Mathematical Creative Thinking-Ethnomathematics based Test: Role of Attitude toward Mathematics, Creative Style, Ethnic Identity, and Parents' Educational Level

Pensamiento creativo matemático - prueba basada en la etnomatemática: rol de la actitud hacia las matemáticas, estilo creativo, identidad étnica y nivel educativo de los padres

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Resumen
El pensamiento creativo desempeña un papel crucial en el éxito académico en matemáticas, influenciado por diversos factores. Sin embargo, el impacto combinado de la educación de los padres, la identidad étnica, la actitud hacia las matemáticas y el estilo creativo en el pensamiento creativo matemático en el contexto de la etnomatemática no ha sido examinado de manera exhaustiva. En este estudio transversal, exploramos estas relaciones entre 896 estudiantes de secundaria seleccionados al azar de cinco escuelas públicas y privadas que completaron una prueba basada en etnomatemática de pensamiento creativo matemático (MCT) y cuestionarios. Los participantes tenían una edad promedio de 13.34 + 1.08 años, y más de la mitad eran hombres (53.7%). Los resultados mostraron que una actitud positiva hacia las matemáticas se relacionaba con niveles más altos de fluidez, flexibilidad y originalidad en el pensamiento creativo, mientras que una sólida identidad étnica se asociaba con una mayor flexibilidad. Aunque el estilo creativo y la educación de los padres tenían una correlación negativa con la creatividad en general, esta relación se volvía positiva al examinarla en diferentes niveles de grado. Curiosamente, la actitud hacia las matemáticas actuaba como mediadora, influyendo en el impacto de la formación educativa de los padres en la creatividad de los estudiantes. Este estudio contribuye a nuestra comprensión de la naturaleza multifacetica del pensamiento creativo matemático, ofreciendo conocimientos para mejorar la educación matemática en la era digital al reconocer la importancia del apoyo parental, la identidad étnica y las actitudes para fomentar la creatividad.
Palabras clave: estilo creativo, identidad étnica, etnomatemática, pensamiento creativo matemático, actitud hacia las matemáticas, educación de los padres.

Abstract
Creative thinking plays a crucial role in academic success in mathematics, influenced by various factors. However, the combined impact of parental education, ethnic identity, attitude towards mathematics, and creative style on mathematical creative thinking within the context of ethnomathematics has not been extensively examined. In this cross-sectional study, we explored these relationships among 896 secondary students randomly chosen from five public and private schools who completed MCT-ethnomathematics based test and questionnaires. The participants had an average age of 13.34 $\pm$ 1.08 years, with males comprising more than half (53.7%). The results showed that a positive attitude towards mathematics was linked to higher levels of fluency, flexibility, and originality in creative

thinking, while a strong ethnic identity was associated with increased flexibility. Although creative style and parental education had a negative correlation with overall creativity, this relationship turned positive when examined across various grade levels. Interestingly, attitude towards mathematics acted as a mediator, influencing the impact of parental educational background on students' creativity. This study contributes to our understanding of the multifaceted nature of mathematical creative thinking, offering insights into enhancing mathematics education in the digital age by recognizing the significance of parental support, ethnic identity, and attitudes in fostering creativity.

Keywords: creative style, ethnic identity, ethnomathematics, mathematical creative thinking, attitude toward mathematics, parental education.

1. Introduction

Exploring creative thinking (CT) is crucial for students' learning experience and academic achievement in mathematics (Kozlowski et al., 2019). To achieve this, incorporating visual culture in education (Grodoski, 2016) and ethnomathematics (Orey & Rosa, 2007; Rosa & Orey, 2015), which acknowledges the cultural dimensions of mathematics, is vital. Moreover, research has highlighted the relationship between mathematical creative thinking (MCT) and students' overall competence and sense of identity within their cultural environment (Hongjia et al., 2018). Hence, MCT is not only an academic pursuit but also a means of strengthening students' affiliation with their ethnicity and culture (Soler Pastor et al., 2022; Tidikis et al., 2018). Despite these insights, the factors influencing student creativity, particularly in mathematics, remain unclear (Liu et al., 2021; Power, 2015; RN Wang & Chang, 2022; Wu et al., 2022). Understanding these factors, especially within the context of mathematics and culture (i.e., ethnomathematics), becomes crucial in devising effective educational strategies and fostering students' intellectual growth. It refers to the culture offers a natural means for students to access a framework for conceptual understanding in mathematics (Harding-DeKam, 2014). Furthermore, attitude plays a crucial role in shaping students' mathematical learning experiences and outcomes, and its impact on MCT has garnered significant attention in scientific research. Recent research by Kurdal & Kaplan (2023) has shown a significant positive correlation between students' metacognitive awareness (i.e., thinking process) and their attitude toward mathematics (ATM). Additionaly, studies indicate that parental education level (PED) is a predictor of mathematics achievement (Hidayatullah & Csíkos, 2023), and creative style is predictive of creativity (Wechsler et al., 2012). While several studies have explored the relationship between MCT and individual factors like PED, ethnic identity, attitude toward mathematics (ATM), and creative style (CST), there exists a research gap regarding their combined impact on MCT. To address this gap, our study aims to examine how these factors interact and influence students' MCT abilities across various grade levels.

2. Literature Review

MCT and Ethnomathematics

MCT has been a subject of growing interest and has received significant research attention (Liu et al., 2021; Power, 2015; Suherman & Vidákovich, 2022b; R.-N. Wang & Chang, 2022; Wu et al., 2022). These factors include ethnomathematics, parents' educational level, ATM, ethnic identity, and creative style. Ethnomathematics enhances students' understanding and appreciation by linking mathematical concepts to real-world contexts and diverse cultural practices (Orey & Rosa, 2007; Rosa & Orey, 2015). The connection between MCT and ethnomathematics lies in the idea that studying and understanding different cultural mathematical practices can stimulate and improve MCT. When individuals are exposed to various mathematical ideas and problem solving methods from various cultural contexts, it can broaden their perspectives and encourage them to think creatively about mathematical concepts (D'Ambrosio & Rosa, 2017; Rosa & Orey, 2016; Suherman & Vidakovich, 2022a).

Role of Parents' Educational Level

Parents' educational level considerably shapes students' academic achievement and educational outcomes and serves as a strong predictor of their involvement in their children's education (Davis-Kean et al., 2021), as well as their ability to provide a supportive learning environment at home (Lehrl et al., 2020). Moreover, parental education plays a crucial role in influencing children's interaction in educational attainment (Gil-Hernández, 2019; Mönkediek & Diewald, 2022), cognitive development (Danovitch, 2019), CT development (C. Tang et al., 2022; Zhao & Yang, 2021), and overall academic success (Tazouti & Jarlégan, 2019). Studies on the influence of ethnic identity on MCT have demonstrated that cultural context plays an important role in shaping the expression of creativity and its development among people in different regions (Cabra & Guerrero, 2022; Karwowski, 2016; Rudowicz, 2003; M. Tang et al., 2018; Torrance, 1974; Zheng et al., 2023).

Creative Styles and Their Contribution to MCT

Creative style refers to individual differences in how creative tasks are approached and engaged (Nori et al., 2018). There was a prevailing belief that CT abilities were limited to a small group of exceptionally talented individuals with unique problem solving and creative skills (Wang et al., 2017). However, recent studies have recognized that creativity can be developed and nurtured in all students through close interactions and supportive environments (Behnamnia et al., 2020; Kim et al., 2016; Renzulli & Reis, 2021). Studies have also shown that creative style influences creativity and that a diverse range of creative styles contribute to innovative CT in various contexts (Chen et al., 2015; Rodet, 2021) and influence approaches to problem solving and academic and career achievement (Ee et al., 2007; Mkpanang, 2016; White & Shah, 2011). These previous studies explored the relationship between MCT and these factors separately; however, there exists a research gap regarding their combined impact on MCT. Moreover, the specific association between parents' educational level and changes in CT in the context of mathematics is unclear. Hence, this study explored the influence of ATM, ethnic identity, parental education, and creative style on MCT among secondary school students. We hypothesized that these variables would have a positive correlation with MCT. Understanding these factors, especially within cultural contexts, is crucial in developing effective educational strategies and fostering students' intellectual growth.

Present Study

The present study, conducted in the context of secondary education in Indonesia, aims to delve into the impact of the MTC-ethnomathematics based test (MCTBE) on students' MCT. This impact is explored with regard to various factors previously mentioned, such as parental educational level, ethnic identity, attitude towards mathematics, and creative style. The rationale for this investigation is grounded in the evidence compiled from a comprehensive literature review. As previously discussed, there is a growing body of research emphasizing the significance of these factors in shaping students' MCT abilities. However, the combined and interactive effects of these factors, particularly in the context of ethnomathematics, have not been extensively explored. Therefore, the current study seeks to bridge this research gap and provide a more comprehensive understanding of how these factors collectively influence students' MCT within the specific educational landscape of Indonesia's secondary schools.

In line with our research objectives, we have formulated the following research questions (RQ) to guide our investigation:

1. (RQ1) How can students' performance on the MTC-ethnomathematics based test (MCTBE) be effectively assessed?
2. (RQ2) What is the collective impact of attitude towards mathematics (ATM), CST, ethnic identity, and PED level on students' performance in the MCTBE?

3. Method

Participants and Procedure

The research involved 896 students who were in grades 7 to 9 and attended both private and public secondary schools in Lampung province, Indonesia. The students were randomly selected and informed consent was obtained from them prior to their participation. The study was carried out in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Doctoral School of Education, University of Szeged (Approval number 6/2023). Confidentiality was maintained, and participants were informed of their right to refuse or withdraw participation anytime during the study without consequence. Students took approximately 120 min to complete the instruments under the supervision of both their teacher and assistant teacher.

Table 1
Participants socio-demographic characteristics

Characteristics	*N*	Percentage (%)	Mean age (years)
Grade			
7	306	34.2	12.21
8	292	32.6	13.41
9	298	33.3	14.43
Gender			
Girl	481	53.7	13.43
Boy	415	46.3	13.24
Ethnic			
Batak	57	6.4	12.91
Bugis	25	2.8	12.76
Java	411	45.9	13.27
Lampung	158	17.6	13.85
Manado	51	5.7	12.76
Minang	35	3.9	13.51
Others	47	5.2	12.98
Palembang	25	2.8	13.44
Sundanese	87	9.7	13.62

Characteristics	***N***	**Percentage (%)**	**Mean age (years)**
Type School			
Private	449	50.1	13.28
Public	447	49.4	13.40

Table 1 presents the characteristics of the participants. Their mean age was 13.34 ± 1.08 years and more than half (53.7%) were males. Table 2 presents their parents' educational levels. Forty-six percent of the participants were from the Javanese ethnic group (45.9%), Lampung (17.6), while Bugis and Palembang were only 2.8%.

Table 2
Parents' highest level of education

Grade	**Mother's Education Level**			**Father's Education Level**		
	I (%)	**II (%)**	**III (%)**	**I (%)**	**II (%)**	**III (%)**
7	0	59.5	40.5	0.3	60.8	38.9
8	0	20.3	79.7	1.0	21.3	77.7
9	8.4	25.2	66.4	13.8	17.1	69.1

Note: I: education without experience, did not complete grade 6; II: primary education, secondary education, high school education; III: higher education (diploma, bachelor, master and doctorate).

Instruments

MCTBE

To assess MCT, we incorporated 20 items from the Tapis Lampung framework, which carries ethnomathematics nuances (Fig. 1). Tapis Lampung serves as a manifestation of mathematical ideas, making it apt to be regarded as a mathematical concept within this context. This categorization is justified by the complex geometric patterns, symmetry, and the incorporation of mathematical principles in its design (Suherman & Vidakovich, 2022a). Tapis Lampung, originating from Indonesia's Lampung province, is rich in cultural and historical significance. Its intricate geometric patterns form the basis for assessing students' Mathematical Creative Thinking (MCT). These patterns engage students in recognizing and manipulating mathematical elements, connecting academic learning with their cultural experiences, particularly in the context of buying and selling activities that are central to Lampung culture. This approach blends math and culture within ethnomathematics, promoting a holistic understanding that extends beyond the classroom, making Tapis Lampung an ideal tool for evaluating MCT.

The items were designed to cover two distinct subtests: the figural and verbal components. In the figural subtest, students were presented with visual representations or diagrams of mathematical concepts and were required to analyze and interpret the figures to demonstrate their CT skills in solving mathematical problems. Moreover, the verbal subtest assessed students' ability to apply MCT through writing and to use clear and logical communication to articulate mathematical ideas, justify their solutions, and evaluate mathematical arguments. The fit of the items was conducted in a previous study using rapid measurement validation (Suherman & Vidakovich, 2022b). The fit indices for the average MCTBE item, including Infit mean square (MNSQ) and Outfit MNSQ, were 1.01 and 0.99, respectively, and the Cronbach's alpha (α) coefficient was 0.76.

Figure 1
An example of the MCTBE item test

No.1. Following is the Tapis Lampung pattern. You can see the triangle pattern in this motif. Make five different pictures from them, based on the pattern you see in the motif. Give a title for each image.

ATM

We developed a set of 26 items to assess ATM. These items were classified into four subscales: self-perception of mathematics, value of mathematics, enjoyment of mathematics, and perceived mathematics achievement. These subscales were adapted from the work of Suherman & Vidákovach (2022). Reliability tests for the four scales, which included consistency reliability using Cronbach's α and composite reliability using McDonald's omega (ω), yielded values ranging from 0.79 to 0.89. The items were measured on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree). Students were asked to indicate their level of agreement with each statement by selecting one of the five response options.

Multigroup ethnic identity inventory (MEI2)

Ethical identity was also measured on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree) using a questionnaire that was adapted from Phinney (1992). The questionnaire had 19 items that were categorized into three subscales: affirmation of belonging, achievement of ethnic identity, and ethnic belonging. The measure of internal consistency to determine the reliability of the three subscales yielded Cronbach's α coefficient ranging from 0.64 to 0.85.

Creative style inventory (CSQ)

This questionnaire assesses the perspectives and techniques individuals employ to foster creativity in their endeavors (Kumar et al., 1997). The questionnaire was adapted from Kumar et al. (1997) into eight subtests with 57 items: creativity capacity, belief in unconscious, use of techniques, use of other people, final product orientation, environmental control/behavioral self-regulation, superstition, and use of sense. The Cronbach's α coefficient for the eight subtests ranged from 0.64 to 0.82. The summary of ATM, MEI2, and CSQ are presented in the table 3.

Table 3
Summary of the validity and reliability.

Variables	**CFI**	**TLI**	**RMSEA**	**SRMR**	α
ATM	0.92	0.91	0.05	0.06	0.85
MEI	0.93	0.91	0.05	0.05	0.73
CSQ	0.94	0.92	0.04	0.05	0.76

Background questionnaire

Information on the parents' highest level of education (PED) was obtained from the students and was categorized into seven, according to the Indonesian education system (1-no formal education, 2-primary education, 3-secondary education, 4-high school, 5-bachelor's, 6-master's, and 7-doctoral).

Overall, the Cronbach's α values obtained for the ATM, MEI2, CSQ, and PED questionnaires were $\alpha = 0.85$, $\alpha = 0.73$, $\alpha = 0.76$, and $\alpha = 0.78$, respectively, indicating an acceptable reliability.

Data Analysis

The first step involved in analyzing the test instruments was to assess their validity. For reliability estimates, we utilized Cronbach's α as an internal consistency indicator using JASP version 0.16.3 (J. Team, 2022). Statistical distribution and correlation analysis was performed using SPSS version 26 while R version 4.2.2 (R. C. Team, 2022) with pirate plots was used to visualize the participants' performance at different grade levels. Path analysis was performed using MPlus version 8 (Muthén & Muthén, 2017) to assess the model's fit. For model evaluation, we considered four main index criteria recommended by Hu & Bentler (1999): comparative fit index (CFI), Tucker Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean squared residual (SRMR). They suggested cutoff criteria close to 0.95 for TLI and CFI, and < 0.05 for RMSEA. In this study, we used maximum likelihood parameter estimates.

4. Results

We used descriptive statistics to examine the correlations between variables (see Table 6). Table 6 shows the descriptive statistics and correlations among variables. There were significant positive correlations (p <.01) between the MCTBE subtests: fluency-flexibility (r = .671), fluency-elaboration (r = .538), fluency-originality (r = .589), flexibility-elaboration (r = .547), flexibility-originality (r = .618), and elaboration-originality (r = .620). ATM was positively related to fluency (r = .107, p <.01), flexibility (r = .085, p <.05), and originality (r = .072, p <.05), and elaboration (r = .038, p <.05). MEI2 had a significant positive correlation with flexibility (r = .096, p < .01), then a positive correlation with other MCTBE subtests. There were negative correlation between MCTBE subtest with CSQ: fluency-CSQ (r = -.013, p > .01) and elaboration-CSQ (r = -.041, p > .01). FE was positively related to fluency (r = .009, p <.01) and flexibility (r = -.002, p <.01). Surprisingly, there was linear relationship between MCTBE subtests (elaboration) and ME (r = .002, p <.01).

Pirate plots were used to visualize the participants' performance by grade level (Fig. 2) and the responses of the model of students at different grade levels for subtest no.1 (Fig. 3). The 9th graders had the highest mean (M_{score}) and standard deviation (SD) fluency subtest scores (16.63 ± 3.77), followed by the 7th graders (16.43 ± 4.13) and the 8th graders (16.27 ± 3.99) (Fig. 2a). Although the 8th graders had a lower mean flexibility score (16.66 ± 6.21) than the 9th graders (17.25 ± 6.20), they were highly proficient and completed the MCTBE subtests (Fig. 2b). For the originality subtest (Fig. 2c), grade 7 had the highest mean score (M = 10.16 ± 2.57), followed by grade 9 (10.13 ± 2.34) and grade 8 (9.78 ± 2.49). This was similar to the elaboration subtest (Fig. 2d), with the 7th graders achieving the highest mean score (6.48 ± 1.29), followed by the 9th graders (6.39 ± 1.28) and 8th grades (6.33 ± 1.29). The detail is in the table 5.

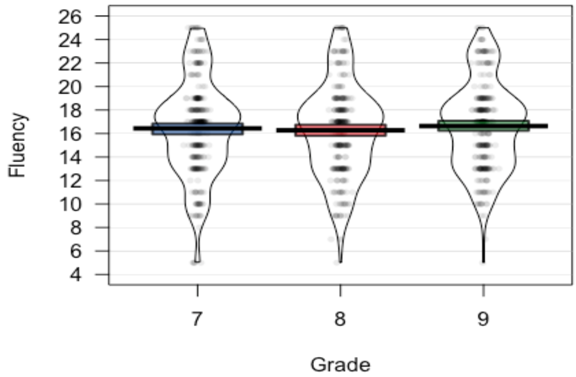
Table 5
Students performance by grade.

Grade	Frequency	Fluency	Flexibility	Elaboration	Originality
7	M_{score}	16.43	16.99	6.48	10.16
	SD	4.13	6.23	1.29	2.57
8	M_{score}	16.27	16.66	6.33	9.78
	SD	3.99	6.21	1.29	2.49
9	M_{score}	16.63	17.25	6.39	10.13
	SD	3.77	6.20	1.28	2.34

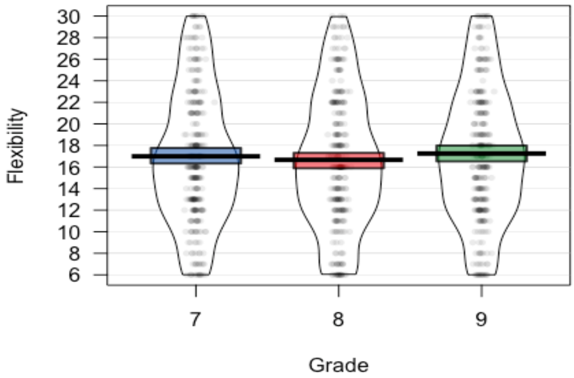
We examined the predictive role of exploratory variables (ATM, MEI2, CST, FE, and ME) on MCTBE scores. A path model was calculated for all grade levels and the model's fit was highly satisfactory [$\chi^2(3) = 5.568$, CFI = .995, TLI = .977, SRMR = .015, RMSEA = .031 (90% CI = .000–.071)]. MCTBE score was significantly associated with ATM (β = .087) and MEI2 (β = .068) (p <.05), but not with CST (β = .029, p = .51), ME (β = .003, p = .92), and FE (−.032, p = .46).

By grade level (Fig. 4), the model's fit was adequate for the 7th grade [$\chi^2(3) = 5.438$, CFI = .991, TLI = .956, SRMR = .024, RMSEA = 0.052 (90% CI: 0.000 - 0.120)]. In seventh grade, ATM (β = .183), MEI2 (β = .071), and CST (β = .044) had positive relationships (p <.05) with MCTBE, while FE (β = −.067, p = .91) and ME (β = −.007; p = 0.41) had negative relationships. FE and ME had a positive indirect influence on CST and ATM, which in turn influenced MCTBE, respectively (β = .725, β = 0.014; p <.05). In eighth grade, MCTBE had a positive association with ATM (β = .002), MEI2 (β = .016), and CST (β = .124) (p <.05), but a negative association with FE (β = −.030, p = .45) and ME (β = -.044; p = 0.67). FE and ME had a positive indirect influence on CST and ATM, which in turn influenced MCTBE, respectively (β = .577, β = 0.066; p <.05).

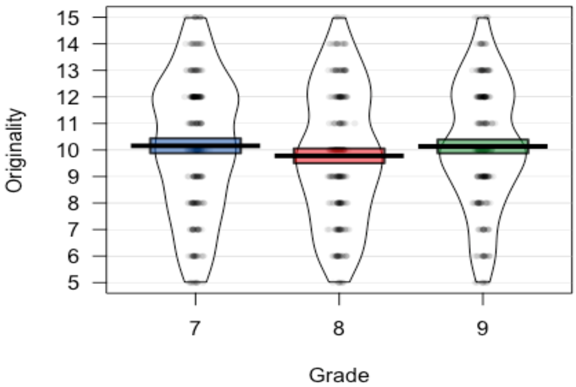
Figure 2
Student performance by grade levels across the four creative thinking tests: a) fluency, b) flexibility, c) originality, and d) elaboration.



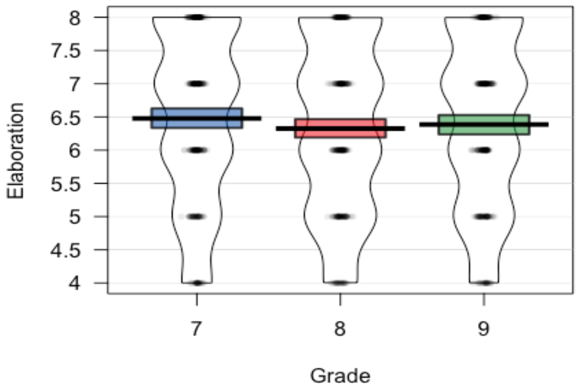
a) Fluency



b) Flexibility



c) Originality



d) Elaboration

In ninth grade, MEI2 (β = .217, $p < .05$) and FE (β = 041, $p < .05$) exhibited a positive direct effect in relation to MCTBE. However, ATM and CST had a negative effect on MCTBE. Overall, fathers' education had a positive effect on their children's MCTBE achievement. Specifically, FE positively contributed to MCTBE achievement (β = .041, $p <.05$). MEI2 also had a positive influence on MCTBE (β = .217, $p <.05$). Furthermore, ME had a direct positive effect on MCTBE achievement in relation to CST and ATM, respectively (β = .002, β = .00001, $p >.05$).

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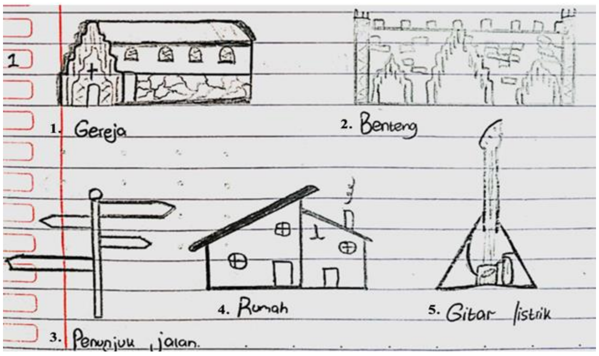
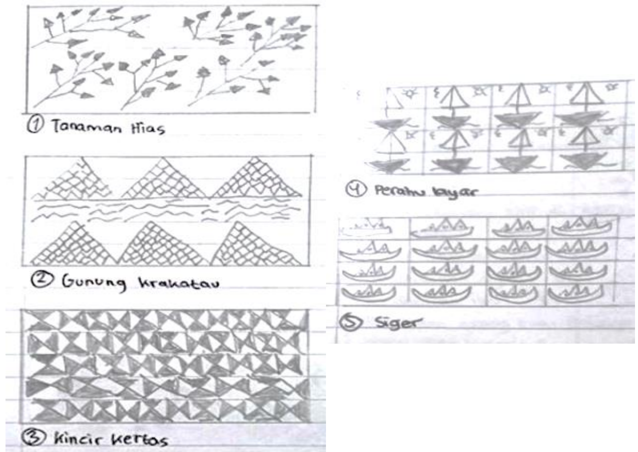
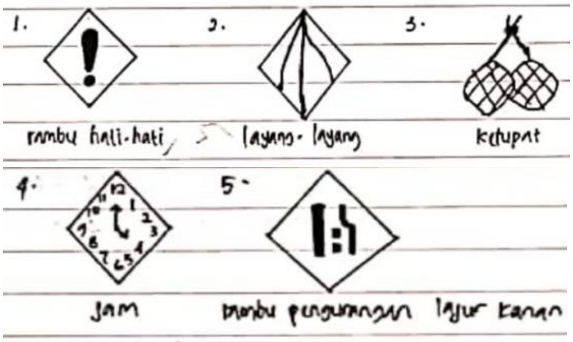
Figure 3
Pattern of students' responses in the flexibility subtest by grade levels.





a) Grade 7 (1 = church; 2 = fortress; 3 = signpost; 4 = house; 5 = classical guitar)

b) Grade 8 (1 = ornamental plants; 2 = Krakatoa Mountain; 3 = paper windmill; 4 = traditional boat; 5 = siger) (traditional headdress)



c) Grade 9 (1 = warning sign; 2 = Kite; 3 = "ketupat"/Diamond-shaped rice cake; 4 = Clock; 5 = Right Lane Ends)

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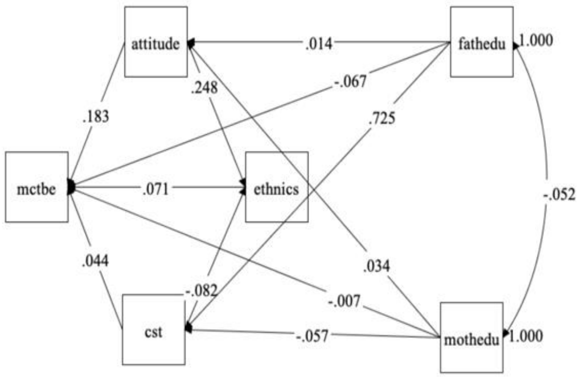
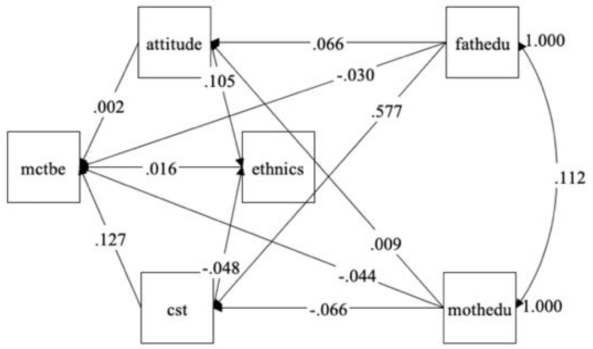
Figure 4

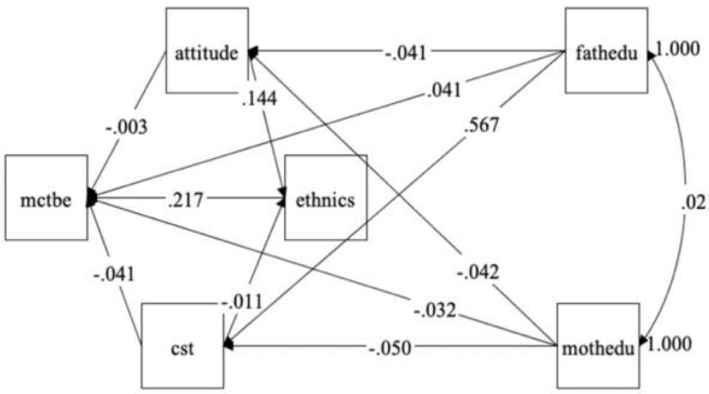
Path models for each grade with standardized values to predict MCTBE: ethnic identity (ethnics), attitude toward mathematics (attitude), creative style test (CSQ), mother's education (mothedu), father's education (fathedu), mathematics creative thinking-based ethnomathematics test (mctbe).



a). 7th grade ($\chi^2(3)$ = 5.438, *CFI* = .991, *TLI* = .956, *SRMR* = .024, RMSEA = 0.052 (90% CI: 0.000–0.120) R^2 = .047)



b). 8th grade ($\chi^2(3)$ = 6.623, *CFI* = .970, *TLI* = .858, *SRMR* = .027, RMSEA = 0.064, (90% CI = 0.000 - 0.132), R^2 = .015)



c). 9th grade ($\chi^2(3)$ = 6.243, *CFI* = .975, *TLI* = .884, *SRMR* = .024, RMSEA = 0.060, 90% CI = 0.000–0.128), R^2 = .049)

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Table 6
Result of model analisis.

Measurement model	**Grade 7th**			**Grade 8th**			**Grade 9th**		
	$\boldsymbol{\beta_0}$	***S.E.***	***p***	$\boldsymbol{\beta_0}$	***S.E.***	***p***	$\boldsymbol{\beta_0}$	***S.E.***	***p***
Ethnics → MCTBE	0.071	0.058	< 0.05	0.016	0.059	> 0.05	0.217	0.056	< 0.01
Attitude → MCTBE	0.183	0.057	< 0.01	0.002	0.059	> 0.05	-0.003	0.057	> 0.05
CST → MCTBE	0.044	0.082	> 0.05	0.127	0.071	< 0.05	-0.041	0.059	> 0.05
Mothedu → MCTBE	-0.007	0.057	> 0.05	-0.044	0.059	> 0.05	-0.032	0.057	> 0.05
Fathedu → MCTBE	-0.034	0.081	> 0.05	-.033	0.072	> 0.05	0.041	0.069	> 0.05
Mothedu → Attitude	0.014	0.057	> 0.05	0.066	0.059	> 0.05	-0.041	0.058	> 0.05
Fathedu → Attitude	0.034	0.057	> 0.05	0.009	0.059	> 0.05	-0.042	0.058	> 0.05
Attitude → Ethnics	0.248	0.054	< 0.01	0.105	0.058	> 0.05	0.144	0.057	< 0.05
CST → Ethnics	-0.082	0.055	> 0.05	-0.048	0.058	> 0.05	-0.011	0.057	> 0.05
Mothedu → CST	0.725	0.027	< 0.01	0.577	0.040	< 0.01	0.567	0.039	< 0.01
Fathedu → CST	-0.057	0.039	> 0.05	-0.066	0.048	> 0.05	-0.050	0.048	> 0.05
Fathedu ↔ Mothedu	-0.052	0.057	> 0.05	0.112	0.058	< 0.05	0.021	0.058	> 0.05

Note: Ethnics = Ethnic identity; CST = creative style test; mothedu =mother's education; fathedu = father's education; MCTBE = mathematics creative thinking-based ethnomathematics test; β_0 = standardized coefficient; S.E. = standard error.

Table 7
Descriptive statistics and correlations among variables.

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. MCTBE	49.84	11.99	1	.857**	.926**	.696**	.788**	.098**	.081*	-.004	.007	-.014
2. Fluency	16.45	3.97		1	.671**	.538**	.589**	.107**	.063	-.013	.009	-.013
3. Flexibility	16.97	6.21			1	.547**	.618**	.085*	.096**	.005	.022	-.009
4. Elaboration	6.40	1.28				1	.620**	.038	.056	-.041	-.017	.002
5. Originality	10.03	2.48					1	.072*	.021	.007	-.028	-.025
6. ATM	95.79	16.23						1	.157**	-.073*	.006	-.005
7. MEI2	69.14	8.48							1	.006	-.019	.005
8. CSQ	80.29	9.68								1	-.049	.010
9. FE	5.07	1.75									1	.645**
10. ME	5.00	1.58										1

Note. N = 896, MCTBE = Mathematics Creative Thinking based Ethnomathematics test, ATM = Attitude towards Mathematics, MEI2 = Multigroup Ethnic Identity Inventory, CSQ = Creative Style Questionnaire, FE = Father Education, ME = Mother Education. ** $p < 0.01$, * $p < 0.05$.

5. Discussion

This study was conducted to better understand the roles of ATM, MEI2, parental education level, and CST in MCTBE. Our findings showed significant correlations between the MCTBE subtests, indicating that they are interrelated. This parallels a previous report that different aspects of CT are inextricably linked with parents education (Pugsley & Acar, 2020), innovative style of creativity (Ramos & Puccio, 2014), and cultural backgrounds have been identified as conducive to nurturing creativity (Luria et al., 2016). Interestingly, people with strong cognitive shift skills and higher intelligence scores are more likely to demonstrate creativity, particularly in terms of producing a greater quantity of ideas, showing flexibility, generating original and unique creative solutions (Pan & Yu, 2018), and able to formulate real solutions (Farida et al., 2022). Studies have highlighted the importance of attitude in fostering CT (Shalley & Gilson, 2004). In this study, ATM had a positive relationship with fluency, flexibility, and originality, but a negative relationship with elaboration, suggesting that students with a positive ATM are more fluent, flexible, and original in their MCT but struggle with elaboration. MEI2 had a positive correlation with flexibility but a negative correlation with other MCTBE subtests. This indicates that students with a strong ethnic identity are more adaptable in their CT, but may not excel in other aspects of CT. This finding is consistent the study by Al-Suleiman (2009) which demonstrated the influence of cultural factors on CT. Surprisingly, the MCTBE subtests did not show significant correlations with CSQ, FE and ME, indicating that creativity ability, environmental control / behavior self-regulation, and family educational level do not have a direct impact on specific aspects of MCT. This contradicts previous research that have suggested that creative style and socioeconomic status are important in promoting CT (Castillo-Vergara et al., 2018; Liang et al., 2022; M.-Z. Wang et al., 2017).

Pirate plots have been shown to be effective in displaying scores distribution and identifying patterns in data (Van Vo & Csapó, 2023). This study used pirate plots to visualize variations in MCTBE scores by grade level. The results revealed interesting patterns in the students' performance at different grade levels in the MCTBE fluency, flexibility, originality, and elaboration subtests. In the fluency subtest, the mean scores of students from grades 7 to 9 showed a gradual decrease, with the lowest mean score observed in the 9th grade. This indicates that as students' progress to higher grade levels, their fluency in CT decline. Similarly, in the originality subtest, the mean scores of students from grades 7 to 9 showed a slight decrease, indicating a possible decrease in their ability to generate original and innovative ideas as they advance in grade levels. Eighth graders achieved a lower score than ninth graders in the flexibility subtest, suggesting that students in eighth grade may have faced some challenges in their CT flexibility, but they were able to overcome these challenges and perform better in ninth grade. The elaboration subtest displayed relatively consistent mean scores across all grade levels, with a slight difference between the seventh and ninth grades. This indicates that students' ability to elaborate and develop their ideas remain relatively stable as they progress through different grade levels. Our finding on the MCTBE subtests is consistent with that of Cheung et al. (2003), which demonstrated that creative potential in college students varied across different years levels, with some aspects of creativity declining in verbal fluency and flexibility as students progressed to higher grades.
Overall, the path model analysis in this study was a good fit and by grades, the model's fit was adequate for the 7th grade, indicating that the selected variables accounted well

for the variance in MCTBE scores. Children and adolescents go through various developmental stages. Grade 7 students may be at a stage where they are more open to influences on their attitudes and creativity. Older students in grades 8 and 9 might be going through stages that emphasize other aspects of development or have already formed more stable attitudes. This outcome supports the findings of Gralewski et al. (2016) who also observed a decline in creative thinking during adolescence, specifically in the Test of Creative Thinking- Drawing Production, which measures figural creativity. The decrease in creativity scores between grade 8 and grade 9 can be attributed to the transition from lower grades (grade 8) to higher grades (grade 9) (Hemdan & Kazem, 2019), where students might begin to adopt more convergent thinking, particularly in applied science or context-based curricula. The process of identity formation during early adolescence, involving the adaptation to social norms and rules, may have a detrimental effect on creative thinking (Hemdan & Kazem, 2019). Furthermore, the rapid developmental changes in the brain, which emphasize a reduction in mathematical concepts, could also be a contributing factor. The results imply that teachers in secondary school, especially in higher-level classes, there should be a focus on promoting activities that encourage divergent thinking in addition to fostering intellectual abilities and academic achievement.

Our findings on significant positive association of ATM and MEI2 with MCTBE scores show that the ability to generate new and favorable original ideas (Davadas & Lay, 2017) and the willingness to explore and take risks in thinking (Grodoski, 2016) are important factors that contribute to higher CT abilities in students. Good attitude is significantly associated with divergent thinking in terms of CT (Basadur et al., 2000), and ethnicity as a moderator of creativity (Paletz & Peng, 2009) and creative style (Ülger & Morsünbül, 2016) are associated with producing original ideas. The positive relationship of ATM, MEI2, and creative style with MCTBE score among 7^{th} and 8^{th} graders in the current study suggests that idea generation, exploratory thinking, and creative style are important factors that contribute to higher CT abilities in students at this grade level.

FE and ME had a negative influence on MCTBE in the 7^{th} and 8^{th} graders, indicating that field dependence and memory efficiency may hinder students CT abilities. One possible explanation for this finding is the disparity between parents educational background and the teaching approach used in MCTBE. Parents with higher levels of education often prefer traditional and formal teaching methods (Li, 2006) that prioritize rote learning and support traditional modes of assessment like standardized testing (Harris, 2015). However, MCTBE encourages creativity, exploration, and the application of mathematics in real-life contexts, which may be unfamiliar and undervalued by parents with limited exposure to such approaches (Jay et al., 2018). Furthermore, some parents may feel unconfident or excluded from supporting their children because they do not understand the modern approaches to teaching mathematics (McMullen & de Abreu, 2011).

The indirect positive influence of FE and ME on MCTBE through their effects on ATM and CST in 7^{th} and 8^{th} graders imply that they indirectly impact CT abilities through their influence on idea generation and creative style. Conversely, ATM and CST had a negative effect on MCTBE in 9^{th} graders, indicating that idea generation and creative style may not be as strong in predicting CT abilities at this grade level. However, fathers' education had a positive impact on their children's MCTBE achievement. This contributes to the growing body of knowledge on the role of family background in creativity, underscores the importance of parental participation and support and provides valuable information for educators and parents to promote positive mathematics learning experiences for children (Retanal et al., 2021). Additionally, the family environment and educational level indirectly contribute to students' cognitive strategies for learning mathematics (Lehrl et al., 2020), which in turn influence their performance in MCT.

6. Limitations and Future Research

This study had some limitations. First, it was a cross-sectional design; hence, a cause and effect relationship could not be established. However, the design offers valuable insights into the developmental trajectory of CT abilities. Second, the study was conducted among a relatively small sample of students of certain grade levels, which may limit the generalizability of the findings to other populations. Third, the study focused solely on MCT and its relationship with attitude, ethnic identity, creative style, and parental education, but did not explore other subjects and potential factors, such as teacher influence, school type, and school climate. Fourth, the study relied on self-report measures, which is subject to response bias and social desirability effects.

While this study provides valuable information on the relationships between ATM, ethnic identity, creative style, parental education, and MCT abilities, it also identifies areas for future research. First, longitudinal designs, diverse samples, and multiple methods (performance-based tasks and divergent thinking tasks) that would help to gain a more comprehensive and nuanced understanding of how the complex interplay of these factors shape MCT among students in different contexts should be explored. Second, observational or behavioral measures would provide more objective assessment of CT abilities. Lastly, exploring CT in various subjects, such as science, language arts, and arts, could shed light on the transferability of CT skills and their application in different academic areas.

7. Conclusions

This study explored the relationship between ATM, ethnic identity, creative style, parents' education, and MCTBE and highlighted the complex interplay of these variables on CT among students of different grade levels. Furthermore, people with strong cognitive shift skills and higher intelligence scores were more likely to be creative, particularly in terms of producing a greater amount of ideas, showing flexibility, and generating original and unique creative solutions. Thus, it demonstrates that idea generation, exploratory thinking, and creative style are important factors in fostering CT abilities. To summarize, the finding of this study pointed out that a positive ATM was associated with greater fluency, flexibility, and originality in CT, but had a negative relationship with elaboration. Similarly, students with a strong ethnic identity showed greater flexibility in creative thinking, while not excelling in other aspects of CT. Interestingly, the MCTBE subtest did not show significant correlations with creative style and parental education for exploration. This suggests that these factors may not have a direct impact on specific aspects of CT in the context of mathematics. Path model analysis showed that ATM and ethnic identity had significant positive associations with MCTBE scores, implying that the ability to generate new and original ideas and the willingness to explore and take risks in thinking were important factors contributing to higher CT abilities in students. In particular, father education positively impacted their children's MCTBE achievement, emphasising the role of parental involvement and support in promoting positive maths learning experiences. It also underscores the importance of improving ATM, embracing cultural sensitivity, promoting parental involvement and support, integrating CT into the curriculum, training teachers, and fostering collaboration between policymakers and researchers in nurturing MCT and enhancing overall educational outcomes in the Indonesian digital society.

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