found that students with higher SPM tend to perform better in tasks requiring creative thinking. Their research highlights how self-perception serves as a mediator, boosting students' confidence and encouraging them to explore diverse problem-solving strategies, leading to more original solutions.

Additionally, positive SPM has been shown to promote confidence and creativity in approaching problems (Mann, 2009). Karwowski (2016) also found that students with high self-perceived competence in mathematics are more likely to engage in creative problem-solving, feeling capable of overcoming complex challenges. Self-perception is strongly linked to self-efficacy, which Bandura (1997) identified as crucial for creative thinking. Individuals with high self-efficacy are more likely to persist in challenging tasks and explore creative solutions. These findings emphasize the importance of fostering students' self-perception of their mathematical abilities, which enhances their cognitive and creative potential in the subject. To support this, educators should employ strategies that not only strengthen mathematical skills but also positively impact students' self-perception. Encouraging a growth mindset, offering positive feedback (Whalen *et al.*, 2024), and creating a supportive learning environment (Ragnarsdottir *et al.*, 2024) can help students develop a more positive self-perception of their abilities, ultimately fostering greater creativity in mathematical thinking. This approach can lead to more innovative mathematical problem-solvers and improved academic success.

The findings of this study also revealed a statistically significant positive relationship between TSC and SPM, confirming the third hypothesis (H3). This result aligns with previous studies by Chen *et al.* (2015) and Karatas *et al.* (2017), which found similar connections between technological confidence and self-perception in mathematics. Specifically, the study suggests that students who are more confident in their technological skills are also more likely to have a positive self-view of their mathematical abilities. Zander *et al.* (2020) similarly concluded that TSC can positively influence SPM, indicating that self-efficacy—the belief in one's ability to succeed in specific tasks—can transfer across different areas.

Other research has further explored the relationship between self-perceived competence in mathematics and positive attitudes toward the subject, showing that these perceptions impact math achievement (Areepattamannil & Kaur, 2012). Additionally, self-efficacy has been shown to affect students' problem-posing and problem-solving skills in mathematics (Görgün & Tican, 2020). Notably, self-confidence has been identified as the most significant noncognitive predictor of academic success, surpassing other self-belief measures such as self-efficacy and self-concept (Kaur & Prendergast, 2022). Therefore, promoting self-efficacy and self-confidence in students is essential for improving their performance in mathematics. Allows individuals to share experiences through creative activities, fostering mutual understanding and collaborative problem-solving (Guaman-Quintanilla *et al.*, 2022). Considering the foundational role of mathematics in education (Yanuarto *et al.*, 2023), leveraging this relationship can help educators create an environment where students feel more capable and confident in both technology and mathematics, ultimately leading to better academic outcomes and a more positive attitude toward the subject.

Our mediation analysis reveals the complex relationship between TSC, SPM, and MCT. The findings show that SPM mediates the relationship between TSC and MCT, with a positive correlation supporting our fourth hypothesis (H4). This result is in line with earlier studies (Kim, 2008; Montague & Van Garderen, 2003; Psycharis & Kotzampasaki, 2019; Zeldin *et al.*, 2008). While strong technological self-confidence can lead to a positive self-perception of mathematical abilities (Ayuso *et al.*, 2020), it does not always translate into better mathematical skills (Mullins *et al.*, 2011). Moreover, students with high technological self-confidence might sometimes overestimate their mathematical abilities (Foster, 2016). Therefore, improving MCT skills requires a balanced approach that considers both students' confidence levels and their actual mathematical competencies. Furthermore, addressed their motivational and cognitive engagement (Vieites *et al.*, 2024).

6. Limitation and future research

A notable limitation of this study is its use of a cross-sectional design, which captures participants' self-perceptions and abilities at only one point in time. This design restricts the ability to draw causal conclusions about how changes in TSC or SPM may influence MCT over time. Furthermore, the sample was mainly drawn from private schools, potentially introducing bias, as students in these schools may have different educational resources and support compared to those in public schools. This sampling imbalance may limit the generalizability of the findings to a wider student population. Additionally, while the self-report questionnaires and tests were validated, they are still susceptible to biases such as social desirability or inaccurate self-assessments from participants.

Future research could address these limitations by employing a longitudinal design to track changes in students' self-perception, technological confidence, and mathematical creative thinking over time, providing a clearer understanding of causality and developmental trends. Expanding the sample to include a more representative mix of public and private school students, as well as participants from diverse geographical regions, would improve the generalizability of the results. Future studies could also explore the impact of specific educational interventions aimed at boosting TSC and SPm, offering valuable insights into how these factors can be developed to enhance MCT skills. Additionally, incorporating qualitative methods such as interviews or focus groups could provide a more in-depth understanding of the underlying factors influencing students' self-perceptions and technological confidence.

7. Conclusions

In conclusion, the positive influence of TSC on MCT, mediated by SPM, emphasizes the importance of developing both TSC and a strong SPM among students. These findings suggest the need for educational strategies that not only integrate technology in meaningful ways but also focus on enhancing students' confidence in their mathematical abilities. As education continues to adapt in the digital age, these insights are crucial for preparing students to meet the complex problem-solving challenges of the future. Furthermore, the study highlights the importance of incorporating technology into mathematics education to foster both student confidence and creativity, particularly in the context of 21st-century learning. It also provides valuable guidance for educators and policymakers seeking to improve mathematics instruction and digital literacy in primary education.

Acknowledgements

We are thankful to the Universitas Islam Negeri Raden Intan Lampung, Indonesia for their research funding support. We also thank the Doctoral School of Education, the University of Szeged, Universitas Muhammadiyah Pringsewu, Politeknik Pelayaran Surabaya, Universitas Sebelas Maret, Universitas PGRI Madiun, and Eötvös Loránd University, which provided suggestions and discussions for an idea in the research view.

References

Ajisebutu, A. E., Adetayo, A., Okediji, O. G., & Enamudu, A. I. (2024). Information Technology Self-Efficacy and Library Portal Use in Nigerian Universities. *Journal of Digital Learning and Education*, *4*(3), 223–236. https://doi.org/10.52562/jdle.v4i3.1273

Alieto, E., Abequibel-Encarnacion, B., Estigoy, E., Balasa, K., Eijansantos, A., & Torres-Toukoumidis, A. (2024). Teaching inside a digital classroom: A quantitative analysis of attitude, technological competence and access among teachers across subject disciplines. *Heliyon*, *10*(2), e24282. https://doi.org/10.1016/j.heliyon.2024.e24282

An, F., Xi, L., Yu, J., & Zhang, M. (2022). Relationship between technology acceptance and self-directed learning: Mediation role of positive emotions and technological self-efficacy. *Sustainability*, *14*(16), art. 10390. https://doi.org/10.3390/su141610390

Areepattamannil, S., & Kaur, B. (2012). Influences of Self-Perceived Competence in Mathematics and Positive Affect toward Mathematics on Mathematics Achievement of Adolescents in Singapore. In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Mathematics education: Expanding horizons* (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia). Mathematics Education Research Group of Australasia.

Attard, C., Mountain, G., & Romano, D. M. (2016). Problem solving, confidence and frustration when carrying out familiar tasks on non-familiar mobile devices. *Computers in Human Behavior*, *61*, 300–312. https://doi.org/10.1016/j.chb.2016.03.001

Ayuso, N., Fillola, E., Masiá, B., Murillo, A. C., Trillo-Lado, R., Baldassarri, S., Cerezo, E., Ruberte, L., Mariscal, M. D., & Villarroya-Gaudó, M. (2020). Gender gap in STEM: A cross-sectional study of primary school students' self-perception and test anxiety in mathematics. *IEEE Transactions on Education*, *64*(1), 40–49. https://doi.org/10.1109/TE.2020.3004075

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.

Barkatsas, A. T., Kasimatis, K., & Gialamas, V. (2009). Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement. *Computers & Education*, *52*(3), 562–570. https://doi.org/10.1016/j.compedu.2008.11.001

Bolaños, F., Salinas, Á., & Pilerot, O. (2023). Instructional techniques and tools reported as being used by teachers within empirical research focusing on in-class digital ability development: A literature review. *Journal of Computers in Education*, *10*(1), 57–81. https://doi.org/10.1007/s40692-022-00222-2

Byungura, J. C., Hansson, H., Muparasi, M., & Ruhinda, B. (2018). Familiarity with Technology among First-Year Students in Rwandan Tertiary Education. *Electronic Journal of E-Learning*, *16*(1), 30-45.

Cai, M., Luo, H., Meng, X., & Liu, J. (2024). Exploring the multidimensional impact of ICT on academic achievement and mental health: Evidence from a large-scale survey of higher vocational students in China. *Journal of Computer Assisted Learning*, *40*(4), 1898–1921. https://doi.org/10.1111/jcal.12995

Chen, M.-J., Lee, C.-Y., & Hsu, W.-C. (2015). Influence of mathematical representation and mathematics self-efficacy on the learning effectiveness of fifth graders in pattern reasoning. *International Journal of Learning, Teaching and Educational Research*, *13*(1), 1-16.

Cobo, C. (2013). Skills for innovation: Envisioning an education that prepares for the changing world. *The Curriculum Journal*, *24*(1), 67–85. https://doi.org/10.1080/09585176.2012.744330

Cretchley, P. (2007). Does computer confidence relate to levels of achievement in ICT-enriched learning models? *Education and Information Technologies*, *12*, 29–39. https://doi.org/10.1007/s10639-006-9004-6

Ding, Y., Klapp, A., & Yang Hansen, K. (2024). The importance of mathematics self-concept and self-efficacy for mathematics achievement: A comparison between public and independent schools in Sweden. *Educational Psychology*, *44*(8), 872–892. https://doi.org/10.1080/01443410.2024.2410217

Dupeyrat, C., Escribe, C., Huet, N., & Régner, I. (2011). Positive biases in self-assessment of mathematics competence, achievement goals, and mathematics performance. *International Journal of Educational Research*, *50*(4), 241–250. https://doi.org/10.1016/j.ijer.2011.08.005

Farida, F., Supriadi, N., Andriani, S., Pratiwi, D. D., Suherman, S., & Muhammad, R. R. (2022). STEM approach and computer science impact the metaphorical thinking of Indonesian students'. *Revista de Educación a Distancia (RED)*, *22*(69), art. 3. https://doi.org/10.6018/red.493721

Fernández-Andújar, M., Alonso, M. O., Sorribes, E., Villalba, V., & Calderon, C. (2022). Internet addiction, phubbing, psychological variables and self-perception of mathematical competence in college students. *Mathematics*, *10*(15), art. 2631. https://doi.org/10.3390/math10152631

Foster, C. (2016). Confidence and competence with mathematical procedures. *Educational Studies in Mathematics*, *91*, 271–288. https://doi.org/10.1007/s10649-015-9660-9

Francis, L. J., Katz, Y. J., & Jones, S. H. (2000). The reliability and validity of the Hebrew version of the Computer Attitude Scale. *Computers & Education*, *35*(2), 149–159. https://doi.org/10.1016/S0360-1315(00)00022-1

Görgün, S., & Tican, C. (2020). Investigation of Middle School Students' Math Self-Efficacy Perceptions and Math Problem Posing Attitudes. *International Education Studies*, *13*(11), 86–98. https://doi.org/10.5539/ies.v13n11p86

Guaman-Quintanilla, S., Chiluiza, K., Bravo Matamoros, A., Everaert, P., & Valcke, M. (2022). What is the state of the art regarding the application of Design Thinking in Higher Education? A scoping review. *Aula Abierta*, *51*(4), 319–328. https://doi.org/10.17811/rifie.51.4.2022.319-328

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Herman, J., & Kerby-Helm, A. (2022). Question of the Week: Can a Low-Stakes Assignment Improve Students' Attitudes? *Journal of Statistics and Data Science Education*, *30*(1), 39–44. https://doi.org/10.1080/26939169.2021.2020697

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Huang, P. M., & Brainard, S. G. (2001). Identifying determinants of academic selfconfidence among science, math, engineering, and technology students. *Journal of Women and Minorities in Science and Engineering*, *7*(4). https://doi.org/10.1615/JWomenMinorScienEng.v7.i4.40

Huang, Y., & Gursoy, D. (2024). How does AI technology integration affect employees' proactive service behaviors? A transactional theory of stress perspective. *Journal of Retailing and Consumer Services*, *77*, art. 103700. https://doi.org/10.1016/j.jretconser.2023.103700

Karatas, H., Bademcioglu, M., & Celik, S. (2017). A study on the relationship between problem solving skills and multiple intelligences of high school students. *International Journal of Education and Practice*, *5*(10), 171–181. https://doi.org/10.18488/journal.61.2017.510.171.181

Karwowski, M. (2016). The dynamics of creative self-concept: Changes and reciprocal relations between creative self-efficacy and creative personal identity. *Creativity Research Journal*, *28*(1), 99–104. https://doi.org/10.1080/10400419.2016.1125254

Kaur, T., & Prendergast, M. (2022). Students' perceptions of mathematics writing and its impact on their enjoyment and self-confidence. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, *41*(1), 1–21. https://doi.org/10.1093/teamat/hrab008

Khalil, I. A., & Prahmana, R. C. I. (2024). Mathematics Learning Orientation: Mathematical Creative Thinking Ability or Creative Disposition?. *Journal on Mathematics Education*, *15*(1), 253–276. https://doi.org/10.22342/jme.v15i1.pp253-276

Kharisudin, I. (2022). Analysis of Mathematical Creative Thinking Skill: In Terms of Self Confidence. *International Journal of Instruction*, *15*(4), 1011–1034. https://doi.org/10.29333/iji.2022.15454a

Kim, D. J. (2008). Self-Perception-Based Versus Transference-Based Trust Determinants in Computer-Mediated Transactions: A Cross-Cultural Comparison Study. *Journal of Management Information Systems*, *24*(4), 13–45. https://doi.org/10.2753/MIS0742-1222240401

Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: What is 'enhanced' and how do we know? A critical literature review. *Learning, Media and Technology*, *39*(1), 6–36. https://doi.org/10.1080/17439884.2013.770404

Krummheuer, G., Leuzinger-Bohleber, M., Müller-Kirchof, M., Münz, M., & Vogel, R. (2013). Explaining the mathematical creativity of a young boy: An interdisciplinary venture between mathematics education and psychoanalysis. *Educational Studies in Mathematics*, *84*(2), 183–199. https://doi.org/10.1007/s10649-013-9505-3

Kunhertanti, K., & Santosa, R. H. (2018). The influence of students' self confidence on mathematics learning achievement. *Journal of Physics: Conference Series*, *1097*(1), art. 012126. https://doi.org/10.1088/1742-6596/1097/1/012126

Liu, Y.-L. E., Lee, T.-P., & Huang, Y.-M. (2023). Enhancing university students' creative confidence, learning motivation, and team creative performance in design thinking using a digital visual collaborative environment. *Thinking Skills and Creativity*, *50*, art. 101388. https://doi.org/10.1016/j.tsc.2023.101388

Lucas, W. A., Cooper, S. Y., Ward, T., & Cave, F. (2009). Industry placement, authentic experience and the development of venturing and technology self-efficacy. *Technovation*, *29*(11), 738–752. https://doi.org/10.1016/j.technovation.2009.06.002

Makri-Botsari, E., & Psycharis, S. (2008). Enhancing Motivation, School Competence and Self-perception of Physics in the Environment of the Cognitive Tutor CTAT during Physics Instruction. In M. D. Lytras, J. M. Carroll, E. Damiani, R. D. Tennyson, D. Avison, G. Vossen, & P. Ordonez De Pablos (Eds.), *The Open Knowlege Society. A Computer Science and Information Systems Manifesto* (pp. 342–353). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-87783-7_44

Malureanu, A., Panisoara, G., & Lazar, I. (2021). The relationship between self-confidence, self-efficacy, grit, usefulness, and ease of use of elearning platforms in corporate training during the COVID-19 pandemic. *Sustainability*, *13*(12), art. 6633. https://doi.org/10.3390/su13126633

Mann, E. L. (2009). The search for mathematical creativity: Identifying creative potential in middle school students. *Creativity Research Journal*, *21*(4), 338–348. https://doi.org/10.1080/10400410903297402

Marsh, H. W., Walker, R., & Debus, R. (1991). Subject-specific components of academic self-concept and self-efficacy. *Contemporary Educational Psychology*, *16*(4), 331–345. https://doi.org/10.1016/0361-476X(91)90013-B

Montague, M., & Van Garderen, D. (2003). A Cross-Sectional Study of Mathematics Achievement, Estimation Skills, and Academic Self-Perception in Students of Varying Ability. *Journal of Learning Disabilities*, *36*(5), 437–448. https://doi.org/10.1177/00222194030360050501

Mullins, D., Rummel, N., & Spada, H. (2011). Are two heads always better than one? Differential effects of collaboration on students' computer-supported learning in mathematics. *International Journal of Computer-Supported Collaborative Learning*, *6*, 421–443. https://doi.org/10.1007/s11412-011-9122-z

Nufus, H., Muhandaz, R., Nurdin, E., Ariawan, R., Fineldi, R. J., Hayati, I. R., & Situmorang, D. D. B. (2024). Analyzing the students' mathematical creative thinking ability in terms of self-regulated learning: How do we find what we are looking for? *Heliyon*, *10*(3), e24871. https://doi.org/10.1016/j.heliyon.2024.e24871

Owsley, C. S., & Greenwood, K. (2024). Awareness and perception of artificial intelligence operationalized integration in news media industry and society. *AI & Society*, *39*(1), 417–431. https://doi.org/10.1007/s00146-022-01386-2

Ozuorcun, N. C., & Tabak, F. (2012). Is m-learning versus e-learning or are they supporting each other? *Procedia-Social and Behavioral Sciences*, *46*, 299–305. https://doi.org/10.1016/j.sbspro.2012.05.110

Park, H., Lawson, D., & Williams, H. E. (2012). Relations between Technology, Parent Education, Self-Confidence, and Academic Aspiration of Hispanic Immigrant Students. *Journal of Educational Computing Research*, *46*(3), 255–265. https://doi.org/10.2190/EC.46.3.c

Passiatore, Y., Costa, S., Grossi, G., Carrus, G., & Pirchio, S. (2024). Mathematics self-concept moderates the relation between cognitive functions and mathematical skills in primary school children. *Social Psychology of Education*, *27*(3), 1143–1159. https://doi.org/10.1007/s11218-023-09854-3

Poon, J. C., Au, A. C., Tong, T. M., & Lau, S. (2014). The feasibility of enhancement of knowledge and self-confidence in creativity: A pilot study of a three-hour SCAMPER workshop on secondary students. *Thinking Skills and Creativity*, *14*, 32–40. https://doi.org/10.1016/j.tsc.2014.06.006

Psycharis, S., & Kotzampasaki, E. (2019). The impact of a STEM inquiry game learning scenario on computational thinking and computer self-confidence. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(4), em1689. https://doi.org/10.29333/ejmste/103071

Ragnarsdottir, G. B., Petursdottir, A.-L., Sigurdardottir, Z. G., Stefansson, K. K., & Oskarsdottir, H. (2024). The development of self-perception of ability in Icelandic children with and without specific learning difficulties. *European Journal of Psychology of Education*, *39*(1), 55–76. https://doi.org/10.1007/s10212-023-00688-3

Rahayuningsih, S., Sirajuddin, S., & Ikram, M. (2021). Using Open-ended Problem-solving Tests to Identify Students' Mathematical Creative Thinking Ability. *Participatory Educational Research*, *8*(3), 285–299. https://doi.org/10.17275/per.21.66.8.3

Reich, D. A., & Arkin, R. M. (2006). Self-doubt, attributions, and the perceived implicit theories of others. *Self and Identity*, *5*(02), 89–109. https://doi.org/10.1080/15298860500441965

Rosales-Márquez, C., Carbonell-García, C. E., Miranda-Vargas, V., Diaz-Zavala, R., & Laura-De La Cruz, K. M. (2025). Self-confidence as a predictor of digital skills: A fundamental pillar for the digitalization of higher education. *Frontiers in Education*, *9*, art. 1515033. https://doi.org/10.3389/feduc.2024.1515033

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *The Future of Children*, *10*(2), 76–101. https://doi.org/10.2307/1602690

Sakellariou, C. (2022). The reciprocal relationship between mathematics self-efficacy and mathematics performance in US high school students: Instrumental variables estimates and gender differences. *Frontiers in Psychology*, *13*, 941253. https://doi.org/10.3389/fpsyg.2022.941253

Schoevers, E. M., Leseman, P. P., Slot, E. M., Bakker, A., Keijzer, R., & Kroesbergen, E. H. (2019). Promoting pupils' creative thinking in primary school mathematics: A case study. *Thinking Skills and Creativity*, *31*, 323–334. https://doi.org/10.1016/j.tsc.2019.02.003

Shen, C., & Pedulla, J. J. (2000). The relationship between students' achievement and their self-perception of competence and rigour of mathematics and science: A cross-national analysis. *Assessment in Education: Principles, Policy & Practice*, *7*(2), 237–253. https://doi.org/10.1080/713613335

Shih, J., Ing, M., Phelan, J., Brown, R., & Maiorca, C. (2019). The Influence of Students' Self-Perceptions and Mathematics Experiences on Learning More Mathematics in the Future. *Investigations in Mathematics Learning*, *11*(3), 220–229. https://doi.org/10.1080/19477503.2019.1582960

Sriraman, B. (2009). The characteristics of mathematical creativity. *ZDM-Mathematics Education*, *41*(1–2), 13–27. https://doi.org/10.1007/s11858-008-0114-z

Suherman, S., Setiawan, R. H., Herdian, H., & Anggoro, B. S. (2021). 21st century STEM education: An increase in mathematical critical thinking skills and gender through technological integration. *Journal of Advanced Sciences and Mathematics Education*, *1*(2), 33–40. https://doi.org/10.58524/jasme.v1i2.29

Suherman, S., & Vidákovich, T. (2022a). Adaptation and Validation of Students' Attitudes Toward Mathematics to Indonesia. *Pedagogika*, *147*(3), 227–252. https://doi.org/10.15823/p.2022.147.11

Suherman, S., & Vidákovich, T. (2022b). Assessment of mathematical creative thinking: A systematic review. *Thinking Skills and Creativity*, *44*, art. 101019. https://doi.org/10.1016/j.tsc.2022.101019

Suherman, S., & Vidakovich, T. (2022). Tapis Patterns in the Context of Ethnomathematics to Assess Students' Creative Thinking in Mathematics: A Rasch Measurement. *Mathematics Teaching Research Journal*, *14*(4), 56–72.

Suherman, S., & Vidákovich, T. (2024a). Relationship between ethnic identity, attitude, and mathematical creative thinking among secondary school students. *Thinking Skills and Creativity*, *51*, art. 101448. https://doi.org/10.1016/j.tsc.2023.101448

Suherman, S., & Vidákovich, T. (2024b). Role of creative self-efficacy and perceived creativity as predictors of mathematical creative thinking: Mediating role of computational thinking. *Thinking Skills and Creativity*, *53*, art. 101591. https://doi.org/10.1016/j.tsc.2024.101591

Supriadi, N., Jamaluddin Z, W., & Suherman, S. (2024). The role of learning anxiety and mathematical reasoning as predictor of promoting learning motivation: The mediating role of mathematical problem solving. *Thinking Skills and Creativity*, *52*, art. 101497. https://doi.org/10.1016/j.tsc.2024.101497

Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people. *Technology in Society*, *65*, art. 101565. https://doi.org/10.1016/j.techsoc.2021.101565

Tang, C., Mao, S., Naumann, S. E., & Xing, Z. (2022). Improving student creativity through digital technology products: A literature review. *Thinking Skills and Creativity*, *44*, art. 101032. https://doi.org/10.1016/j.tsc.2022.101032

Tully, D., & Jacobs, B. (2010). Effects of single-gender mathematics classrooms on self-perception of mathematical ability and post secondary engineering paths: An Australian case study. *European Journal of Engineering Education*, *35*(4), 455–467. https://doi.org/10.1080/03043797.2010.489940

Ventrella, F. M., & Cotnam-Kappel, M. (2024). Examining digital capital and digital inequalities in Canadian elementary schools: Insights from teachers. *Telematics and Informatics*, *86*, art. 102070. https://doi.org/10.1016/j.tele.2023.102070

Vieites, T., Iglesias, A., Freire, F. M. D., Pita, L. D., & Llorente, C. R. (2024). Motivación, enfoques de trabajo en los deberes escolares y rendimiento académico en estudiantes de Educación Secundaria Obligatoria [Motivation, homework approaches and academic performance in high school students]. *Aula Abierta*, *53*(3), 229–237. https://doi.org/10.17811/rifie.20555

Voica, C., Singer, F. M., & Stan, E. (2020). How are motivation and self-efficacy interacting in problem-solving and problem-posing? *Educational Studies in Mathematics*, *105*(3), 487–517. https://doi.org/10.1007/s10649-020-10005-0

Wei, Z. (2023). Navigating Digital Learning Landscapes: Unveiling the Interplay Between Learning Behaviors, Digital Literacy, and Educational Outcomes. *Journal of the Knowledge Economy*, *15*(3), 10516–10546. https://doi.org/10.1007/s13132-023-01522-3

Whalen, K. A., Renkl, A., Eitel, A., & Glogger-Frey, I. (2024). Digital re-attributional feedback in high school mathematics education and its effect on motivation and achievement. *Journal of Computer Assisted Learning*, *40*(2), 478–493. https://doi.org/10.1111/jcal.12889

Yanuarto, W. N., Maat, S. M., Setyanigsih, E., Isnawan, M. G., & Zakaria, M. I. (2023). The Moderating Model of Teaching Anxiety on Teaching Beliefs and TPACK Effect to ICT Literacy among Pre-Service Mathematics Teachers. *Mathematics Teaching Research Journal*, *15*(3), 50–72.

Zander, L., Höhne, E., Harms, S., Pfost, M., & Hornsey, M. J. (2020). When grades are high but self-efficacy is low: Unpacking the confidence gap between girls and boys in mathematics. *Frontiers in Psychology*, *11*, art. 552355. https://doi.org/10.3389/fpsyg.2020.552355

Zeldin, A. L., Britner, S. L., & Pajares, F. (2008). A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *45*(9), 1036–1058. https://doi.org/10.1002/tea.20195