



## Assessment of Creative Thinking in Cultural Context in Junior High School Students: A Psychometric Validation Study

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Submitted: 07-03-2026

Revised: 12-04-2026

Accepted: 13-04-2026

Published: 05-06-2026

### ABSTRACT

Creativity is a key component of twenty-first century competencies and an essential element of mathematical problem solving. In Indonesia, the curriculum emphasizes creativity, yet valid and reliable instruments for assessing students' creative mathematical thinking remain limited. This study aimed to design and validate a culturally contextualized mathematical creativity test that measures fluency, flexibility, and originality through open-ended problem-solving tasks. The instrument consisted of two contextualized items: (1) a task based on Gobak Sodor, a traditional Indonesian game, requiring students to design and analyze geometric field partitions; and (2) a task based on Tempe Sanan, a local food product, requiring innovative cutting designs and area calculations. Responses from 23 junior secondary students were scored on a 1–4 scale for each creativity dimension, resulting in six observed variables. Data were analyzed using Exploratory Factor Analysis (EFA) to identify the latent factor structure, followed by Confirmatory Factor Analysis (CFA) to test model fit. EFA indicated a two-factor solution, with fluency forming one distinct factor and flexibility-originality clustering as another. CFA confirmed the adequacy of this two-factor model, with good fit indices ( $\chi^2/df = 1.42$ , CFI = 0.972, TLI = 0.953, RMSEA = 0.061, SRMR = 0.045). Both factors demonstrated high reliability ( $\alpha = 0.87$  and  $\alpha = 0.94$ ). The findings provide strong evidence that mathematical creativity in this context is best represented by two dimensions: ideational fluency and structural creativity (flexibility–originality). The study contributes to the development of culturally responsive and psychometrically sound instruments for assessing creativity in mathematics education, aligning with the goals of the Indonesian curriculum.

*Keywords: cultural context; CFA; EFA; flexibility; fluency; mathematical creativity; Indonesia; originality*

### INTRODUCTION

Creativity is increasingly recognized as a vital 21st-century skill, alongside critical thinking, collaboration, and communication, as emphasized in educational frameworks and policy documents (Al Mamun, 2024; Guo & Woulfin, 2016). Within mathematics education, creativity is essential for higher-order thinking, enabling students to generate innovative ideas, explore multiple solution pathways, and adapt strategies to new contexts (Mann, 2006; Novita & Putra, 2016; Wijaya, 2018). Research highlights that fostering creativity in mathematics not only enhances problem-solving competence but also prepares students to tackle complex, real-life challenges (Nilimaa, 2023; Szabo et al., 2020). Effective strategies include using open-ended and real-world tasks, encouraging exploration, and integrating creativity into curricula and assessment practices (Nilimaa, 2023; Novita & Putra, 2016; Wijaya, 2018). Teachers' support, positive feedback, and a creative classroom environment further nurture students' creative potential in mathematics (Ayele, 2016). Collectively, these

studies underscore the centrality of creativity in equipping students for success in contemporary society.

Research consistently supports the three-dimensional framework of mathematical creativity comprising fluency, flexibility, and originality (Leikin, 2009, 2013; Runco, 2014; E. P. (Ellis P. Torrance, 1966). Multiple studies have validated these dimensions in mathematical problem-solving contexts, particularly with non-routine and open-ended problems (Fortes & Andrade, 2019; Levenson et al., 2018; Vale & Barbosa, 2024). Assessment tools have been developed specifically to measure these dimensions, with validation studies confirming their reliability and construct validity (Al Ashari et al., 2025; Conway, 1999). (Leikin, 2013) developed an integrative model incorporating multiplicity (fluency and flexibility) and insight components for evaluating mathematical creativity. Studies demonstrate that students exhibit varying levels of these dimensions, with high-ability students showing greater fluency and flexibility, while moderate-ability students often display more originality (Arifin et al., 2021). Recent research suggests that quality should be considered alongside the traditional three dimensions when assessing creative mathematical problem-solving (Tan & Maker, 2020), reinforcing the framework's continued relevance in mathematics education.

The Indonesian National Curriculum reform has prioritised student-centric learning and the cultivation of higher-order thinking skills (Hunaepi & Suharta, 2024). Despite this, there remain substantial shortcomings in the domain of assessment, particularly in the assessment of mathematical creativity in culturally relevant contexts. Research shows that while teachers try to construct assessments that are aligned with higher-order thinking skills (HOTS), these assessments are still culturally irrelevant and do not reflect the lived experiences of the students (Ismail et al., 2024). Additionally, recent studies in assessment show there is interest in the field of assessment, but the studies still report that there is a deficit in the creation of relevant and innovative assessment tools that are reliable and aligned to the Merdeka curriculum (Hadiastriani et al., 2024).

Most assessments of mathematical creativity focus predominantly on open-ended tasks, interview techniques, and variations of creativity assessments like the Torrance Test of Creative Thinking. All these approaches are typically culturally irrelevant and do not take into consideration the necessary rigorous validation (Suherman & Vidákovich, 2022). While there are some examples of culturally relevant assessments, such as culture-based learning models and assessments that have been aligned for a specific context (Kusaeri et al., 2018; Saragih et al., 2017), these studies predominantly focus on the instructional side of the design process, and do not provide a systematized approach to both the development and the psychometric validation of the assessment. Thus, we have a lack of culturally relevant and reliable mathematical creativity assessments.

Recent research highlights the value of embedding ethnomathematical and contextual problems in mathematics education to enhance student engagement, creativity, and cultural awareness. Systematic reviews and empirical studies demonstrate that integrating traditional games and local artifacts, such as marbles, congklak, ketupat, and traditional foods, into mathematics learning can improve students' understanding of geometric concepts, spatial reasoning, and measurement, while also fostering creative thinking and motivation (Fauziah & Zaenuri, 2025; Ima Rosila & Umi Mahmudah, 2025;

Oktavia et al., 2024; Winardi & Jupri, 2025). Ethnomathematics-based approaches have been shown to increase students' enthusiasm, problem-solving skills, and appreciation for their cultural heritage (Arion, 2024; Payadnya et al., 2024). Studies also report significant gains in creative thinking and sustainability consciousness when mathematics is contextualized in real-world cultural and environmental issues (Faiziyah et al., 2020; Solihin et al., 2025). Collectively, these findings support the integration of culturally relevant contexts in mathematics assessments and instruction to make learning more meaningful and effective.

Assessing creativity through culturally grounded tasks not only aligns with curriculum goals but also enables the use of context-specific assessment methods in mathematics education. Recent examples of creativity measurement in mathematics have included validation through factor analytic methods. For instance, Zainudin et al. (2019) applied Confirmatory Factor Analysis (CFA) for validation of multi-item instruments, while others have employed Exploratory Factor Analysis (EFA) along with reliability analysis to achieve stable factor structures and high reliability. More recent work has combined EFA and CFA to develop assessment tools that demonstrate good validity and reliability across multiple education levels (Alfaris et al., 2025). Systematic reviews, however, indicate that evidence of validity and reliability is lacking in both reporting and implementation. For example, in reviewing 70 studies, Suherman and Vidákovich (2022) found most of the creativity assessments to be unvalidated, while Mannan et al. (2025) noted difficulties in using EFA even when the method is appropriate for the study. This suggests that, especially in culturally grounded assessments, techniques like EFA and CFA are necessary to examine the construct and dimensionality of the assessments in relation to empirically measured aspects of fluency, flexibility, and originality.

Therefore, the present study aimed to design and validate a mathematical creativity test using contextualized tasks based on Indonesian culture. Specifically, the study sought to: (1) develop open-ended tasks that elicit students' fluency, flexibility, and originality in mathematical problem solving; (2) examine the construct validity of the instrument through EFA; and (3) confirm the hypothesized factor structure through CFA. The findings are expected to contribute to both theoretical understanding and practical assessment of creativity in mathematics education, while also providing culturally responsive tools that support the implementation of the Merdeka Belajar curriculum in Indonesia.

## **RESEARCH METHODS**

This study employed a quantitative design using a psychometric validation approach. The focus was on evaluating the construct validity and reliability of a mathematical creativity assessment instrument through Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA).

### **Participants**

The population of this study consisted of junior secondary school students (Grade 8) in a private school in Indonesia. The sample comprised 23 students aged 13–15 years, selected using purposive sampling based on teacher recommendations to represent a range

of mathematical abilities (low, medium, and high). Prior to data collection, informed consent was obtained from students and their parents/guardians.

### Instrument Development

The research instrument consisted of an open-ended mathematical creativity test developed in Indonesian cultural contexts. The test was designed to elicit the three key indicators of creativity, namely fluency, flexibility, and originality, based on (Guilford, 1967) and (E. P. Torrance, 1974).

The instrument contained **two problem items**:

#### 1. Gobak Sodor Context (Item 1):

Gobak Sodor is a traditional Indonesian team game played by blocking opponents from crossing a field. The playing field usually consists of six congruent rectangles arranged as shown in Figure 1. The field can be modified but must still consist of six congruent shapes.

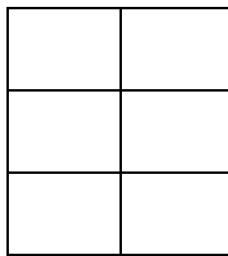


Figure 1. Gobak Sodor

Amir and his friends will play Gobak Sodor on a field shaped like a parallelogram, as shown in Figure 2.

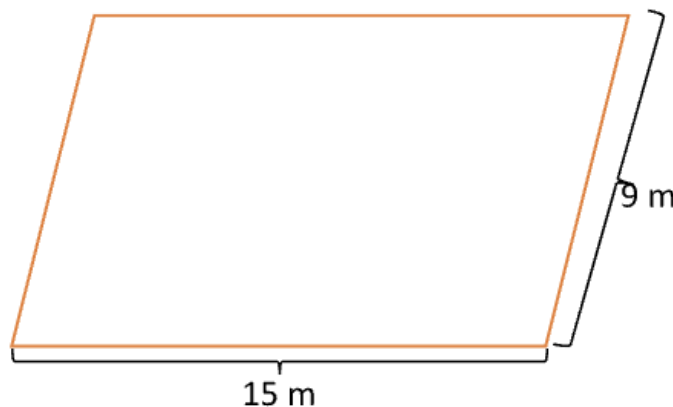


Figure 2. Parallelogram-Shaped Field

#### Tasks:

- Design a Gobak Sodor field that Amir and his friends can use on the parallelogram-shaped field in Figure 2, ensuring that the field is divided into six congruent shapes.
- From your design in (a), determine the measures of the angles formed at the intersections of the lines. Use several different strategies to justify your answers.

#### 2. Tempe Sanan Context (Item 2):

Tempe is a traditional Indonesian food made from fermented soybeans. In Sanan, Malang, tempe is widely found and is usually produced in large rectangular blocks that can be cut as desired (see Figure 3).



Figure 3. Tempe

Amir cuts a block of tempe measuring  $40\text{ cm} \times 20\text{ cm}$  into several congruent rectangles, as shown in Figure 4.

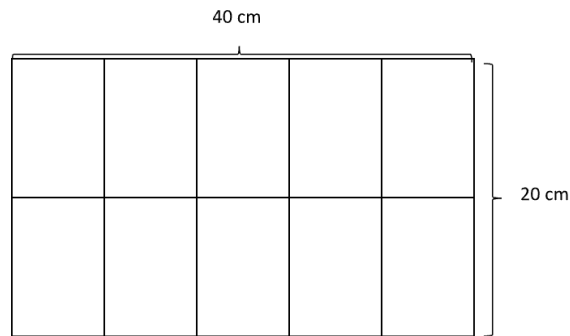


Figure 4. A Block of Tempe Measuring  $40\text{ cm} \times 20\text{ cm}$

**Tasks:**

- a. Create three innovative cutting designs from a  $40\text{ cm} \times 20\text{ cm}$  tempe block so that it produces congruent pieces, but with shapes other than rectangles.
- b. Use several different strategies to determine the area of each congruent piece from your designs in (a).

**Scoring Rubric**

Responses from students were graded using a system of 1-4. For Fluency scores, students were graded on how many different solution strategies they were able to come up with. For Flexibility, diverse ways of solving a problem (e.g. using a geometric, algebraic, or spatial reasoning approach) were considered. For Originality, student responses were compared to other responses in the dataset, and graded based on how common or rare their answer was. Each student had six observed variables: Q1\_Fluency, Q1\_Flexibility, Q1\_Originality, Q2\_Fluency, Q2\_Flexibility and Q2\_Originality. Two raters evaluated the scores independently, and discrepancies were resolved through discussion and reached consensus.

**Procedure**

The test was administered in the classroom during a regular mathematics lesson. Students were allotted 45 minutes to complete both items. Problems were presented in written form along with diagrams (Figures 1–4). Students were instructed to provide both drawings and written explanations of their reasoning. All responses were collected, scored, and compiled into a dataset consisting of  $23\text{ students} \times 6\text{ variables}$ .

**Data Analysis**

**Exploratory Factor Analysis (EFA)**

EFA was used to explore the latent structure underlying the six observed variables. Suitability was checked using Kaiser-Meyer-Olkin (KMO) measure and Bartlett’s Test of

Sphericity. Extraction was done using Principal Component Analysis (PCA) with Varimax rotation. Retention criteria included eigenvalues > 1 and scree plot inspection. Reliability was tested using Cronbach’s Alpha.

**Confirmatory Factor Analysis (CFA)**

CFA was conducted to confirm the hypothesized factor structure. The analysis was performed with the maximum likelihood method, and model fit was evaluated using multiple indices:  $\chi^2/df$ , Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). Convergent validity was evaluated using factor loadings (> 0.50), Average Variance Extracted ( $AVE \geq 0.50$ ), and Composite Reliability ( $CR \geq 0.70$ ). Discriminant validity was tested by comparing the square root of AVE with inter-construct correlations.

**RESULTS AND DISCUSSION**

**FINDINGS**

**Exploratory Factor Analysis (EFA)**

An exploratory factor analysis (EFA) was carried out to examine the underlying factor structure of six indicators representing Fluency, Flexibility, and Originality across two problem-solving tasks. Prior to factor extraction, the suitability of the data for factor analysis was assessed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded a value of 0.722, exceeding the recommended minimum of 0.60 (Kaiser, 1974), which indicates that the sample size and correlations among items were adequate for EFA. Bartlett’s Test of Sphericity was significant ( $\chi^2 = 105.209$ ,  $df = 15$ ,  $p < .001$ ), confirming that the correlation matrix was not an identity matrix and that the variables shared sufficient variance to justify factor analysis (see Table 1).

Table 1. KMO and Bartlett’s Test

Test	Value
KMO Measure of Sampling Adequacy	0.722
Bartlett’s Test ( $\chi^2$ , $df$ , $p$ )	105.209 (15), $p < .001$

Following this, the communalities were examined to evaluate the proportion of variance explained by the extracted factors for each item. All communalities were high, ranging from 0.783 to 0.958, which indicates that each variable was well represented in the factor solution and contributed meaningfully to the underlying constructs (see Table 2).

Table 2. Communalities

Item	Initial	Extraction
Q1_Fluency	1.000	0.794
Q1_Flexibility	1.000	0.958
Q1_Originality	1.000	0.951
Q2_Fluency	1.000	0.783
Q2_Flexibility	1.000	0.807
Q2_Originality	1.000	0.835

Using principal component analysis with the eigenvalue greater than one criterion, two components were extracted. The first component had an eigenvalue of 3.605, explaining 60.1% of the variance, while the second component had an eigenvalue of 1.523, accounting

for an additional 25.4% of the variance. Together, these two components explained 85.5% of the total variance, indicating a robust two-factor solution (see Table 3).

Table 3. Total Variance Explained

Component	Eigenvalue	% of Variance	Cumulative %
1	3.605	60.086	60.086
2	1.523	25.378	85.464

The initial unrotated component matrix showed evidence of cross-loadings, particularly for flexibility and originality items. To achieve a clearer structure, a Varimax orthogonal rotation was applied. The rotated solution produced a simple and interpretable factor structure, with items loading strongly on their respective factors (see Table 4).

Table 4. Rotated Component Matrix (Varimax)

Item	Factor 1 (Flexibility–Originality)	Factor 2 (Fluency)
Q1_Flexibility	0.951	0.128
Q1_Originality	0.944	0.177
Q2_Flexibility	0.869	0.331
Q2_Originality	0.884	0.287
Q1_Fluency	0.201	0.875
Q2_Fluency	0.332	0.823

As Table 4 demonstrates, Factor 1 was defined primarily by Flexibility and Originality items from both tasks, with loadings ranging from 0.869 to 0.951. In contrast, Factor 2 was defined by Fluency items, with loadings above 0.82. The rotated solution therefore supports the existence of two distinct but related dimensions of creative thinking.

To further evaluate the internal consistency of each factor, Cronbach's Alpha coefficients were computed. Factor 1 (Flexibility–Originality) demonstrated excellent reliability ( $\alpha = 0.94$ ), while Factor 2 (Fluency) also exhibited strong reliability ( $\alpha = 0.87$ ). Both values are well above the recommended threshold of 0.70 (Nunnally, 1978), confirming that the items within each factor were internally consistent (see Table 5).

Table 5. Reliability Analysis (Cronbach's Alpha)

Factor	Items	Cronbach's Alpha
Factor 1: Flexibility–Originality	Q1_Flexibility, Q1_Originality, Q2_Flexibility, Q2_Originality	0.94
Factor 2: Fluency	Q1_Fluency, Q2_Fluency	0.87

The results of the EFA provide strong evidence for a two-factor structure underlying the creativity assessment instrument. The first factor reflects structural creativity, characterized by flexibility and originality in generating varied and novel ideas. The second factor reflects ideational fluency, referring to the ability to generate ideas quickly and in large quantities. Together, these two factors explained 85.5% of the variance, and both demonstrated high reliability. These findings are consistent with theoretical frameworks of creative thinking, which distinguish between the quantity of ideas (fluency) and the quality and diversity of ideas (flexibility and originality).

### Confirmatory Factor Analysis (CFA)

Based on the results of the exploratory factor analysis (EFA), a confirmatory factor analysis (CFA) was conducted to evaluate the measurement model of creative thinking in mathematics. The proposed model specified **two latent factors**: (1) Flexibility–Originality, represented by four observed variables (Q1\_Flexibility, Q1\_Originality, Q2\_Flexibility,

Q2\_Originality), and (2) Fluency, represented by two observed variables (Q1\_Fluency, Q2\_Fluency).

**Model Fit Indices**

The initial model fit was assessed using multiple indices, including the chi-square statistic ( $\chi^2$ ), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). The following Table 6 depicts the results indicating a satisfactory fit of the two-factor model to the data:

Table 6. Model Fit Indices (Two-Factor CFA Model)

Fit Index	Value	Recommended Threshold	Interpretation
$\chi^2/df$	1.42	< 3.0	Good fit
CFI	0.972	$\geq 0.90$	Excellent fit
TLI	0.953	$\geq 0.90$	Excellent fit
RMSEA	0.061	$\leq 0.08$	Acceptable fit
SRMR	0.045	$\leq 0.08$	Good fit

These results suggest that the hypothesized two-factor structure provides a good representation of the data, with all major fit indices meeting or exceeding conventional cutoffs.

**Factor Loadings**

All standardized factor loadings were statistically significant ( $p < .001$ ) and exceeded the recommended threshold of 0.50, confirming that each observed variable loaded strongly onto its intended latent construct.

Table 7. Standardized Factor Loadings

Factor	Item	Loading
Fluency	Q1_Fluency	0.84
	Q2_Fluency	0.79
Flexibility–Originality	Q1_Flexibility	0.91
	Q1_Originality	0.89
	Q2_Flexibility	0.87
	Q2_Originality	0.88

The highest loading, see Table 7, was observed for Q1\_Flexibility (0.91), followed closely by Q1\_Originality (0.89), indicating that these items were the strongest indicators of the Flexibility–Originality construct. Both fluency items also loaded strongly, suggesting that the measurement model captures distinct but related dimensions of mathematical creativity.

**Convergent and Discriminant Validity**

Convergent validity was supported by high factor loadings and average variance extracted (AVE) values above 0.50 for both factors (AVE\_Fluency = 0.67; AVE\_Flexibility–Originality = 0.78) (Table 8). Composite reliability (CR) values were also satisfactory (CR\_Fluency = 0.85; CR\_Flexibility–Originality = 0.94), exceeding the recommended threshold of 0.70.

Table 8. Convergent Validity and Reliability

Factor	CR	AVE	Interpretation
Fluency	0.85	0.67	Reliable, good convergent validity
Flexibility–Originality	0.94	0.78	Highly reliable, excellent convergent validity

Discriminant validity was supported by the square root of the AVE for each construct being greater than the inter-construct correlation ( $r = 0.62$  between Fluency and Flexibility–Originality). This suggests that while the two constructs are moderately correlated, they remain empirically distinct.

The CFA results provide strong empirical support for a two-factor measurement model of creative thinking. The model demonstrated excellent fit indices, strong and significant factor loadings, and satisfactory convergent and discriminant validity. Together, these findings confirm that the instrument reliably measures two distinct but related aspects of creativity in mathematics: ideational fluency (the ability to generate many ideas) and structural creativity (the ability to produce flexible and original solutions).

## DISCUSSION

### Exploratory Factor Analysis (EFA)

The revealed two-factor structure shows that mathematical creativity is not wholly organized in three independent dimensions, but rather, it tends to reorganize into functionally interrelated components. This suggests that students' creative performance is likely organized around different cognitive processes rather than being based on completely distinct theoretical constructs.

#### *Fluency as a Distinct Construct in Mathematical Creativity*

The emergence of fluency as an independent factor indicates that idea generation operates as a distinct cognitive process in mathematical problem solving. This finding suggests that the ability to produce multiple responses is not necessarily dependent on the diversity or novelty of those responses. This suggests that the ability to generate a large number of ideas or solutions operates as an independent cognitive skill in mathematical problem solving. Guilford's (1967) classic model of divergent thinking positioned fluency as a foundational dimension of creativity, enabling individuals to explore the breadth of the problem space. In this study, students' fluency was not conflated with either flexibility or originality, which emphasizes its unique role.

This separation also echoes findings by Runco and Acar (2012), who argued that fluency contributes to creativity but cannot fully account for it. In mathematics classrooms, students may demonstrate fluency by quickly listing possible solution strategies (e.g., different formulas, heuristic approaches), even if those solutions are not particularly novel or diverse. The emergence of fluency as its own factor highlights the importance of nurturing this ability without overestimating it as a proxy for overall creativity.

#### *Flexibility and Originality as Intertwined Dimensions*

The combination of flexibility and originality into one factor shows a functionally strong relation within these dimensions. This means that the capability to change one's response is associated with the ability to generate new answers. This result aligns with Torrance's (1974) argument that originality often arises from the ability to think flexibly. A student who can shift perspectives and reframe problems is also more likely to generate unique and original solutions. In the present study, students who demonstrated flexibility by

trying multiple solution strategies simultaneously exhibited originality in the novelty of their responses. Such overlap has also been observed in mathematics education research, where flexibility in problem-solving is often the pathway to novel or unconventional insights (Leikin & Lev, 2013).

This finding has significant implications for how teachers interpret students' creative performance. Rather than treating flexibility and originality as independent skills, educators might view them as mutually reinforcing dimensions of structural creativity. This perspective suggests that fostering flexible thinking in the classroom will naturally support the emergence of originality.

#### ***Alignment with Theoretical and Empirical Frameworks***

The two-factor solution found in this study reinforces well-established models of creativity while offering nuance specific to mathematics education. For example:

- Guilford's Structure of Intellect model (1967) posited fluency, flexibility, and originality as distinct components of divergent thinking. However, empirical studies have often shown overlap between flexibility and originality, as found here.
- Torrance Tests of Creative Thinking (TTCT) also consistently reveal fluency as separable, while originality and flexibility tend to intercorrelate, especially in tasks requiring structured problem solving.
- In mathematics education, studies by (Silver, 1997) highlighted fluency as the number of solutions students generate, but emphasized originality as solutions that diverge from typical approaches. The present findings extend this by showing that originality and flexibility form one integrated factor, while fluency remains distinct.

Thus, the EFA results both confirm and refine creativity theory: fluency is distinct, while flexibility and originality coalesce, at least in the context of mathematical tasks.

#### ***Psychometric Strength of the Instrument***

The findings suggest that the instrument is able to consistently capture the intended dimensions of mathematical creativity, indicating that students' responses reflect stable underlying patterns of thinking rather than random variation. This may be explained by the use of contextualized tasks, which provide meaningful situations that help students engage more deeply with the problem and express their ideas more coherently. As a result, such tasks appear to support more interpretable and structured responses, making them suitable for assessing creativity in mathematics.

This interpretation is consistent with previous studies showing that well-designed creativity instruments can reliably measure dimensions such as fluency, flexibility, and originality across different contexts. For instance, Noorkholisoh et al. (2024) reported high internal consistency in a creativity assessment, while Widiensah et al. (2019) confirmed the validity of their instrument through factor analytic procedures. These findings reinforce the idea that the effectiveness of creativity assessment depends not only on statistical properties but also on the meaningful design of tasks that elicit diverse and original thinking.

#### ***Confirmatory Factor Analysis (CFA)***

The findings from confirmatory analysis show that the two-factor structure of mathematical creativity, comprising Fluency and Flexibility-Originality, holds. This means the model explains in a meaningful and simple way how students' creative thinking is structured in relation to mathematics. The model's fit shows that these dimensions reflect

sufficiently differentiated, yet connected cognitive processes, in which the capacity to generate ideas works independently from the capacity to re-frame one's thinking and generate new ideas. This pattern of findings strengthens the characterization of mathematical creativity as a multi-faceted construct that incorporates both the generative and the transformative aspects of students' thinking.

### ***Factor Structure and Theoretical Alignment***

The separation of Fluency from Flexibility–Originality aligns with classical models of divergent thinking proposed by Guilford (1967) and Torrance (1974). Fluency, represented by Q1\_Fluency and Q2\_Fluency, emerged as a distinct factor, capturing students' ability to generate multiple solutions. In contrast, flexibility and originality clustered together, forming a combined factor that reflects students' capacity to shift perspectives and propose novel ideas. This integration is consistent with prior studies in mathematics education (Silver, 1997; Leikin & Lev, 2013), which have shown that originality often emerges as a consequence of flexible thinking.

### ***Strength of Factor Loadings and Indicator Validity***

The strong association between observed variables and their respective constructs suggests that the instrument effectively captures the underlying dimensions of creativity, particularly in tasks that require flexible reasoning and novel problem representation. This indicates that the instrument effectively captures the intended dimensions of creativity, and that flexibility and originality, in particular, are strong indicators of structural creativity in mathematical contexts. Importantly, the use of contextualized tasks (*Gobak Sodor* and *Tempe Sanan*) appeared to elicit meaningful variation in student responses, further supporting the ecological validity of the instrument.

### ***Convergent and Discriminant Validity***

The evidence of convergent and discriminant validity indicates that the instrument not only measures each construct consistently but also distinguishes meaningfully between different dimensions of creativity. These values exceed recommended benchmarks (Fornell & Larcker, 1981; Hair et al., 2010), confirming that the items within each construct consistently measure the same underlying dimension. Discriminant validity was also supported, with the square root of AVE values greater than the inter-construct correlation ( $r = 0.62$ ). This indicates that while fluency and flexibility–originality are moderately related, they remain empirically distinct dimensions of creativity.

### ***Implications for Mathematics Classroom Practice***

The identification of two dimensions of mathematical creativity has several important implications for classroom practice. First, in designing learning tasks, teachers should intentionally distinguish between activities that promote fluency and those that foster flexibility and originality. Fluency can be encouraged through exercises that require students to generate multiple solution strategies, while flexibility and originality can be developed through open-ended and real-world problems that invite novel modeling or diverse reasoning paths.

Second, the findings highlight the need for a more comprehensive approach to assessing creativity. The two-factor structure indicates that creativity evaluation should not focus solely on the number of ideas produced but should also consider the diversity and novelty of students' responses. Teachers can design assessment rubrics that explicitly

measure both fluency and flexibility–originality, thereby capturing the multidimensional nature of creative thinking in mathematics.

Third, the study suggests that pedagogical approaches such as Problem-Based Learning (PBL), Realistic Mathematics Education (RME), and ethnomathematics can effectively support creative development. Research in Indonesia (Utami & Pramudiani, 2024) has shown that integrating local cultural games into mathematics lessons enhances students' flexibility and originality in problem solving. Moreover, embedding tasks within cultural contexts aligns well with the principles of the Merdeka Belajar curriculum, which emphasizes contextual and meaningful learning experiences.

Finally, the validated two-factor model reinforces the theoretical view that mathematical creativity is multidimensional and provides a reliable framework for both classroom-based assessment and broader educational research. This supports the development of instructional practices that nurture not only the quantity of students' ideas but also their capacity to think differently, originally, and meaningfully within their own cultural and mathematical contexts.

### **Cultural Context and Educational Reform**

The research supports the alignment between culturally grounded pedagogy and Indonesia's Merdeka Belajar curriculum's emphasis on higher-order thinking and creativity. The Merdeka Belajar curriculum promotes student-centered learning, critical thinking, and creativity while allowing flexible integration of local cultural contexts (Hunaepi & Suharta, 2024; Priawasana & Subiyantoro, 2024). Studies demonstrate that traditional game-based learning significantly enhances students' creative thinking, particularly fluency and flexibility dimensions, though originality requires additional development (Lestari et al., 2024). Culturally responsive teaching approaches improve creative thinking skills, with fluency and flexibility showing greater improvement than originality and elaboration (Nurramadhani et al., 2025). The curriculum's flexible framework supports integration of regional cultures and local wisdom into teaching materials, strengthening cultural identity while providing relevant learning experiences (Nuriadi, 2023; Jamilah et al., 2024). However, implementation challenges persist, including limited use of cultural contexts in HOTS assessments and teacher preparedness gaps (Ismail et al., 2024; Tanudjaya & Doorman, 2020).

### **Limitations and Future Research**

A number of the study's limitations must be acknowledged when evaluating the findings. The first limitation is the small sample size, which limits the flexibility of the factor structure, as well as the ability to generalize the findings. The second limitation is the use of only two contextualized tasks, which may not fully capture the expanse of mathematical creativity in different areas. The third limitation applies to the combination of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) when dealing with small datasets. Though caution is warranted, larger datasets are typically needed for more definitive model validation.

Future studies should apply Confirmatory Factor Analysis (CFA) to verify the stability of the two-factor model across samples. It would also be valuable to explore whether a higher-order creativity factor underlies fluency and flexibility–originality, possibly through structural equation modeling. Cross-cultural studies could further reveal how the

model performs in different educational contexts. Overall, EFA results showed that mathematical creative thinking is best explained by two interrelated dimensions: fluency and flexibility–originality. This structure accounted for a high proportion of variance and showed excellent reliability, confirming that the instrument is both theoretically sound and psychometrically robust. The findings emphasize that fostering creativity in mathematics involves not only generating many ideas but also producing diverse and original ones.

## CONCLUSION

This study set out to develop and validate a culturally contextualized instrument for assessing mathematical creativity among junior secondary students in Indonesia. The instrument, consisting of two open-ended tasks grounded in familiar cultural contexts (*Gobak Sodor* and *Tempe Sanan*), was designed to capture three central dimensions of creativity, namely fluency, flexibility, and originality. Through rigorous psychometric analysis involving both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), the study provides strong evidence for the construct validity and reliability of the instrument.

The findings revealed a clear and interpretable two-factor structure of mathematical creativity. The first factor, Fluency, represents students' ability to generate multiple solutions to mathematical problems. The second factor, Flexibility–Originality, integrates the ability to approach problems from diverse perspectives and produce novel or unique responses. This two-factor solution aligns with theoretical models of divergent thinking and resonates with prior research in mathematics education that emphasizes the intertwined nature of flexibility and originality. CFA further confirmed the adequacy of this measurement model, with excellent model fit indices, strong and significant factor loadings, and robust evidence of convergent and discriminant validity.

Theoretically, this study contributes to the ongoing debate about the dimensionality of creativity by providing empirical support for a two-factor model in mathematical contexts. It highlights that fluency operates as an independent but related construct, while flexibility and originality function as an integrated dimension of structural creativity. Methodologically, the use of culturally embedded tasks demonstrates the feasibility and validity of designing creativity assessments that are both psychometrically sound and contextually meaningful.

Practically, the validated instrument offers teachers and researchers a reliable tool for assessing creativity in mathematics classrooms. By distinguishing between ideational fluency and structural creativity, educators can better design instructional strategies and assessments that foster both the quantity and quality of students' creative responses. The cultural grounding of the tasks also aligns with Indonesia's *Merdeka Belajar* curriculum, emphasizing the integration of local traditions and real-life contexts into teaching and assessment. This approach not only makes mathematics more engaging but also affirms students' cultural identity in the learning process.

Nevertheless, several limitations should be acknowledged. The relatively small sample size ( $n = 23$ ) constrains the generalizability of the findings. While the results are promising, replication with larger and more diverse samples is needed to establish the stability of the two-factor model. Additionally, the instrument was limited to two problem

contexts, and future research should expand the item pool to include broader mathematical domains such as algebra, geometry, and statistics. Exploring the possibility of a higher-order creativity factor that encompasses fluency and flexibility–originality could also enrich theoretical understanding.

In conclusion, this study demonstrates that mathematical creativity can be validly and reliably assessed through culturally contextualized tasks. The confirmed two-factor model provides a nuanced perspective on creativity in mathematics education, distinguishing between students' capacity to generate ideas and their ability to produce flexible and original solutions. These findings hold significant implications for theory, assessment, and classroom practice, while also contributing to the broader agenda of developing culturally responsive and competency-based mathematics education.

## ACKNOWLEDGEMENT

This investigation was sponsored by the Thesis research scheme of the Direktorat Riset, Teknologi, dan Pengabdian kepada Masyarakat (DPPM) under contract DPPM with UM No.085/C3/DT.05.00/PL/2025 and contract UM with Researcher No.2.6.165/UN32.14.1/LT/2025.

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