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A psychometric validation of a creativity assessment instrument for pre-service teachers in using generative AI

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ABSTRACT

The integration of generative artificial intelligence (GenAI) in education is accelerating rapidly, creating new demands for teachers to engage creatively with AI-supported pedagogical practices. This study aimed to develop and validate a measurement instrument for assessing the creativity of pre-service teachers in using GenAI. Content validity was established through expert judgment involving specialists in computer science, educational technology and assessment. Empirical data were collected using a performance-based assessment administered to pre-service teachers from ten universities across five provinces in Indonesia. Data analysis employed Aiken's V for content validity, confirmatory factor analysis (CFA) for construct validity, and generalizability theory (G theory) for instrument reliability. The results indicated satisfactory content validity, with an Aiken's V index of 0.78. CFA demonstrated the measurement model exhibited a good fit with the empirical data and all indicators contributed significantly to their respective construct dimensions ($p<0.05$). Reliability analysis showed score variance was primarily attributable to differences in students' abilities (0.406), rather than item variance (0.064) or person–rater interaction (0.032). The relative (0.852) and absolute (0.843) G-coefficients exceeded recommended thresholds. Overall, 54.18% of participants demonstrated high to very high levels of creativity, confirming the instrument meets psychometric standards for measuring pre-service teachers' creativity in using GenAI.

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1. INTRODUCTION

Artificial intelligence (AI) has developed rapidly over the past decade. The development of AI has accelerated since the emergence of large language model (LLM)-based technology, which is capable for generating text, images, videos, and various other human-like creations. The ability of AI genes to generate a wide variety of things has brought about many changes in the completion of work in both professional and educational fields. This development is in line with its increasing intervention in human life, including in the field of education. Research trends in education have also increased, indicating a rise in AI intervention in education. For example, more than 500 publications on AI in K-12 education in Asia between 1996 and 2025, underscoring that the integration of AI into education has become a global concern [1], while over 3,800 studies on generative artificial intelligence (GenAI) in education were published between 2022–2025 [2]. GenAI, especially ChatGPT, demonstrates support for communication, idea generation, and information

synthesis in academic learning, with its effectiveness depending on disciplinary context [3]. Thus, GenAI interventions in education are not just small experiments, but have entered a broader phase and require critical evaluation of their effectiveness, implementation challenges, and pedagogical implications. This trend matters because teacher education institutions are now expected to prepare future teachers who can use GenAI not only technically but also creatively and pedagogically. Without such readiness, the quality of teaching and students' learning experiences may be adversely affected, particularly in contexts where digital transformation in education is progressing rapidly, such as Indonesia.

The increasingly massive GenAI intervention in education requires teachers to adapt to carry out their functions. Teachers are required to understand AI developments, be skilled in operating it, and be able to evaluate its impact on the learning process [4]. In this context, creativity has become a key dimension of GenAI proficiency. This study is grounded in Guilford's theory of creativity [5], specifically the concept of divergent thinking, which encompasses four dimensions of creativity: fluency, flexibility, originality, and elaboration. These dimensions provide the conceptual foundation for understanding how GenAI can support creative thinking through idea exploration, the generation of alternative solutions, and the elaboration of ideas within a human-AI collaboration-based learning process. Accordingly, the use of GenAI in idea generation, instructional design, and educational problem-solving requires users to demonstrate fluency, originality, flexibility, and elaboration in adapting and developing GenAI outputs [6]. In this sense, GenAI functions not merely as an automated tool, but as a creative partner that facilitates collaboration between humans and machines in redesigning and developing new ideas [7]. For pre-service teachers, the ability to use GenAI creatively is particularly important because early experience in designing prompts, adapting AI outputs, and developing context-sensitive learning resources can shape their future professional competence [8]−[10]. If such competencies are not cultivated during teacher preparation, future teachers may struggle to integrate GenAI meaningfully in classroom practice.

Despite the growing integration of GenAI in education, a major challenge remains the limited availability of instruments to assess its creative pedagogical use. The lack of robust frameworks for evaluating how educators use GenAI creatively in teaching constrains effective classroom integration while raising concerns about academic integrity, originality, and the evolving role of teachers in AI-enhanced learning environments [11]−[13]. Existing assessment approaches, including the divergent association task (DAT), alternative uses task (AUT), and creativity support tools (CST), provide valuable measures of divergent thinking and creative support, but they were not specifically designed to evaluate creativity in human–GenAI interaction, particularly within pedagogical contexts [14]−[17]. As a result, validated performance-based instruments that specifically capture creativity in the pedagogical use of GenAI remain scarce, limiting efforts to evaluate and strengthen AI-supported teaching practices.

Addressing this gap, this study develops a novel instrument to measure pre-service teachers' creativity in utilizing GenAI for pedagogical purposes. Unlike general creativity assessments, the proposed instrument conceptualizes creativity as the integration of creative thinking, pedagogical decision-making, and human–AI collaboration in educational settings. Its development applies advanced validation procedures to ensure conceptual robustness and empirical reliability including expert judgment using Aiken's V, confirmatory factor analysis (CFA), and generalizability theory (G theory). Theoretically, this study extends creativity assessment research by operationalizing creative pedagogical use of GenAI as a measurable construct in teacher education. Practically, the instrument provides evidence to support teacher training, curriculum design, and educational policy related to responsible AI integration. Given the increasing role of GenAI in future classrooms, a valid and contextually relevant instrument is essential to identify pre-service teachers' creativity profiles and inform strategies for preparing them to use AI creatively, critically, and ethically, particularly in the Indonesian context. Hence, the novelty of this study lies in the development of a psychometrically validated, performance-based instrument that specifically measures pre-service teachers' creativity in pedagogical GenAI use by integrating Guilford's [5] creativity dimensions with human–AI collaboration and pedagogical decision-making, thereby addressing a significant gap in existing creativity assessment frameworks for AI-supported education.

2. METHOD

This study employed a research and development (R&D) design with psychometric validation to systematically develop, refine, and evaluate the quality of the instrument. The instrument development process was adapted from established scale development frameworks proposed by Boateng *et al.* [18], encompassing domain identification, conceptual definition, dimension specification, item generation, content validation, scale construction, reliability testing, and validity evaluation. This research was conducted on the Java Island, specifically in the provinces of Jakarta, West Java, Central Java, Special Region of Yogyakarta, and East Java. This research was conducted from February 2025 to November 2025. The participants involved

were students from 10 universities spread across the provinces. Each province was represented by public and private university. In addition, the sample included students from diverse academic disciplines, namely science (chemistry), mathematics, and language education programs, to provide broader disciplinary representation. A total of 299 pre-service teachers were selected by stratified sampling across 10 universities to ensure representation across institutional types and regions. This number of respondents exceeds 200, which is generally considered adequate for CFA to produce stable and reliable parameter estimates [19].

Data collection was carried out using two main techniques. The first technique aimed to establish content validity through expert judgment. Several experts were involved, namely 7 experts consisting of 2 information technology experts, 3 educational technology experts, and 2 assessment experts. Among these experts, 4 were lecturers, 2 were researchers, and 1 was an industry professional. The experts provided input by completing validation sheets and participating in focus group discussions (FGDs). The second technique involved empirical data collection using project-based assignments. Students were given project guidelines, and their project records in the form of portfolios became the primary data source. Participants were given 90 minutes to complete the project assignment. They were allowed to select the GenAI tools based on their familiarity and were instructed to log in using their own accounts. The worksheets were distributed through Google Drive, completed offline, archived their work history using GenAI, and uploaded to Google Drive after the task was finished.

The research instruments were specifically designed to measure pre-service teachers' creativity in utilizing GenAI. Creativity was conceptualized based on four elements: fluency, originality, flexibility, and elaboration [20], which were adjusted to the context of GenAI use in project completion. The project focused on the preparation of a learning design, as it was considered the most feasible task for students to complete within a limited time frame without involving school administrators or multiple stakeholders. The instruments consisted of project guidelines, project worksheets, and assessment rubrics. The assessment rubric measured four dimensions of creativity in the pedagogical use of GenAI: fluency (3 items), flexibility (3 items), originality (3 items), and elaboration (4 items), resulting in 13 rubric items. Each item was assessed using a four-level analytic rubric ranging from 1 (lowest performance) to 4 (highest performance). For example, in the fluency dimension, a score of 1 indicated no relevant instructional ideas, whereas a score of 4 indicated more than two relevant alternative instructional ideas adapted to the selected case. Higher originality scores reflected the integration of specific pedagogical keywords, contextual considerations, and subject-matter characteristics into prompts and AI evaluation processes.

The results of students' work were assessed using a rubric developed by the researcher, producing polytomous scores. The raters who evaluated the students' work consisted of three individuals with relevant expertise and professional backgrounds in chemistry, mathematics, and English. The rating procedures included understanding the project worksheet, reviewing the assessment rubric, establishing a shared understanding of the scoring procedures, and conducting the evaluation process.

Data analysis began with the examination of content validity using qualitative and quantitative expert data. Qualitative data from FGDs were summarized descriptively, while quantitative data were analyzed using the Aiken formula [21]. Construct validity was examined using CFA. Model fit was evaluated using absolute fit indices, including goodness-of-fit index (GFI), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA); incremental fit indices, including comparative fit index (CFI), Tucker–Lewis index/non-normed fit index (TLI/NNFI), normed fit index (NFI), relative fit index (RFI), incremental fit index (IFI), and relative noncentrality index (RNI); and parsimony normed fit index (PNFI), following established criteria [19], [22]−[28].

Reliability was estimated using G theory, which allows for comprehensive identification of multiple sources of measurement error, including person, item, rater, and their interactions. Reliability indices included the G-coefficient for relative decisions and the Phi coefficient for absolute decisions. The values of ≥0.80 were considered indicative of very good reliability [29], [30].

Aiken's V was selected because it enables the evaluation of agreement among experts regarding the clarity, relevance, and adequacy of the items [31]. Meanwhile, CFA is considered appropriate for validating the underlying structure of an instrument by ensuring that the items are aligned with the theoretical constructs [32]. In addition, G theory provides a comprehensive framework for evaluating reliability and structural validity, particularly in educational and psychological assessment contexts [33]. Therefore, the combination of Aiken's V, CFA, and G theory offers a robust foundation for ensuring content validity, construct alignment, and the overall reliability of the instrument comprehensively.

3. RESULTS

3.1. Content validity

The content validation stage produced input from 7 experts involved. Based on expert assessment, it was concluded that the Aiken formula produced an index of 0.78. A value of 0.78 indicates a moderate to

high level of agreement among the experts, suggesting that the item is valid for inclusion. According to Aiken, with 7 experts conducting the assessment, there were 4 answer choices for raters to choose from, and with a 5% error tolerance, the instrument was proven to be content valid if the Aiken index was above 0.76. Thus, the instrument for measuring the creativity of pre-service teachers in using AI is proven to be valid and suitable for use (of course with various improvements in accordance with expert advice).

3.2. Construct validity

Before conducting CFA, it is necessary to ensure that the data used meets the assumptions for factor analysis. The measure of sampling adequacy (KMO) value is used to determine the extent to which the pattern of relationships between variables is sufficient for factor analysis. The KMO value above 0.70 indicating that the data is very suitable for further analysis [19]. The analysis results show that the KMO value=0.832, indicating that the sample size and the relationship between variables are sufficient for exploratory and CFA. Meanwhile, Bartlett's test of sphericity serves to test whether the correlation matrix between variables differs significantly from the identity matrix. The Bartlett test results show a significant number ($p<0.05$). Thus, it can be concluded that there is a strong correlation between the indicators, so the data is suitable for analysis using a factor approach [24].

As illustrated in Figure 1, CFA confirmed that the CREA_AI construct was represented by four dimensions: elaboration, originality, flexibility, and fluency. Standardized factor loadings from the higher-order construct to the first-order dimensions ranged from 0.74 to 0.96, indicating strong associations. Originality ($\lambda=0.96$) and fluency ($\lambda=0.95$) emerged as the strongest contributors. At the indicator level, most items demonstrated satisfactory loadings above 0.70, except OR1 ($\lambda=0.58$), which was relatively lower but still acceptable. Several correlated residuals were identified, suggesting shared variance among conceptually similar indicators.

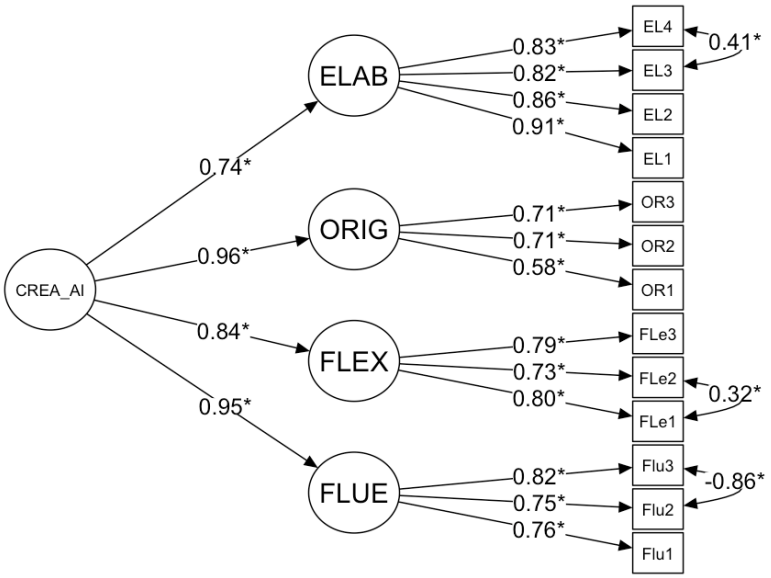


Figure 1. Construct of the instrument

A few modifications were made to the construct to refine the model so that it had a better fit index. Error covariances were added based on theoretical similarity between items measuring closely related aspects of instructional design structure. In this model, the relationships between the added errors, namely EL3–EL4, Fle1–Fle2, and Flu2–Flu3, indicated similarities in meaning among items within the same dimension.

EL3 refers to the ability to develop a learning design with a structured format, appropriate language use, and internal consistency, while EL4 emphasizes the inclusion of all minimum required elements of a learning plan, meaning that the structured format in EL3 essentially reflects the presence of these elements. Fle1 and Fle2 both focus on the ability to modify prompts to adjust GenAI outputs to the selected case, differing only in the components being modified, namely learning steps and learning assessment. Meanwhile, Flu2 and Flu3 are closely related in that generating more alternative ideas for learning assessment is associated with a greater number of revision or iteration cycles to improve and enrich the generated results. The results of the model fit analysis of the construct are shown in Table 1.

Table 1. Model fit of the instrument construct

Index	Value	Criteria	Conclusion	Index	Value	Criteria	Conclusion
CFI	0.982	≥0.95	Fit	RNI	0.982	≥0.95	Fit
TLI	0.976	≥0.95	Fit	GFI	0.983	≥0.95	Fit
NNFI	0.976	≥0.95	Fit	PNFI	0.722	≥0.50	Fit
RFI	0.961	≥0.95	Fit	RMSEA	0.072	≤0.08	Fit
IFI	0.982	≥0.95	Fit	SRMR	0.077	≤0.08	Fit

The CFA results show that the GenAI usage creativity measurement model has an excellent level of fit with empirical data. Absolute fit indices, including GFI, SRMR, and RMSEA, indicate that the model accurately represent the data structure. A GFI value close to 1 indicates that the proportion of variance-covariance explained by the model is high, while RMSEA and SRMR values around the 0.08 threshold indicate the level of model approximation error to the population data. Incremental fit indices (CFI, TLI, NNFI, RFI, IFI, and RNI) all exceed the recommended threshold of 0.95, indicating that the proposed model explains the relationships among indicators substantially better than baseline models and reflects the latent structure of creativity in GenAI use both empirically and theoretically.

From a parsimony fit perspective, the PNFI value of 0.722 is above the commonly used threshold of 0.50 as an indicator of the balance between model fit and complexity [22]. This shows that the model not only well fitted but also structurally efficient, using a proportional number of parameters to explain the relationships among variables. Overall, these results confirm that the developed construct structure is stable, valid, and representative for measuring pre-service teachers' creativity in utilizing GenAI in educational contexts, with detailed CFA statistics presented in Table 2.

The results of CFA show that all indicators have a significant relationship with the latent constructs being measured, as evidenced by p-values<0.05 for all items. In terms of factor loading strength (standardized loading), all values are above the minimum threshold of 0.50 [19], [23], ranging from 0.578 to 0.909. Thus, it can be concluded that the construct validity of this instrument is proven, and the factor structure in the GenAI usage creativity measurement model is valid in measuring the creativity dimensions of pre-service teachers in utilizing GenAI technology.

Table 2. CFA results of the measurement instrument

Factor	Item	Est	SE	z	p-val	Std. all	R^2
FLUE	Flu1	0.238	0.054	4.402	0.000	0.763	0.582
FLUE	Flu2	0.260	0.061	4.296	0.000	0.751	0.563
FLUE	Flu3	0.265	0.070	3.787	0.000	0.819	0.671
FLEX	FLe1	0.441	0.059	7.523	0.000	0.805	0.647
FLEX	FLe2	0.452	0.063	7.203	0.000	0.730	0.533
FLEX	FLe3	0.394	0.052	7.619	0.000	0.792	0.627
ORIG	OR1	0.157	0.072	2.170	0.030	0.578	0.334
ORIG	OR2	0.203	0.094	2.147	0.032	0.706	0.499
ORIG	OR3	0.191	0.088	2.162	0.031	0.715	0.511
ELAB	EL1	0.567	0.045	12.486	0.000	0.909	0.826
ELAB	EL2	0.582	0.045	12.840	0.000	0.859	0.739
ELAB	EL3	0.498	0.040	12.389	0.000	0.818	0.669
ELAB	EL4	0.497	0.040	12.586	0.000	0.833	0.693
CREA_AI	FLUE	3.046	0.796	3.824	0.000	0.950	0.903
CREA_AI	FLEX	1.541	0.252	6.124	0.000	0.839	0.704
CREA_AI	ORIG	3.590	1.731	2.074	0.038	0.963	0.928
CREA_AI	ELAB	1.108	0.138	8.019	0.000	0.742	0.551

3.3. Reliability

To examine the reliability of the instrument, this study uses G theory. A summary of the analysis results is summarized in Table 3. The results show that the person component contributed the largest proportion of variance at 0.406, while the item component only contributed 0.064, and the person: rater interaction was relatively small (0.032). The generalizability coefficient shows a relative G value of 0.852 and an absolute G value of 0.843, both of which exceed the reliability threshold of 0.80 [29], [30]. Thus, the GenAI creativity measurement instrument can be declared reliable.

3.4. Profile of AI creativity use by pre-service teachers

The increasingly massive use of AI, especially GenAI, among students requires creativity in order to be utilized optimally. The dimensions of creativity used as a framework in this study include fluency, flexibility, originality, and elaboration, which form the basis for measuring students' creativity in using GenAI. The results of the student performance tests were then observed and measured using a rubric that had

been validated in terms of both content and construct. Table 4 is a snapshot of students' creativity in using GenAI to develop learning designs.

Table 3. Results of assessment consistency analysis using G theory

Component	Variants	Proportion variance	Error relative	Error absolute
Person	0.4376	0.406	0	0
Item	0.0693	0.064	0	0.065
Person: Rater	0.0348	0.032	0.457	0.427
Residual	0.5374	0.498	0.543	0.507
G-coefficient relative		-	0.852	-
G-coefficient absolute		-	-	0.843

Table 4. Overview of student creativity in using GenAI in each observation item

Items	Observation	Avg	SD
Flu1	The ability to generate alternative ideas for instructional steps aligned with the selected case.	3.15	1.00
Flu2	The ability to generate alternative ideas for assessing learning in accordance with the selected case.	2.83	1.11
Flu3	The number of prompt revision cycles (iterations) conducted to improve or enrich the generated outputs.	2.65	1.04
	Average of fluency	2.88	
FLe1	The ability to modify prompts to align GenAI outputs with the selected instructional case.	2.72	1.01
FLe2	The ability to modify prompts to align GenAI outputs with the design of learning assessments in accordance with the selected case.	2.18	1.14
FLe3	The ability to articulate the rationale for modifying the substance in a manner that is (1) clear, (2) logical, and (3) precise.	2.43	0.91
	Average of flexibility	2.44	
OR1	Precision in selecting keywords to describe the case	2.99	1.01
OR2	The ability to incorporate keywords into the initial prompt	3.07	1.07
OR3	The ability to integrate pedagogical knowledge and subject-specific characteristics when formulating prompts and evaluating GenAI outputs	2.60	1.00
	Average of originality	2.88	
EL1	The ability to generate instructional steps that are aligned with learning objectives, educational level, subject-matter characteristics, and the instructional context (case)	2.96	0.93
EL2	The ability to generate learning assessments that are aligned with learning objectives, educational level, subject-matter characteristics, and the instructional context (case)	2.62	1.01
EL3	The ability to construct an instructional plan with a structured format, appropriate language use, and consistency across components	2.70	0.91
EL4	The ability to develop an instructional plan that includes all essential components.	2.68	0.89
	Average of elaboration	2.74	

Based on Table 4, the highest average item for students was fluency and originality, which was 2.88 out of a maximum score of 4, while elaboration was 2.74 and flexibility ranked lowest at 2.44. Table 5 shows the distribution of pre-service teachers' creativity in five categories, with most students at a high to very high level of creativity (54.18%). However, there are still students with low to very low creativity (23.41%), indicating the need for special attention to improve their creativity.

Table 5. Level of creativity of pre-service teachers

Categories	Range						Freq.	Percentage (%)
Very high	42.25	≤	X				70	23.41
High	35.75	≤	X	<	42.25		92	30.77
Moderate	29.25	≤	X	<	35.75		67	22.41
Low	22.75	≤	X	<	29.25		40	13.38
Very low			X	<	22.75		30	10.03

4. DISCUSSION

The instrument developed to measure pre-service teachers' creativity in the use of GenAI demonstrates strong content validity, construct validity, and reliability. An instrument is considered to have satisfactory content validity when it comprehensively captures all relevant aspects of the construct under investigation [34]. Content validation involved seven experts from computer science, educational technology, and assessment backgrounds, ensuring technical accuracy, pedagogical relevance, and psychometric soundness. The adequacy of content validity was further supported by an Aiken's V coefficient of 0.78, which falls within the acceptable range suggested in the literature [35]. This multidisciplinary review process confirms that the instrument comprehensively represents the construct of creativity in the use of GenAI.

Construct validity was examined using CFA, supported by adequate KMO and Bartlett's test results, indicating the suitability of the data for factor analysis. The measurement model demonstrated strong absolute, incremental, and parsimonious fit indices, suggesting that the latent structure consistently captures empirical relationships among indicators and is structurally efficient. All indicators—fluency, flexibility, originality, and elaboration—were significantly associated with the overarching latent construct. Among these, elaboration exhibited the highest factor loadings, indicating that the ability to develop logical, comprehensive, and well-structured learning designs represents a salient manifestation of creativity in GenAI use, aligning with the view of AI as a co-creator facilitating iterative idea development [7].

In contrast, the flexibility dimension demonstrated moderate factor loadings. The results indicate that pre-service teachers are still adapting to the dynamic processes involved in prompt formulation and the modification of GenAI outputs. This finding is consistent with Liu *et al.* [10], who emphasize that effective educational use of AI requires not only technical proficiency but also critical and prompt literacy, enabling users to interrogate, adapt, and co-design AI systems in pedagogically meaningful ways.

G theory was employed to examine the reliability of the instrument [36]. Analysis using G theory that accounts for multiple sources of variance, including raters and items, is essential because inter-rater variance and item variance are often major sources of unreliability in performance-based assessments [37], [38]. The results indicated that score differences were predominantly attributable to differences in students' abilities, as reflected by the largest proportion of person variance (0.406), compared with item variance (0.064) and person–rater interaction variance (0.032). The relatively small item and person–rater variance components suggest that raters demonstrated adequate consistency, such that assessment decisions were not substantially influenced by who conducted the rating [39].

The assessment instrument demonstrated high consistency for both comparative and absolute decision-making, as evidenced by the relative G coefficient (0.852) and absolute G coefficient (0.843), both exceeding the established threshold. The G coefficient reflects the overall reliability and generalizability of test scores across individuals and measurement occasions [36]. In performance assessment contexts, inter-rater consistency and inter-item stability are crucial for drawing trustworthy conclusions [40].

From the performance test profile, the highest proportion of students fell within the high to very high creativity categories. These results indicate that pre-service teachers have demonstrated strong creative potential in using GenAI, particularly in the dimensions of fluency, originality, and elaboration. However, the flexibility dimension remained relatively lower than the other dimensions. This finding suggests the need for pedagogical interventions that emphasize exploratory skills, as the integration of GenAI in education requires not only technological competence but also the strengthening of creative metacognition [41].

The findings of this study extend the methodological contribution of combining G theory and CFA, an approach that remains relatively uncommon in the development of AI-based measurement instruments. More importantly, this study introduces a validated performance-based instrument specifically designed to assess pre-service teachers' creativity in GenAI-assisted instructional design, addressing a gap in previous studies that largely relied on self-reported AI competence measures. By integrating multidimensional creativity constructs with advanced psychometric validation, this study offers a novel framework for assessing creativity in AI-supported learning contexts.

Based on the overall findings, the instrument meets the psychometric criteria required to measure the creativity of pre-service teachers in using GenAI. These findings not only introduce a new measurement tool but also provide a conceptual foundation emphasizing that teachers' digital creativity should be considered a core competency in teacher education curricula. A valid and reliable instrument is critical to ensuring that the data generated accurately reflect the construct being measured and can be trusted for decision-making. Such instruments yield consistent, generalizable, and highly credible data when applied appropriately [42].

The instrument was developed with careful attention to each stage of the process, beginning with the construction of a clear and comprehensive theoretical framework grounded in relevant literature to ensure full coverage of the intended constructs, followed by rigorous item design and empirical testing. These factors are key determinants of an instrument's validity and reliability [43]. Instrument development may be suboptimal without careful planning and accessible, theory-based guidance from the literature [44].

The fluency and originality dimensions exhibited higher scores than the other two dimensions. This pattern may be attributed to the fact that GenAI provides idea scaffolding that enhances idea generation and supports effective keyword selection. This finding is consistent with Hadas and Hershkovitz [45], who reported that exposure to digital idea sources can increase idea fluency and novelty by enabling augmented cognitive search processes that expand the ideational search space. Human–GenAI collaboration allows users to develop ideas more rapidly and diversely through iterative prompting, thereby enhancing the ability to generate alternative solutions in learning contexts [46]. In this sense, GenAI appears to support creativity dimensions associated with divergent idea production, particularly fluency and originality, because AI systems can quickly generate multiple variations, examples, and conceptual combinations. This tension

indicates that while GenAI has been shown to enhance individual creativity, it may also pose a risk of reducing collective idea diversity, as outputs may converge and become increasingly similar [47], [48].

In contrast, the elaboration dimension tended to be lower than fluency and originality, while flexibility emerged as the lowest among all four dimensions. This pattern may be explained by limited pedagogical knowledge and contextual understanding of instructional design. This pattern can also be influenced by the context of teacher education in Indonesia which still tends to be oriented towards standardized learning formats and procedural compliance. As a result, prospective teachers more often utilize GenAI to speed up assignment completion rather than exploring more adaptive and flexible learning approaches. Although AI can accelerate and enrich the ideation phase, the ability to logically modify GenAI outputs and assemble coherent instructional designs still requires metacognitive training, prompt literacy, and targeted pedagogical guidance [47]. Without well-developed prompt literacy, users tend to engage only in surface-level revisions, resulting in constrained elaborative creativity, particularly in pedagogical tasks such as designing instructional steps and assessments [46]. Thus, GenAI shapes creativity dimensions differently: it strongly facilitates initial idea generation, it does not guarantee that users will develop those ideas into flexible or well-structured forms, as flexibility and elaboration continue to depend on users' own cognitive and pedagogical capacities [49].

The findings indicate that while pre-service teachers demonstrate strong fluency and originality in using GenAI, their flexibility remains comparatively lower. This finding highlights an important contradiction in AI-supported creativity research: although GenAI effectively supports idea generation, it does not automatically enhance adaptive thinking. From a theoretical perspective, this reflects the distinction between divergent idea production and adaptive cognitive restructuring. The lower flexibility may also be explained by limited prompt literacy, indicating that effective AI use requires not only access to tools but also higher-order metacognitive skills.

5. CONCLUSION

The development of a creativity measurement instrument for pre-service teachers' use of GenAI, encompassing four dimensions: fluency, flexibility, originality, and elaboration. Content validity was supported by an Aiken's index of 0.78. Construct validity was established through CFA, with overall fit indices exceeding recommended thresholds. The CFA results further indicated that all indicators were significantly associated with their respective latent constructs (p-value<0.05). Reliability was confirmed through G theory, with relative (0.852) and absolute (0.843) G coefficients exceeding the 0.80 threshold. The creativity instrument meets the established psychometric criteria. The results also highlight opportunities for instrument replication in other contexts and underscore the importance of digital creativity as a core competency in teacher education curricula. Furthermore, this instrument can be adopted in future studies to examine creative pedagogical use of GenAI across diverse educational contexts and populations, while also supporting its implementation as an evidence-based assessment tool in teacher education programs. These findings have important implications for teacher education, curriculum development, assessment, and educational policy. The results suggest that teacher education curricula should integrate prompt literacy, AI-supported pedagogical design, and reflective human–AI collaboration to help pre-service teachers develop not only fluency and originality, but also adaptive creativity characterized by flexibility and elaboration. In addition, the validated instrument may support assessment practices by providing a performance-based tool to evaluate authentic AI-integrated pedagogical competence rather than relying solely on self-reported measures. At the policy level, the findings highlight the need to incorporate AI-integrated competencies into teacher education standards and guidelines for responsible and effective GenAI use in learning environments.

This study has several limitations that warrant consideration. First, empirical validation was conducted among pre-service teachers from ten universities across five provinces in Indonesia, and the findings cannot be directly generalized to in-service teachers, pre-service teachers in other countries, students from non-education programs, or learners at other educational levels. Second, although this study provides robust evidence of content validity, construct validity, and reliability, future studies are encouraged to conduct CFA cross-validation using independent samples and more comprehensive item-level analyses to further strengthen the psychometric evidence. Third, this study focused primarily on construct-level psychometric validation; therefore, detailed item-level analyses were not conducted. Fourth, creativity was measured using a single performance-based assessment within a relatively controlled research context. Creativity in GenAI use may vary depending on task type, disciplinary domain, and pedagogical context, which were not explored in this study. Based on these limitations, future research is recommended to conduct further validations across different populations, geographical regions, and educational contexts, including longitudinal studies, to strengthen the instrument's external validity and examine the development of GenAI-related creativity over time. To strengthen the findings, future research should further examine item

functioning to support refinement of the instrument. Ultimately, this instrument is recommended not only as a measurement tool but also as a diagnostic tool for pre-service teachers, provided its use is accompanied by instructional approaches that integrate prompt literacy, AI-based pedagogical design, and reflective practice.

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This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

We have obtained informed consent from all individuals included in this study. This research has been reviewed and approved by the Social Sciences and Humanities Ethics Committee of the National Research and Innovation Agency (BRIN), Indonesia, as stated in the Ethical Clearance Approval Letter for Social Sciences and Humanities Research No. 316/KE.01/SK/04/2025.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [ADP], upon reasonable request.

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