Vocational: Journal of Educational Technology
E-ISSN 3063-6639 | P-ISSN 3063-6647
Volume 2. No. 1, September 2025
https://jurnal.smpharapanananda.sch.id/index.php/vocational/

Research Article

Evaluating Creative Problem-Solving Test for Elementary Students: Evidence from Factor Analyses

Herianto[1,2*], Raden Rosnawati[1], Andi Jusmiana[1,3], Ashiraf Mabanja[4]

[1]Universitas Negeri Yogyakarta, **Indonesia**
[2]Institut Turatea Indonesia, **Indonesia**
[3]Universitas Pejuang Republik Indonesia, **Indonesia**
[4]Islamic University in Uganda, **Uganda**
Correspondence Author: herianto3pasca.2022@student.uny.ac.id

Keywords:
Creative Problem Solving, Creativity Assessment, Factor Analysis, Elementary Education.

Abstract

The lack of reliable and valid instruments to assess creative problem-solving (CPS) in elementary students is a primary problem, especially within evolving educational frameworks. Purpose of this Research: This study aimed to examine the validity and reliability of a CPS assessment instrument focusing on the dimensions of originality, completeness, and practicality to develop a more accurate measurement model. Research Methods: Using a quantitative, cross-sectional design, the data were analyzed using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Research Sample: Data were collected from a sample of 150 elementary school students in South Sulawesi Province, Indonesia. Results and Implications: The results indicated that the CPS instrument is best represented by two aspects: originality and completeness, while the practicality aspect was excluded. The implication of this finding is the provision of a refined, valid, and reliable two-factor CPS model. Impact: The impact is that educators now have a more robust tool to accurately measure student creativity, which supports the cultivation of 21st-century skills and informs curriculum development by focusing on empirically supported aspects of creative problem-solving.

Received: *Jun. 27, 2025.* ***Revised:*** *Jul. 23, 2025.* ***Accepted:*** *Aug. 01, 2025.* ***Published:*** *Sep. 01, 2025.*

Introduction

Creativity and problem-solving ability have emerged as essential competencies for learners, receiving significant attention as core skills for the 21st century [1]. In Indonesia, the implementation of the Merdeka Curriculum reflects a national commitment to fostering these skills by promoting differentiated and flexible learning tailored to the needs and contexts of students [2], [3]. This curriculum grants schools the autonomy to develop learning experiences that consider student characteristics and advances in science while still adhering to national educational standards [2]–[5]. This framework integrates character education, 21st-century skills, literacy, and numeracy, offering a unique opportunity to develop diverse creativity assessment procedures at the elementary school level.

How to Cite: Herianto, Rosnawati, R., Jusmiana, A., & Mabanja, A. (2025). Evaluating Creative Problem-Solving Test for Elementary Students: Evidence from Factor Analyses. *Vocational: Journal of Educational Technology*, *2*(1), 23–32. https://doi.org/10.58740/vocational.v2i1.459

Despite this opportunity, the measurement of creativity in children presents considerable challenges, as creativity is a psychological attribute that can only be assessed indirectly through observable indicators [6], [7]. Currently, there is no universally accepted measurement model that provides absolute values corresponding to a student's true creative abilities [8]. While several studies have proposed assessment procedures to approximate students' creativity scores with reasonable accuracy [9]–[11], these models often yield high variance in scores, making it difficult to distinguish between actual ability and genuine creative potential.

The specific problem addressed in this study is the lack of a reliable and valid measurement model for assessing creative problem-solving (CPS) abilities among elementary school students. Existing models often fail to provide consistent differentiation between students' actual abilities and their creative potential, particularly when applied within the context of Indonesia's Merdeka Curriculum. Furthermore, although past research has focused on aspects like fluency, flexibility, and originality [12], additional criteria such as practicality are often considered in open-ended assessments without comprehensive validation, creating a gap in the literature [13], [14]. This gap underscores the need for rigorous testing and refinement of CPS assessment instruments to ensure they accurately reflect the dimensions they are intended to measure.

The purpose of this research is to develop a more precise and contextually relevant CPS measurement model by investigating the validity and reliability of its dimensions and identifying which aspects are most robust for evaluation. By focusing on the most valid factors, specifically originality and completeness, this study aims to produce a refined assessment tool. The implications of this research are to provide educators with an accurate instrument to foster creativity, inform curriculum development, and support the cultivation of problem-solving skills among young learners in the Indonesian elementary education context.

Literature Review

The measurement of creativity in children presents considerable challenges. As a psychological attribute, creativity can only be assessed indirectly through observable symptoms or indicators [6], [7]. To date, there is no universally accepted measurement model that provides absolute values corresponding to a student's true creative abilities [8]. Although several studies have proposed assessment procedures to estimate students' creativity scores with reasonable accuracy [9]–[11], these models often produce high variance in scores, making it difficult to distinguish between actual ability and true creative potential.

A review of the literature reveals that most previous research has concentrated on measuring aspects such as fluency, flexibility, and originality as core components of creativity [12]. However, in open-ended assessments like the Creative Problem-Solving (CPS) test, additional criteria including the quantity, accuracy, and practicality of students' ideas are often considered [13], [14]. Despite these advancements, a lack of comprehensive validation of these models remains, particularly within the context of Indonesia's elementary education system and the Merdeka Curriculum. This study seeks to fill this gap by systematically evaluating the validity and reliability of CPS assessment

instruments and exploring the factors that best capture creative problem-solving abilities in this unique educational setting.

The novelty of this research lies in its approach to refining the CPS measurement model by focusing on the most valid and reliable aspects, specifically originality and completeness, and by involving multiple assessors in the evaluation process. By employing quantitative and qualitative methods, including factor analysis and teacher interviews, this study offers an original contribution to the field by developing a CPS assessment instrument that is both accurate and applicable to the Indonesian elementary education context.

Research Methods

This study employed a quantitative, cross-sectional design to examine the validity and reliability of a CPS test for elementary school students. The research focused on the trial, validation, and reliability testing of the CPS instrument using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), consistent with best practices in educational measurement [15].

The CPS instrument was developed based on established constructs in the literature, encompassing three main aspects: originality, completeness, and practicality [12], [13]. Each aspect was operationalized into three observable indicators, resulting in a total of nine test items Table 1. The instrument was designed for upper elementary students (grades 4 and 5) and consisted of nine open-ended questions in the domains of mathematics and science. Student responses were evaluated by teachers using an assessment rubric, with each item scored on a Likert scale ranging from 0 to 5, adapted from the Consensual Assessment Technique [16].

Table 1. Aspects and Indicators of Creative Problem-Solving Test

Aspects	Indicators	Initial	score range
Originality (ORG)	Shows novelty	ORG1	0-5
	Using different concepts	ORG2	0-5
	Self-determined	ORG3	0-5
Completeness (COM)	Write down answers (even if they are not exact)	COM1	0-5
	Show patterns	COM2	0-5
	Full answer	COM3	0-5
Practically (PRA)	The right answer	PRA1	0-5
	Short and concise answers	PRA2	0-5
	Show guesses on answers	PRA3	0-5

Data collection was conducted during the first semester of 2022 and involved 150 students from five highly accredited elementary schools in South Sulawesi Province, Indonesia. The assessment was administered in three sessions, each comprising three questions, to accommodate the cognitive load and attention span of the students. Teachers served as raters independently scoring each student's response according to the rubric criteria.

Before factor analysis, preliminary assumption tests were conducted, including the Kolmogorov-Smirnov normality test and the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity, to ensure suitability for factor analysis

[17]. Principal Component Analysis (PCA) was initially used to explore the structure of the instrument. Items with anti-image correlation values above 0.40 were retained, and factors with eigenvalues greater than 1 were considered significant contributors to the construct [17], [18].

Subsequently, Exploratory Factor Analysis (EFA) with varimax rotation was conducted using SPSS to identify the underlying factor structure and to determine the validity of each item. Factor loadings greater than 0.5 were considered evidence of construct validity [19]. The reliability of the instrument was evaluated using Cronbach's alpha, with a threshold of 0.83 indicating high reliability [20].

Confirmatory Factor Analysis (CFA) was performed using LISREL 8.80 software to further assess the construct validity and model fit of the CPS instrument. Model fit was evaluated using multiple indices, including p-value (> 0.05), RMSEA (< 0.08), chi-square/df ratio (> 2), NFI (≥ 0.90), CFI (≥ 0.90), and IFI (≥ 0.90) [15]. Structural equation modeling was used to examine the relationships among the indicators and aspects, with t-values greater than 1.660 ($df = 147, \alpha = 0.05$) considered statistically significant.

Results and Discussion

Before conducting factor analysis on the aspects and indicators of the CPS Test, assumption testing was performed on the trial data from 150 elementary students. The normality test using the Kolmogorov-Smirnov statistic indicated that the data for all assessed aspects originality (0.063 > 0.05), completeness (0.069 > 0.05), and practicality (0.053 > 0.05) were normally distributed. The KMO measure of sampling adequacy was 0.692, exceeding the recommended threshold of 0.5, and Bartlett's test of sphericity was significant ($p < 0.001$), confirming that the data were suitable for factor analysis.

A. Principal Component Analysis

Principal Component Analysis (PCA) was conducted to explore the factor structure of the CPS instrument. The anti-image correlation values for all nine indicators exceeded 0.40, indicating that each item was suitable for inclusion in further analysis. Table 2 presents the anti-image matrix.

Table 2. Anti-image Matrice

Item	Anti-image Correlation	Item	Anti-image Correlation	Item	Anti-image Correlation
1	0,615	4	0,752	7	0,489
2	0,636	5	0,681	8	0,540
3	0,947	6	0,629	9	0,498

The Initial Eigenvalues revealed the presence of two principal components with eigenvalues greater than 1, explaining 33.79% and 22.00% of the total variance, respectively. Together, these two components accounted for 55.79% of the total variance, suggesting a two-factor solution for the CPS construct.

B. Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) with varimax rotation was then performed to further clarify the factor structure. All nine indicators

demonstrated factor loadings greater than 0.5, indicating strong construct validity. However, the reliability analysis using Cronbach's alpha yielded a value of 0.79, which, while acceptable, did not meet the higher threshold of 0.83 recommended for high-stakes educational assessments. Notably, the analysis revealed a negative correlation for all indicators and the practicality aspect, suggesting that this aspect did not align well with the underlying construct measured by the instrument.

C. Confirmatory Factor Analysis

To confirm the factor structure identified in the EFA, Confirmatory Factor Analysis (CFA) was **conducted** using LISREL 8.80. The two-factor model, consisting of originality and completeness, demonstrated good model fit: $\chi^2/df = 1.74$, $p = 0.073$, RMSEA = 0.057, NFI = 0.91, CFI = 0.93, and IFI = 0.92. All factor loadings were statistically significant ($t > 1.660$, $p < 0.05$), supporting the validity of the model. The practicality aspect, however, showed consistently negative or weak loadings and was therefore excluded from the final model to improve overall fit and interpretability. Figure 1 presents the modified path of creative problem solving measurement diagram.

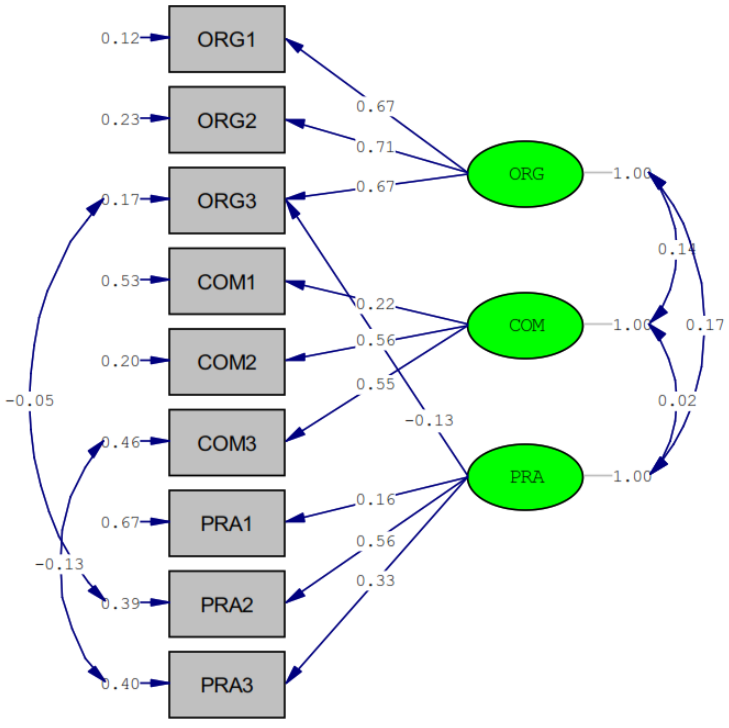

Figure 1. Modification of Creative Problem-solving Measurement Diagram Path

The results of this study indicate that the CPS instrument, when limited to the aspects of originality and completeness, demonstrates acceptable validity and reliability for assessing creative problem-solving abilities in elementary school students. All indicators for these two aspects are valid, with strong factor loadings and satisfactory reliability. The

practicality aspect, however, did not contribute positively to the dimensions and should be reconsidered or revised in future iterations of the instrument. These findings suggest that a refined CPS measurement model focusing on originality and completeness, and involving multiple assessors for scoring, can provide a more accurate and reliable assessment of students' creative problem-solving abilities.

D. Discussion

The present study aimed to evaluate the validity and reliability of the CPS test for elementary school students, focusing on the constructs of originality, completeness, and practicality. The findings contribute to the ongoing discourse on creativity assessment in education, particularly within the context of Indonesia's Merdeka Curriculum, which emphasizes differentiated, student-centered learning and the development of 21st-century competencies [2], [3].

The results of the assumption tests, including normality and sampling adequacy, confirmed that the dataset was appropriate for further factor analysis. PCA and EFA revealed that the CPS instrument's items loaded strongly onto two main factors, originality and completeness, while the practicality aspect demonstrated weak or negative correlations with the overall construct. These findings are consistent with previous research suggesting that, while fluency, flexibility, and originality are core components of creativity [21]–[23], the inclusion of practicality as a distinct factor may not always enhance the psychometric properties of creativity assessments in educational settings [13], [14].

The reliability analysis indicated that the instrument, when limited to the aspects of originality and completeness, achieved an acceptable Cronbach's alpha value, supporting its use for classroom assessment. However, the reliability did not reach the higher threshold often recommended for high-stakes testing, suggesting that further refinement, such as item revision or rater training, may be necessary to improve internal consistency [23].

CFA further validated the two-factor structure, with model fit indices meeting established criteria. The exclusion of practicality from the final model improved both the fitness and interpretability of the test, aligning with the gap analysis and theoretical framework outlined in the introduction. This refinement addresses a key gap in the literature, where previous CPS measurement models have not always been systematically validated in diverse educational contexts, particularly in Indonesia.

The study's findings offer several important implications. First, they underscore the importance of focusing on originality and completeness as primary dimensions of creative problem solving in elementary education. These aspects are not only theoretically grounded but also empirically supported as reliable indicators of students' creative abilities. Second, the results suggest that the practicality aspect, while potentially relevant in some contexts, may require further conceptual clarification or alternative operationalization to serve as a valid component of CPS assessment.

Furthermore, the involvement of raters (teachers) in scoring student responses, as recommended by the Consensual Assessment Technique [16], enhances the objectivity and reliability of the assessment process. This approach is particularly valuable in educational environments where subjective judgments can introduce bias or inconsistency.

In terms of novelty and contribution, this research provides a validated, contextually relevant model for assessing creative problem solving among Indonesian elementary students. It addresses the limitations of previous models by empirically testing the instrument's structure and offering a clear rationale for the exclusion of less reliable aspects. The refined CPS test can inform curriculum development, teacher training, and educational policy by providing a robust tool for measuring and fostering creativity in the classroom.

Nevertheless, several limitations should be acknowledged. The study was conducted in a specific regional context with a limited sample size, which may affect the generalizability of the findings. Future research should consider larger, more diverse samples and explore the potential for further refinement of the practicality aspect or the inclusion of additional creativity dimensions.

In conclusion, this study demonstrates that a CPS assessment instrument emphasizing originality and completeness provides a valid and reliable measure of creative problem solving for elementary school students. The findings support the ongoing development of creativity assessment tools that are both theoretically sound and practically applicable within the evolving landscape of 21st-century education

Conclusion

This study aimed to investigate the validity and reliability of the Creative Problem-Solving (CPS) test designed for elementary school students, focusing on the dimensions of originality, completeness, and practicality. The study significantly contributes to addressing the problem of a lack of validated CPS assessment tools by demonstrating that the instrument is best represented by two main aspects: originality and completeness. The impact of these results is the development of a more streamlined and reliable measurement model that showed a good fit with the sample data, thereby providing a robust tool for evaluating the creative problem-solving abilities of elementary students. However, this study has limitations, including its execution in a specific regional context with a limited sample size, which may affect the generalizability of the findings. Therefore, it is recommended that future research replicate this study with larger and more diverse student populations to further refine the measurement model. The implication of this research for educational development is that the validated CPS instrument can be integrated into classroom assessment practices to support the development of creativity and problem-solving skills, in line with the goals of the Merdeka Curriculum and 21st-century education.

Acknowledgments

No funding information from the author.

Author Contributions

H: Conceptualization, Writing-Original Draft, Methodology, Investigation, Data Curation, and Visualization. AJ: Formal Analysis, Investigation, Data Curation, and Visualization. AM: Methodology, Resources, Writing-Original Draft,

Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

Additional information

No additional information from the authors.

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