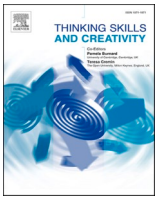
Thinking Skills and Creativity 51 (2024) 101448

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: www.elsevier.com/locate/tsc



Relationship between ethnic identity, attitude, and mathematical creative thinking among secondary school students

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ARTICLE INFO

Keywords:
Mathematical creative thinking
Attitude toward mathematics
Ethnic identity
Secondary school
Structural equation modeling

ABSTRACT

Several studies have investigated the relationship between attitude, ethnicity, and mathematical creative thinking among secondary school students. Nonetheless, there is a lack of information regarding how ethnicity serves as a mediator in the correlation between attitude towards mathematics and mathematical creative thinking. To address this gap, the current study employed a descriptive correlational structural equation model to examine a hypothetical model. A survey was conducted among 896 secondary school students, consisting of 415 males and 481 females. Descriptive and correlational data analysis was performed using SPSS and Mplus. Ethnicity/culture and attitude significantly promoted creativity in mathematics, suggesting that an increase in ethnicity leads to a better attitude toward mathematics and higher mathematical creative thinking. Additionally, a positive relationship was observed between attitude toward mathematics and mathematical creative thinking, indicating that students who have positive attitude are more likely to perform creative thinking. Mathematical creative thinking increased as attitude and ethnicity increased. Overall, the correlation between attitude and ethnicity was significantly impacted by the promotion of critical thinking skills in mathematics. These findings are beneficial for mathematics educators in designing more effective courses that align with 21st century educational trends.

1. Introduction

Mathematics is well-known in both traditional and non-traditional societal cultural activities (Kelly, 2019). Thus, these endeavors encompass notions of ethnomathematics or cultural mathematical concepts and recognize the significance of creative thinking (CT) in realizing that every culture (ethnic identity) and corresponding attitudes entail distinctive approaches and intricate justifications to comprehend and alter their respective realities. Mathematics assessment tool incorporates both realistic and cultural aspects, namely ethnomathematics within the framework of mathematical creative thinking (MCT). A previous research found that attitude (J. Liu et al., 2021) and culture (Rouland et al., 2014) are the factor influencing CT.

The significance of mathematics education as an indispensable facet of a comprehensive education has been acknowledged for quite some time (Adler, 2017), as it imparts students with essential competencies and information vital to contemporary society (English & Halford, 2012). Despite this, many students struggle with mathematics (Xin, 2019), developing negative attitudes toward the subject that can have lasting impacts on their academic and personal lives (Aguilera-Hermida, 2020). On the contrary, pupils who

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https://doi.org/10.1016/j.tsc.2023.101448
Received 23 March 2023; Received in revised form 2 December 2023; Accepted 4 December 2023
Available online 10 December 2023

have a deeper understanding and respect for mathematics may demonstrate greater motivation to engage in creative ways of thinking and investigate mathematical concepts in unconventional ways (Matsko & Thomas, 2014). Furthermore, issues of ethnic identity can exacerbate these difficulties, with students from diverse backgrounds often facing additional challenges in accessing and engaging with mathematics (Franke et al., 2007). In other words, different cultural backgrounds can significantly shape the impact of factors such as age, gender, or environment on a child's creative cognitive abilities (Shah & Gustafsson, 2021).

The past few years have witnessed a surge in the interest towards MCT as a feasible remedy for these predicaments (Bart et al., 2015; Durnali et al., 2023; Puspitasari et al., 2018; Wannapiroon & Pimdee, 2022). In this line, it is important to recognize that MCT is crucial to addressing various challenges in the field. By developing this skill, students may be able to overcome a negative attitude toward mathematics (ATM) and engage more meaningfully with the subject (Taşkin & Sezer, 2022), while also promoting greater understanding and appreciation of diverse cultures and perspectives (Porter et al., 2022). Previous research has shown that a positive ATM is crucial for academic success (Berger et al., 2020), with negative attitudes linked to lower achievement (Barkatsas et al., 2009), decreased motivation (White et al., 2019), and lower participation in science, technology, engineering, and math fields (Butler-Barnes et al., 2021). In other words, attitude is more powerful and significantly associated with creative thinking skill variables (Basadur et al., 2000). Similarly, Sánchez et al. (2022) research revealed that certain participants articulated a link between students' attitudes and the formulation of activities, particularly in terms of fostering students' creativity. Additionally, research has suggested that students' attitude closely linked with their creative thinking abilities. Furthermore, research has demonstrated the importance of ethnic identity in shaping educational experiences, with students from diverse backgrounds facing additional challenges in accessing and engaging with mathematics (Zhao et al., 2005). Therefore, the specific relationship between ethnic identity and dialectical thinking demonstrates a positive association with creativity (Paletz & Peng, 2009). Alt et al. (2023) elucidated that concerning controlled variables related to student characteristics, ethnicity emerged as a significant factor in the creativity post-test. The researcher emphasized the importance of diverse attitudes (Hidayatullah & Csíkos, 2023) and considering the influence of cultural backgrounds (Mims et al., 2022) to stimulate creative thinking in the context of mathematics.

Although there has been some research on the role of positive ATM and cultural understanding in promoting positive MCT, the literature remains relatively limited. Furthermore, there has been little research on the specific relationship between MCT, ATM, and ethnic identity. This paper investigated the relationship between MCT, ATM, and ethnic identity. This would provide insights into the potential of MCT as promoting positive ATM and foster greater cultural understanding and appreciation. Our findings would have significant implications for mathematics education and diversity and inclusion initiatives, highlighting the importance of promoting MCT as a key component of a modern, equitable, and effective education system. The primary objectives of this study were to address the subsequent research inquiries:

1. To what extent do ATM and ethnic identity intersect with MCT?
2. What impacts do exogenous variables have on endogenous variables (ATM on ethnic identity, ATM on MCT, and ethnic identity on MCT)?
3. Is there any mediating effect of ethnic identity on the relationship between ATM and MCT?

2. Theoretical Background

2.1. MCT

The assessment of creativity through creative products has generally been centered on employing divergent production tests, such as those created by Guilford (1959) and Torrance (1966). A subject is provided with an issue with various solutions or a circumstance with multiple reactions, which is a common feature of such assessments. Students must learn critical thinking, and analysis abilities that can be used in many aspects of life. As they acquire the required mathematics in the framework of ethnomathematics, students build talents, enhanced creativity, and a solid set of research habits. This indicates that ethnomathematics refer to mathematical notions integrated with cultural practices and recognizes that peoples' cultures generate unique strategies and complex explanations to know and change their reality (Rosa & Orey, 2011). Ethnomathematics, encompassing diverse cultural perspectives and practices related to mathematics, provides a rich context for students to engage with mathematical concepts in varied real-life settings. This exposure to different cultural approaches fosters a deeper understanding and appreciation of mathematics (Meng & Liu, 2022), allowing students to perceive it as a dynamic and adaptable discipline.

MCT refers to the ability to approach mathematical problems in a flexible, innovative, and open-minded manner, using creativity and imagination to explore new solutions and perspectives (Kharisudin, 2022; Sadak et al., 2022; Sengil-Akar & Yetkin-Ozdemir, 2022). Creativity and CT are often associated with artistic endeavors, but they are also essential in problem-solving across various domains, including mathematics. MCT refers to the ability to generate original and innovative solutions to mathematical problems by thinking outside the box and employing non-traditional approaches (Munakata et al., 2021). It involves the ability to think outside the box, develop unique approaches to problem-solving, draw connections between seemingly unrelated concepts (Moore-Russo & Demler, 2018), the application of imagination, intuition, and divergent thinking to mathematical concepts and problems, and the development of new ideas, concepts, and solutions that are not constrained by conventional thinking (Beghetto & Kaufman, 2014).

Previous research has defined MCT as a multi-dimensional construct that encompasses several cognitive processes, including flexibility, originality, elaboration, and fluency. Suherman & Vidákovich (2022b) defined MCT refers to the proficiency of creating unique and innovative resolutions to mathematical problems by employing different strategies, procedures, and heuristics that involve flexible and divergent thinking. This definition emphasizes the importance of not only arriving at a correct solution, but also the

process of generating new and original ideas and strategies. The authors noted that MCT involves several components, including fluency, flexibility, originality, and elaboration, and can be applied to a wide range of mathematical tasks and problems. Similarly, Daher et al. (2020) highlighted the role of intuition and divergent thinking in developing MCT skills.

Several theoretical frameworks have been proposed to explain creativity, including the componential theory of creativity by Amabile (2011) and the systems model of creativity by Fulton & Paton (2016). The componential theory suggests that creativity is influenced by three main components: domain-relevant skills, creativity-relevant processes, and task motivation. Meanwhile, the systems model proposes that creativity is a product of the interaction between the individual, the domain, and the field.

Szabo et al. (2020) presented a framework of MCT, which includes three dimensions: fluency and flexibility (the ability to generate a variety of ideas and approaches to a problem), originality and novelty (the ability to come up with unique and innovative solutions to a problem), and elaboration and transformation (the ability to develop and refine ideas by expanding on them and transforming them in new ways). These dimensions are interconnected and necessary for effective mathematical problem-solving and the development of 21st century skills. The framework emphasized the importance of fostering mathematical creativity in education to prepare students for future challenges and opportunities. Overall, these theoretical frameworks and previous studies suggest that creativity and CT are important components of mathematical problem-solving and that individuals who exhibit higher levels of creativity may be better equipped to engage in MCT.

2.2. Attitudes toward mathematics (ATM)

ATM refers to an individual's positive or negative feelings, beliefs, and perceptions about mathematics and its relevance and importance in their lives (Soni & Kumari, 2017). It includes components such as interest, confidence, enjoyment, motivation, and anxiety of the subject. ATM plays a significant role in students' academic achievement, persistence in mathematics, and future career choices (Sithole et al., 2017; Yildirim, 2017; Yu & Singh, 2018) and various factors such as teaching methods, classroom environment, cultural and social background, and personal experiences influence ATM. Measurement and improvement of attitude in mathematics are important goals in mathematics education (Lin et al., 2016). A framework proposed by Fennema & Sherman (1976) and Attitude Toward Mathematics Inventory (ATMI) (Tapia & Marsh, 2004) identified three (confidence, interest, and perceived usefulness) and four (confidence, value, enjoyment, and motivation) dimensions of ATM, respectively. and these dimensions are positively correlated with students' achievement in the subject (Tapia & Marsh, 2004).

Previous studies have indicated that students who possess a favorable attitude towards mathematics (ATM) exhibit higher academic achievement in the subject and demonstrate a greater likelihood of pursuing math-related disciplines and vocations (Ceci & Williams, 2010). Additionally, ATM has been shown to be impacted by variables including gender, ethnicity, and socioeconomic status (SES) (Forgasz et al., 2004). According to a study, there is a positive correlation between students' enthusiasm for mathematics and their involvement in the process of problem-solving and exploration of mathematical concepts (Schindler & Bakker, 2020). Hence, understanding of students' ATM is important for educators and researchers as it can help inform interventions and strategies to improve students' engagement and performance in the subject.

2.3. Ethnic identity

The examination of ethnic identity has been a topic of research due to its significance for identity formation and psychological wellbeing (Rivas-Drake et al., 2014). In an effort to produce a meaningful measure of ethnic identification, the Multigroup Ethnic Identity Measure, consisting of 14 items, was created by Phinney (1992), which analyzes three components of ethnic identity: positive ethnic attitudes and belonging, ethnic identity achievement, and ethnic behaviors. Existing research demonstrates that ethnic identity is directly correlated with significant outcome variables, such as individuals' coping techniques with prejudice.

There are a number of theoretical frameworks that have been used to study ethnic identity. One of the most influential models is the Social Identity Theory (Hogg, 2016), which suggests that an individual's sense of identity is shaped by their membership in social groups, such as gender, race, ethnicity, or religion. According to this theory, individuals form an identity in part through their comparison of their own group to other groups. Thus, ethnic identity may be strengthened by intergroup contact and comparison, as well as by factors such as shared cultural practices and values. Another theoretical framework that has been used to study ethnic identity is the Developmental Niche Theory (Rogoff, 2003), which suggests that an individual's development is shaped by the interplay between three environments: the physical environment, the social environment, and the cultural environment. According to this theory, ethnic identity may be strengthened by exposure to and participation in cultural practices and traditions, as well as by the support and guidance of parents and other family members.

Previous research has identified a number of factors that can influence the development and expression of ethnic identity (Richardson et al., 2015; Trimble, 2007; Umaña-Taylor et al., 2013; Williams & Lewis, 2021; Woo et al., 2020). These include age, gender, SES, cultural values, discrimination and prejudice, and intergroup contact. For example, research by Richardson et al. (2015) has shown that individuals who experience discrimination based on their ethnicity may have a stronger sense of ethnic identity as a way to cope with the negative experiences. One recent study by Umaña-Taylor et al. (2013) examined the relationship between family ethnic socialization and ethnic identity among Latino adolescents and explored whether this relationship was a family-driven, youth-driven, or reciprocal process. The results of the study showed that family ethnic socialization was positively associated with ethnic identity exploration and affirmation among Latino adolescents (Umaña-Taylor et al., 2013). In addition, the study found that the relationship between family ethnic socialization and ethnic identity was a reciprocal process, meaning that family ethnic socialization practices were both influenced by and influenced adolescents' ethnic identity development. In other words, adolescents

who were more engaged in exploring and affirming their ethnic identity were more likely to receive family ethnic socialization practices that supported their ethnic identity, and these practices, in turn, further facilitated the adolescents' ethnic identity development.

A theoretical figure that has been used to conceptualize ethnic identity is the Ethnic Identity Development Model proposed by Phinney (1990). The model suggests that individuals move through three stages in the development of ethnic identity: (1) the unexamined stage, where individuals have little awareness of their ethnic identity; (2) the exploration stage, where individuals begin to explore their ethnic identity and what it means to them; and (3) the achieved stage, where individuals have a clear sense of their ethnic identity and are comfortable expressing it to others. The model also suggests that individuals may move back and forth between stages as they encounter new experiences and challenges related to their ethnic identity.

2.4. Relationship between attitude and creativity

ATM and MCT are closely linked, as students' attitudes and beliefs about mathematics can have a notable influence on their ability to engage in creative and innovative mathematical thinking (P.-H. Liu & Niess, 2006). Studies have demonstrated that students with positive ATM are more motivated, persistent, and likely to engage in creative problem-solving strategies (Higgins, 1997; Lubienski, 2000; Scherer & Gustafsson, 2015; Stipek, 2002). Positive attitudes can also lead increased self-efficacy (Poortvliet & Darnon, 2014), or confidence in one's ability to succeed in mathematics (Christensen & Knezek, 2020; Suryadi & Santoso, 2017), which in turn can support advanced and creative mathematical thinking (Mann, 2009). On the other hand, students who have negative ATM are more likely to avoid or disengage from mathematical tasks (Gunderson et al., 2012), leading to lower levels of motivation and fewer opportunities for CT (Hussein & Csíkos, 2023). Negative attitudes can also contribute to feelings of anxiety or self-doubt, which can interfere with the cognitive processes involved in CT (Amin et al., 2023). A possible reason for this disparity is that students who exhibit a positive ATM are more inclined to partake in MCT activities (Bevan & Capraro, 2021). In other words, students who enjoy and value mathematics may be more motivated to think creatively and explore mathematical ideas in novel ways (Matsko & Thomas, 2014), and those who engage in MCT activities may develop a greater appreciation for the subject. Similarly, a study by Yoon et al. (2015) found that students' attitude was significantly changed correlated with their creativity in learning programs. Furthermore, Existing research, links ATM to creativity (De-La-Peña et al., 2021), mathematical achievement (Pásztor et al., 2015), and mathematical problem-solving (Cooper et al., 2018). In summary, the relationship between ATM and MCT is important and become more useful for students. While positive attitudes can support and enhance CT, negative attitudes can hinder it. Hence, our foundation is to explore the relationship between ATM and students' MCT.

2.5. Relationship between attitude and ethnicity

The relationship between ethnic identity and ATM is an important area of research in education. Studies have suggested a relationship between students' ethnic identity and their ATM. A study by Butty (2001) found that Black and Hispanic students who receive in mathematics classes has an effect on their mathematics achievement and students' ATM. Another study by Townsend & Belgrave (2000) shown that attitude is predictor for students racial identity. Verdín & Godwin (2018) found that Latino students who participated in a mathematics program that incorporated elements of their cultural background had higher levels of mathematics self-efficacy and a stronger sense of ethnic identity. Therefore, there is an opportunities linked between positive attitude and different ethnicities in education (Byrd & Legette, 2022).

Overall, the relationship between ATM and ethnicity is important, and is influenced by a range of cultural and social factors. While students from minority ethnic groups are more likely to have negative ATM, interventions aimed at improving attitudes toward the subject can benefit students from diverse backgrounds. It is critical to recognize that ethnic identity is a complex and multifaceted construct that is influenced by a range of factors including cultural and societal norms, family background, and individual experiences. ATM can also be influenced by diverse factors, including teaching practices, curriculum, and personal factors (self-efficacy and motivation).

2.6. Relationship between creativity and ethnicity

The relationship between MCT/creativity and ethnic identity has been explored in recent studies. The study by Kozlowski & Si (2019) explored the potential of mathematical creativity as a tool for fostering equity in mathematics education. The authors argued that traditional approaches to mathematics education often favor certain forms of knowledge and ways of thinking, resulting in inequitable outcomes for students from diverse backgrounds. They remarked that emphasizing mathematical creativity can help to challenge these inequities and create a more inclusive and equitable learning environment. By emphasizing flexible and imaginative thinking, teachers can create a more inclusive and engaging learning environment that values and recognizes the diverse backgrounds and experiences of all students. Paletz & Peng (2009) examined the relationship between naive dialectical thinking (the ability to perceive and integrate contradictory information), ethnicity, and creativity. The researchers discovered that respondents who indicated elevated levels of naive dialectical thinking achieved higher scores on measures of creativity and Asian participants scored higher on measures of naive dialectical thinking compared to European American participants. However, they did not find a significant relationship between ethnicity and creativity scores after controlling for dialectical thinking, suggesting that dialectical thinking is a cognitive process that contributes to creativity, and that cultural differences in dialectical thinking may partially explain differences in creativity between ethnic groups.

The relationship between cultural identity and academic achievement (i.e., mathematical creativity) among Latino youth students was explored by Martinez-Fuentes et al. (2021). The authors found that students who reported stronger cultural identity engaged in more creative and innovative mathematical problem-solving strategies and suggested that cultural identity provides a sense of purpose and meaning and supports more intrinsic motivation and engagement in mathematical problem-solving.

Overall, these studies suggest a positive relationship between MCT/creativity and ethnic identity. Incorporating cultural traditions and values into the mathematics curriculum may help to promote a stronger sense of identity and belonging, which can support more innovative and creative problem-solving approaches.

2.7. Ethnicity as a mediator between attitude and creativity

Bandura & Walters (1977) theory underscores how individuals learn from their environment, including cultural influences. Ethnicity represents the cultural context shaping beliefs and attitudes (Umaña-Taylor et al., 2014), including those toward subjects like mathematics. As per Social Learning Theory, people observe, imitate, and learn from behaviors and attitudes within their cultural setting (Bandura, 1969). In math, diverse ethnic backgrounds can impact experiences with CT (Chua, 2018). This cultural influence mediates attitudes toward math and creative potential. Ethnicity thus mediates between attitude and creative thinking in math, shaping perceptions. Cultural attitudes that encourage or discourage risk-taking and unconventional thinking affect one's willingness to engage in creative problem-solving (Al-Mamary & Alshallaqi, 2022). If a culture values creative thinking in math, individuals may develop higher creative abilities, whereas discouragement may impact one's motivation to solve creatively.

In regard to the previous study, students' attitude has a direct relationship between their ethnicity (Rinnooy Kan et al., 2023; Yli-Panula et al., 2022) and creativity (Han & Suh, 2023; Jiatong et al., 2021; Ruiz-Palomino & Zoghbi-Manrique-de-Lara, 2020). When students exhibit a positive and strong attitude towards their ethnicity, they tend to demonstrate higher engagement in CT within the field of mathematics (Uekawa et al., 2007). Similarly, Orakci & Durnali (2023) proposed that CT in mathematics can predict attitude toward in mathematics. Additionally, Naiman et al. (2023) discovered that ethnicity serves as a predictor of attitude. In essence on the observed correlations among attitude towards mathematics, ethnicity, and creativity, this study postulates that ethnic identity may serve as a mediator in the relationship between attitude towards mathematics and MCT. Therefore, our model has displayed in Fig. 1.

2.8. Study context

In Indonesia, mathematics education is recognized as a crucial component of the education system, with the government investing significant resources in improving mathematics teaching and learning. However, students in Indonesia often struggle with mathematics and require improvement in their attitudes toward the subject. Furthermore, Indonesia is a diverse country, with over 1,300 ethnic groups, and there is growing recognition of the importance of promoting inclusivity and diversity in education. However, ethnic identity remains an important aspect of many Indonesians' lives, influencing their attitudes and behavior.

Further, CT and attitude are also important concepts in Indonesia's educational system. CT is emphasized as an important skill that students should develop because it is necessary for innovation and problem-solving, which are crucial for the country's development. To promote CT, Indonesian schools often encourage students to engage in activities such as brainstorming, group discussions, and project-based learning. Attitude is also considered important in Indonesia's educational system. A positive attitude toward learning is believed to be necessary for academic success. Therefore, Indonesian schools place emphasis on cultivating positive attitudes toward learning, particularly in subjects such as mathematics, science, and language. This is achieved through various methods such as creating engaging and interactive learning environments, providing positive feedback to students, and encouraging them to set goals and strive toward achieving them.

3. Materials and Methods

3.1. Participants

The study randomly selected 896 students from secondary schools in Lampung province, Indonesia. We selected 27 classes randomly chosen from a total of seven schools, focusing on grades 7th through 9th in Lampung. Data were collected online using *a google form*. All participants provided informed consent prior to their participation in the study.

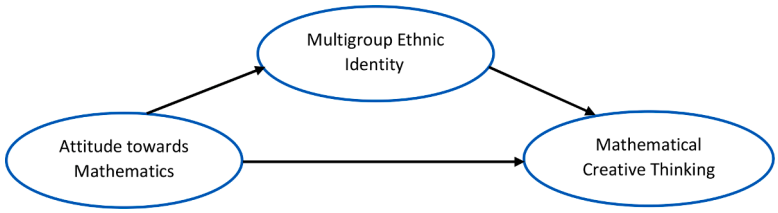

Fig. 1. Conceptual model.

Table 1 explain the demographic characteristics of the students. Of the 896 participants, 415 were males with a mean age of 13.24 ±1.04 while 481 were females, with a mean age of 13.43±1.11. The mean age of all participants was 13.34±1.08.

3.2. Instruments

This research adapted three several instruments to examine ethnic/cultural identity: (1) the mathematical creative thinking based Ethnomathematics test (MCTTBE), (2) the questionnaire on attitudes toward mathematics inventory for secondary education (ATMSE), and (3) the multigroup ethnic identity inventory (MEI2).

The MCTTBE is a 20-item instrument that was developed by Suherman and Vidákovich (2022c) in the context of *Tapis Lampung* as an ethnomathematics nuanced. The test has both figural and verbal components and the items cover fluency, flexibility, originality, and elaboration. The figural assessment consisted of two tasks: picture construction, which involved creating an image by adding onto a basic shape, and picture completion, which required the participant to finish an incomplete drawing and provide it with a title. The verbal test was also carried out in this study. For example, guessing required a participant to list possible causes for pictured action, product improvement necessitated the participant to enhance an image, the task of modification was given, while the task of unusual uses required the participant to generate multiple potential applications for an everyday object (J. C. Kaufman et al., 2008). Scores were assigned based on classified responses. The highest scores for fluency and flexibility were 5. Originality was scored according to percentages: above 3% = 0, above 2% and below 3% = 1, above 1% and below 2% = 2, and below 1% = 3. Elaboration was assigned either 1 or 2 scores. The fit indices, Infit mean square (MNSQ) and Outfit MNSQ of the MCTTBE item average, were determined to be 1.01 and 0.99, respectively. Cronbach's Alpha coefficient was 0.76 and the raw variance explained by measurements was 61.4%, which exceeded 20%.

ATMSE is a 26-item questionnaire that was also developed by Suherman and Vidákovich (2022a). Six items was used to measure self-perception of mathematics ("I am really good at math"), six items measured the value of mathematics ("I feel confident in my abilities to solve mathematics problems"), six items measured enjoyment of mathematics ("The subject taught in mathematics classes is very interesting"), and eight items measured perceived mathematics achievement ("I am sure I will be successful in math class"). The items were measured on a five-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = agree, and 5 = *strongly agree)* and students were asked to indicate their agreement with each statement by selecting from these options. The tests of reliability (consistency reliability using Cronbach alpha (α) and composite reliability using McDonald's omega (ω)) for the four scales ranged between 0.79 and 0.89. Specifically, the self-perception of mathematics subscale showed the highest reliability, scoring at Crb$\alpha = 0.79$ and $\omega = 0.79$. Similarly, the value of mathematics subscale also exhibited high reliability, with a Crb$\alpha = 0.79$ and $\omega = 0.79$. Moreover, both enjoyment of mathematics (Crb$\alpha = 0.89$; $\omega = 0.89$) and perceived mathematics achievement (Crb$\alpha = 0.87$; $\omega = 0.87$) demonstrated strong reliability. This instrument has valid in the Indonesian context.

The MEI2 questionnaire was adapted from Phinney (1992). The 19-item tool assessed students' knowledge of traditional clothing and motifs, cultural identity, and the association between culture and academics, namely, affirmation belonging (5 items: "I am very proud of my ethnic group and its achievements") and"), ethnic identity achievement (5 items: "I've spent time researching my own ethnic group's history, traditions, and customs"), and ethnic belonging (9 items: "I enjoy preserving the traditions of my ethnic group's heritage"). This was also rated on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability values for the three subscales ranged between 0.64 and 0.85. In regard to each subscale, the highest reliability was observed in the affirmation and belonging subscale, registering at Crb$\alpha = 0.76$ and $\omega = 0.76$. Likewise, the ethnic belonging subscale showed commendable reliability levels, recording Crb$\alpha = 0.85$ and $\omega = 0.83$. Additionally, ethnic identity achievement demonstrated acceptable Cronbach's alpha and omega coefficients at Crb$\alpha = 0.69$ and $\omega = 0.64$. Hence, the instruments are viable to assess ethnic identity.

Table 1
Characteristic of Participants.

Demographics		Frequency	Percentage (%)
Gender	Female	481	53.7
	Male	415	46.3
Grade	7^{th}	306	34.2
	8^{th}	292	32.6
	9^{th}	298	33.3
School Place	Private	449	50.1
	Public	447	49.9
Living Place	City	460	51.3
	District	436	48.7
Ethnicity	Batak	57	6.4
	Bugis	25	2.8
	Java	395	44.1
	Lampung	131	14.6
	Manado	34	3.8
	Minang	23	2.6
	Others	47	5.2
	Palembang	24	2.7
	Sundanese	160	17.9

Table 2
Correlation coefficient, standard deviation, and mean.

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. **MCT**	49.84	12.00	1													
1. Flu	16.45	3.97	.857**	1												
1. FLe	16.97	6.21	.926**	.671**	1											
1. EL	6.40	1.28	.696**	.538**	.547**	1										
1. OR	10.03	2.47	.788**	.589**	.618**	.620**	1									
1. **ATT**	95.79	16.23	.098**	.107**	.085*	.038	.072*	1								
1. SP	21.42	5.38	.066*	.079*	.055	.020	.046	.903**	1							
1. VM	23.51	3.07	.079*	.084*	.060	.029	.084*	.596**	.371**	1						
1. EM	29.43	5.93	.109**	.104**	.103**	.047	.077*	.936**	.796**	.523**	1					
1. PM	21.43	4.67	.074*	.092**	.062	.028	.042	.854**	.729**	.320**	.720**	1				
1. **ETH**	69.14	8.48	.081*	.063	.096**	.056	.021	.157**	.050	.189**	.164**	.156**	1			
1. AB	19.32	2.73	.069*	.038	.083*	.060	.032	.013	-.076*	.167**	.023	-.006	.750**	1		
1. EA	17.97	2.55	.068*	.046	.081*	.046	.028	.128**	.049	.170**	.117**	.128**	.842**	.577**	1	
1. EB	31.85	4.77	.068*	.066*	.079*	.041	.003	.204**	.106**	.150**	.216**	.213**	.898**	.452**	.631**	1

$p < 0.01$; *$p < 0.05$; N = 896; **1. MCT: Mathematical creative thinking, 2. Flue: Fluency, 3. Fle: Flexibility, 4. EL: Elaboration, 5. OR: Originality, **6. ATT**: Attitude, 7. SP: Self-perceive of mathematics, 8. VM: Value of mathematics, 9. EM: Enjoyment of mathematics, 10. PM: Perceived mathematics achievement, **11. ETH:** Ethnic, 12. AB: Affirmation belonging, 13. EA: Ethnic identity achievement, 14. EB: Ethnic belonging.

3.3. Data collection procedure

The study received approval from the Institutional Review Board of the Doctoral School of Education, University of Szeged, Hungary, which followed ethical guidelines set by the institution. Additionally, informed consent was obtained from all participants who agreed to take part in the study. To conduct the study, we sought permission from the school principals in order to distribute the questionnaires and tests. In each school's online test, analytical processes were implemented. The survey was deployed online via a google form test, and a link was sent to the students and their teachers via email or social media application. Under the guidance of their teachers, the participants responded to the test within 120 min, used 40 min to fill out the questionnaire, and their responses were delivered via the link. The data were recorded anonymously and privately and will be available for data analysis.

3.4. Data analysis

The data was analyzed using SPSS version 26 and Mplus version 8. The data were analyzed for the item's internal consistency with Cronbach alpha, construct validity with confirmatory factor analysis, and item's validity with Rasch analysis. We also performed a correlation analysis to explore the relationship between MCT and subtest of MCTTBE and between MCT, attitude, and ethnic identity.

4. Results

4.1. Association between MCT, ATM, and ethnic identity

Table 2 shows relationship between the variables. In Table 2, MCT ($M = 49.84$, $SD = 12.00$), ATM ($M = 95.79$, $SD = 16.23$), and ethnic identity ($M = 69.14$, $SD = 8.48$) were rated as "agree." There was a positive correlation between MCT and attitude ($r = 0.098$; $p < 0.01$), MCT and ethnic identity ($r = 0.081$; $p < 0.05$), attitude and MCT ($r = 0.157$; $p < 0.01$).

4.2. Overall effects and structural paths prior to the inclusion of the mediator variable

Table 3 presents the results of the structural paths analysis of the exogenous variables (attitude and ethnic identity) on the endogenous variable (MCT) in this study. The total effects of attitude on MCT ($\beta = 0.54$, $SE = 0.03$, $CR = 22.37$, $p < 0.001$) and ethnic identity ($\beta = 0.55$, $SE = 0.02$, $CR = 25.93$, $p < 0.001$) were both positive and significant, indicating that a positive ATM and a positive ethnic identity are associated with higher MCT. The total effect of ethnic identity on MCT ($\beta = 0.24$, $SE = 0.03$, $CR = 8.78$, $p < 0.001$) was also positive and significant, suggesting that having a positive ethnic identity is related to higher MCT. The R^2 value indicates that the exogenous variables explain 29.4% of the variance in MCT and the SE and CR values suggest that the results are robust and reliable. These results show that ATM was a significant predictor of both MCT and ethnic identity; a one unit increase in attitude resulted in a corresponding increase in MCT and ethnic identity by 0.54 and 0.55 units, respectively. Similarly, ethnic identity significantly predicted MCT; a one unit increase in ethnic identity led to an increase in MCT by 0.24 units. Overall, these findings suggest that ATM and ethnic identity are significant factors in the development of MCT.

4.3. The structural routes and direct effects, after the inclusion of the mediator variable

Covariance-based structural equation modeling (CB-SEM) was employed to examine the connection between attitude and MCT, where ethnicity as a mediator, are presented in Fig. 2. The goodness-of-fit indices for the path model are as follows: [$\chi^2(55) = 4195.92$, $p < 0.001$, RMSEA = 0.077, CFI = 0.948, TLI = 0.930, and SRMR = 0.044]. These results suggest that the proposed model is a good fit for the data.

Based on the model in Fig 2, ATM had a significant and positive direct effect on MCT ($\beta = 0.10$, $p < 0.05$), and ethnic identity ($\beta = 0.07$, $p < 0.001$). Ethnic identity also had a positive direct effect on MCT, but this was not statistically significant ($\beta = 0.15$, $p > 0.05$). In addition, there is any effect of attitude on MCT will be fully mediated through ethnicity. In this study, ATM indirectly influenced MCT through the mediating effect of ethnic identity [β (.15) x β (.07)] = .011, $p < 0.001$.

The regression correlation coefficients between ATM and MCT significantly decreased after the mediator variable, ethnic identity, was incorporated into the model, as presented in Tables 3 and 4 and Fig. 2. Furthermore, the mediated effect of ethnic identity on the association between ATM and MCT was statistically significant ($p < .05$). Thus, ethnicity played a crucial role in mediating the relationship between ATM and MCT.

Table 3
Structural paths and total effects leading up to a mediator variable.

	Exogenous variables	Structural Paths	Endogenous variables	β	R^2	SE	CR	p
Total effects	Attitude	→	MCT	0.54	0.49	0.03	22.37	< 0.001
	Attitude	→	Ethnics	0.55	0.29	0.02	25.93	< 0.001
	Ethnics	→	MCT	0.24		0.03	8.78	< 0.001

"β = Estimate; R^2 = Square Multiple Correlation; SE = Standard Error, CR = Critical Ratio"

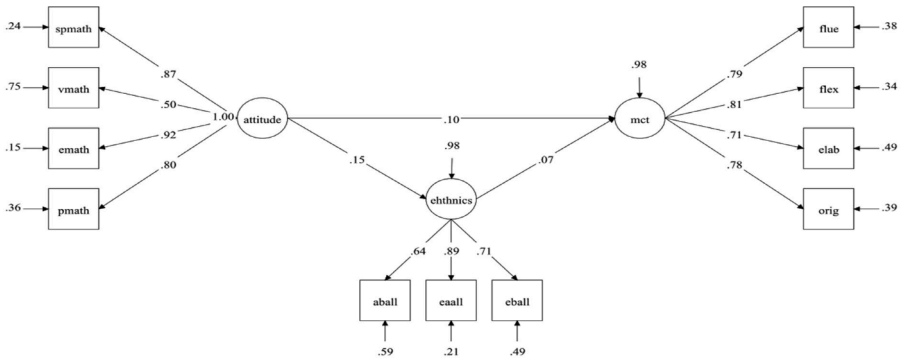

Fig. 2. A path diagram was utilized to display the standardized estimates of the model's goodness of fit.

Table 4
The direct effects and structural routes after adding a mediator variable.

	Exogenous variables	Structural Paths	Endogenous variables	β	R^2	SE	CR	p
Direct effects	Attitude	→	MCT	0.10	0.01	0.04	2.53	< 0.05
	Attitude	→	Ethnics	0.15	0.02	0.04	3.79	< 0.001
	Ethnics	→	MCT	0.07	-	0.04	1.66	$> .05$

β = Estimate; R^2 = Square Multiple Correlation; SE = Standard Error, CR = Critical Ratio

5. Discussion

The research findings showed that there was a notable and positive association between ATM, MCT, and ethnic identity, suggesting that having a positive attitude towards the subject could result in increased academic success and a more robust feeling of ethnic identity. Students with positive attitudes were likely to benefit more from the influence of both MCT and ethnic identity in their academic and personal endeavors. Thus, it can be inferred that cultivating a positive ATM could potentially have a positive impact on academic performance and personal identity. It is known that attitude plays a crucial role in regulating achievement and preventing distraction from minor issues. Previous studies have shown that a positive attitude toward learning and the task at hand can enhance focus on the primary objective, enabling individuals to work more efficiently toward achieving their desired outcomes (Huang et al., 2022; Tseng et al., 2013). By maintaining a positive attitude toward the main goal, individuals can free up mental capacity to strive for novel and inventive methods of attaining success, for example, in final examinations (Nja et al., 2022). Furthermore, research has shown that a positive attitude can lead to greater persistence in the face of challenges and setbacks, which is a key factor in achieving success (Wong & Fry, 2013). Therefore, it is important to cultivate a positive attitude toward learning and achievement to maximize performance and achieve success.

This study showed that CT can be enhanced through education, particularly in the field of mathematics, which can stimulate innovative ideas and actions. This is consistent with a previous research by (Hu et al., 2016). As education is an interdisciplinary field, there are many ways to achieve successful learning outcomes. Attitudinal change and elimination of CT barriers can help individuals develop multiple solutions to problems (Sowden et al., 2015). The present study highlights the importance of promoting a positive attitude and CT in educational context, as it can significantly influence students' success in problem-solving tasks.

The outcomes of the path analysis indicated that MCT was significantly predicted by ethnic identity. This is in line with previous studies (Bogilović et al., 2017; S. B. Kaufman et al., 2016; Saad et al., 2013). Social environment and cultural values influence the types of creative activities that individuals engage in. This study also supports findings that people who had multicultural social networks had a higher level of idea flow and creativity and were more likely to engage in creative problem-solving and generate more innovative ideas compared to those who had monocultural social networks. Hence, this study provides valuable insights into how culture, including multiculturalism, influences creativity and innovation and highlights the need to consider cultural factors when developing strategies to promote creativity in different cultural contexts.

In addition, ethnic identity mediated the relationship between ATM and MCT. This parallels previous studies (Jackson & Wilson, 2012; Laurence et al., 2018; Verdín & Godwin, 2018). Ethnicity may act as a mediator between attitude and mathematical creative thinking due to the cultural context and values associated with an individual's ethnic identity. Attitude shapes how one perceives and engages with mathematics, and these perceptions may be influenced by cultural beliefs or values tied to ethnicity, thereby impacting mathematical creative thinking. This finding can be explained in terms of Indonesia's unique cultural context, which is known for its multicultural environment in which a variety of ethnic groups such as Batak, Lampung, Javanese, Manado, and Mining coexist. Indonesian students prioritize academic performance to secure future career opportunities (Anwar et al., 2021; Bukodi et al., 2008; Hermino & Arifin, 2020; Maskur et al., 2022). Although they are highly motivated to learn mathematics (Shin et al., 2018), which

indicates a positive ATM, this motivation may be influenced by external pressure from parents, teachers, relatives, and peers, which can have a negative impact on their overall wellbeing. Instead of exerting excessive pressure on students, schools and families should focus on inspiring them to learn and pursue their interests. Furthermore, parents and teachers should encourage students to pursue their talents and interests within the curriculum to improve their CT in mathematics.

6. Limitations and Future Research

Firstly, while measuring novel-idea flow was useful for some research questions, it did not fully capture the flow of ideas between individuals or how attitude and ethnicity influenced MCT. While the mediator variable, ethnic identity, led to a significant decrease in the correlation between attitude and MCT, the method relied on participants to select the ideas to report, which may have been influenced by recall and social desirability biases (Maxwell & Cole, 2007; Van Vo & Csapó, 2023).

Secondly, this was a cross-sectional study among only secondary school students. Self-reports as indicators of MCT performance are subject to bias, and with a small sample size, path models were only carried out within the marginal model for each cohort, which could affect the path analysis results. Hence, caution should be exercised when generalizing the results of this study. This underscores the need for large-scale investigations in the future.

Lastly, the study focused on the relationship between attitudes, ethnicity, and MCT, and did not consider other potential predictors of MCT (age, gender, and SES). Consequently, future research could investigate other mediator variables that could help to explain the relationship between ethnicity, attitude, and MCT. In addition, further research could explore the role of other factors such as educational background, cultural differences, and personality traits, in the development of MCT. Moreover, interventions could be designed to improve ATM and promote a positive ethnic identity among students, which could lead to improved MCT abilities.

Despite these limitations, the present study served as a foundation for further research into the content and origins of idea flow in educational settings. Future research could build on this methodology to improve the accuracy of idea-reporting measurements.

7. Conclusion

This study utilized path analyses and a cross-sectional approach to provide empirical evidence on how attitude and ethnicity can facilitate the generation of new ideas and improve students' performance in MCT. The findings revealed that ethnicity and attitude are significant factors in promoting creativity in mathematics, suggesting that having a positive ATM and a positive ethnic identity are crucial elements in the development of MCT. These findings would help mathematics educators to promote a positive ATM among students through stimulating and meaningful activities that enable students to explore mathematical concepts in a creative and interactive manner. While this study offers important information regarding the factors that influence the development of MCT, further investigation is required to comprehend the complex interaction among these variables. This can assist educators to design more effective teaching strategies that promote MCT among their students.

CRediT authorship contribution statement

Suherman Suherman: Conceptualization, Writing – original draft, Formal analysis, Methodology, Writing – review & editing, Visualization. **Tibor Vidákovich:** Supervision, Funding acquisition, Writing – review & editing.

Declaration of Competing Interest

There are no conflicts of interest to declare.

Data availability

Data will be made available on request.

Acknowledgements

We would like to thank the Tempus Public Foundation of the Hungarian Government (Grant Number: SHE-26219-004/2020) for the funding support for this study. Also, we appreciate the University of Szeged, Hungary (Open Access Grant Number: 6191) for suggestions and discussions for an idea in the research view.

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