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ASSESSING CREATIVE THINKING: DEVELOPMENT, RELIABILITY, VALIDITY, AND EXPLORATORY FACTOR ANALYSIS OF A MULTIDIMENSIONAL SCALE

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ABSTRACT

This study develops and validates a 10-item scale designed to assess the dimensions of creative thinking, namely fluency, flexibility, and originality. The study focuses on establishing the psychometric properties of the proposed scale through a systematic validation process. A total of 29 participants were involved in the study. Data analysis included reliability testing and exploratory factor analysis (EFA). The results indicated moderate internal consistency, with a Cronbach's alpha of 0.604, which is considered acceptable for exploratory research. Construct validity was examined using EFA, which identified three distinct components corresponding to fluency, flexibility, and originality. These components accounted for 66.4% of the total variance. Varimax rotation revealed that fluency and originality were closely related, whereas flexibility emerged as a distinct factor. Overall, the findings suggest that the scale demonstrates acceptable psychometric properties and can serve as a useful tool for assessing creative thinking in educational and research contexts. Future studies are recommended to refine items with low factor loadings to further improve the scale's validity and reliability.

KEYWORDS: Creative Thinking, Psychometric Validation, Exploratory Factor Analysis, Scale Development, Reliability, Construct Validity.

INTRODUCTION

Owing to its distinctive potential that brings forth innovation and new solutions to problems, creative thinking is considered an essential skill in many areas, including education, business, and technology (Handayani et al., 2020; Kaufman & Beghetto, 2009; Purnomo et al., 2023; Runco & Jaeger, 2012). Moreover, there is a growing demand to assess and comprehend this multifaceted construct effectively, as creative abilities in education and the labor market are in increasing demand (López et al., 2024; Plucker et al., 2004; Rebecchi et al., 2024). However, considering its importance for creativity, it is relatively easy to assert that creativity presents certain difficulties regarding its definition, dimensions, measurement, and evaluation; it comprises a whole range of dimensions, including fluency, flexibility, and originality (Aleinikov, 2013; Lhuillery et al., 2023; Redó et al., 2021; Runco, 2014; Runco & Jaeger, 2012). As one of the constructs, creative thinking involves aspects pertaining to the cognitive and affective domains, which are expressed in various ways; thus, it is imperative to use various multidimensional metrics to triangulate its measurement components (Kaufman & Beghetto, 2009).

Despite advances in creativity measurement, significant concerns remain unaddressed. These are related to the availability of validated, reliable, and theoretically grounded instruments (Batey, 2012; Chaudhuri et al., 2024; Dumas & Kaufman, 2024; Kaufman et al., 2013; Sawyer & Henriksen, 2023). In the case of creativity, Korean researchers seek a theoretical basis for commercial products, and methods such as divergent thinking tests and self-reports appear incapable of capturing the dimensions of creativity in a manner that enables clear distinctions (Jang & Ko, 2017; Kaufman et al., 2013). Such undisciplined and cost-free measurement attempts alter the concept itself, as evidenced by the psychometric soundness present in many existing tools. Concepts such as construct validity, internal consistency, and factor structure are integrated into tools used for educational or organizational purposes (DeVellis, 2017; Field, 2017; Monticone et al., 2021; Wehner et al., 2020). Thus, there is an urgent need for creative tools that guarantee accuracy and consistency, regardless of the people or places being used (Runco, 2014). However, in recent years, many scholars have addressed what these tools should entail. The latest studies included in the available body of research answer these questions broadly and show the latest standards on how creative ability should be divided into emulation, innovation, synthesis, and transformation.

To tackle the differing scopes of creative thinking, researchers have synthesized scaffolding tools such as the Four-C Model of Creativity, which divides creativity into four levels: Mini-C, Little-C, Pro-C, and Big-C (Dumas & Kaufman, 2024; Kaufman & Beghetto, 2009). Another well-known cognitive model is the Componential Model of Creativity, which focuses on the interdependence of cognitive, motivational, and environmental factors in fostering creativity (Amabile & Pratt, 2016). Nevertheless, despite the progress of conceptual frameworks, the tools developed based on these models have certain limitations in terms of understanding the different aspects of creative thinking (Plucker & Makel, 2021). Most of these scales have been found to emphasize one dimension (e.g., originality), with little regard for other important dimensions, such as fluency and flexibility (Sternberg & Lubart, 1993).

Emphasis has been placed on new specific attempts aimed at improving these shortcomings to enable the simultaneous evaluation of several dimensions of creativity. These attempts were made by exploring multidimensional scales (Jordanous & Keller, 2016; Villani & Antonietti, 2020). Kaufman et al. (2016) noted that the Runco Ideational Behavior Scale (RIBS) was created to assess the fluency of ideas, whereas the creativity styles questionnaire-revised (CSQ-R) examined flexibility and originality. These scales strive to address construct validity, reliability, and factor structure issues; however, they often suffer from low internal consistency, and their specific factors are poorly defined (DeVellis, 2017). Furthermore, this gap in the literature highlights the importance of developing and enhancing multifaceted—but particularly psychometrically sound—tools for measuring creativity (Plucker & Makel, 2021).

In response to the noted aggressions, this study presents the Emergence Response Development Scale, a 10-item measure of the dimensions of fluency, flexibility, and originality, and which closely embodies the foundational thinking of the afore-mentioned creativity core. The development of the scale was centered on theories of creativity, particularly those which consider creativity as a multi-dimensional construct (Runco & Jaeger, 2012; Kaufman & Sternberg, 2019). The design of each item on the scale was aimed at capturing the distinct characteristics of the respective dimensions, with fluency items intended to target the ability to generate a breadth of ideas, flexibility items aimed at measuring cognitive shifts and re-alignment as well as adaptive criteria, and originality items aimed at

measuring the production of ideas that are new and different (Kaufman & Beghetto, 2009; Sternberg, 2019).

This scale development process underwent strategy development that included ensuring content validity through expert opinions, item refinement according to theoretical definitions, and item statistics measures, such as reliability, construct validity, and Exploratory Factor Analysis (EFA) (DeVellis, 2017). EFA was important because it showed how the various factors making up the scale theory were related to each other and the existence of three major factors that correlated with fluency, flexibility, and originality were established (Field, 2018; Tabachnick & Fidell, 2019). Conducting the EFA with a Varimax rotation increased the clarity of the factor loadings, making the different dimensions more interpretable (Kline, 2015). This research also provides new knowledge on creativity measurement, which would be useful in this field.

First, it provides a scale that is not limited to the shortcomings of previous tools employed to measure creative thinking, as it focuses on several dimensions to achieve its purpose (Runco, 2020). This scale integrates complexity by moving away from conventional scales that confine creativity to one factor; it incorporates fluency, flexibility, and originality as interrelated processes (Kaufman & Beghetto, 2009). Second, construct validity evaluation, EFA, and reliability analysis corroborated the psychometric rigor of the tool, articulating the utility and lacunae, which are usually absent in existing creativity measures (Field, 2018; Plucker et al., 2016).

Moreover, the development of the scale is appropriate for the current focus in research on creativity, which is the need to develop and validate multidimensional measures that cut across various spheres, including educational, organizational, and creative industries (Kaufman & Sternberg, 2019). Emphasizing secondary originality in EFA as a separate factor and its detailed study is also new, as it allows us to consider originality to be spontaneous and understand its deliberate execution, which is rarely the case in other scales (Sternberg, 2019; Runco & Jaeger, 2012). The bidimensional framework is to be validated, and measurements of the three core components of the creative thought process—fluency, flexibility, and originality—are to be advanced.

The specific research questions guiding this study are as follows:

1. How trustworthy is the newly formulated 10-item creative thinking scale for the concerned indicators?
2. Is the scale extended to interpret adequate construct validity on the measures across fluency, flexibility, and originality?
3. What is the relevant dimensional structure of the scale established through EFA?

By addressing these questions, this study aims to develop a psychometrically valid and reliable scale for creative thinking that can be used in diverse contexts and groups. The relevance of this study is supported by the increasing focus on creativity as a vital 21st century skill (Plucker & Makel, 2021). As creativity is essential for problem identification and solving, Sayers (2016) suggested that educators, psychologists, and other organizational leaders must deploy effective tools aimed at measuring and fostering creative potential. Today's tools are commonly used in terms of holistic understanding, leading to their relevance to research and practice (Kaufman & Sternberg, 2019). This study aims to achieve this objective through a reliable instrument with constructs that measure creative thinking and indicate how the constructs interact to enhance creativity (Runco, 2020).

This study makes two contributions to the existing literature. First, a psychometrically sound tool grounded in theory and measuring creative thinking could contribute to research activities in the fields of creativity science and educational psychology (Kaufman et al., 2016). Second, it has encouraged and, in this case, earned practical implications for educators, psychologists, and employers by providing a reasonable means of identifying and nurturing creativity in people (Plucker & Makel, 2021). Thus, by enhancing the measurement of creative thinking, this work promotes the more general agenda of designing educational strategies, management approaches, and policy frameworks that focus on creativity as one of the important competencies in the globalized world of the future (Glăveanu, 2020).

1. METHOD

This study assessed the psychometric characteristics of a tool comprising 10 items developed to assess the creative thought process in terms of fluency, flexibility, and originality. To this end, the study adopted various approaches, including correlational approaches through reliability, validity, and EFA. This section describes the study population, procedure, development of instruments, and analysis regarding the measurement aspects of the study to strengthen the measurement of the variables under investigation.

1.1. Participants

The study sample included individuals across a range of 29 largely skewed demographic groups. The participants were mainly 12–14 years old, secondary school students from Indonesia, which enabled a fair basis for generalizing the creative thinking scale across various cultures. Participants were recruited through voluntary participation following an in-class invitation after the completion of regular mathematics instruction. The inclusion criteria were that participants (1) had previously learned the mathematical topic used in the test items, (2) willingly agreed to participate in the study, and (3) were familiar with and frequently interacted with the cultural contexts embedded in the problem items. These criteria ensured that the participants possessed sufficient background knowledge to comprehend the mathematical and contextual constructs of the creative thinking scale, consistent with Field (2017).

The KMO measure was slotted during the factor analysis phase to evaluate sampling adequacy, but the indication reflects that the sample might have some limitations in terms of representativeness owing to a low KMO value of 0.399. Although this KMO value indicates a greater potential for challenges in optimal factor extraction (Hair et al., 2010), the sample was regarded as fit for the initial scoping investigation, especially for evaluating the preliminary form and psychometric properties of the scale (Tabachnick et al., 2019).

1.2. Instrument Development

This study developed a tool with 10 items and measured three areas of creative thinking: fluency, flexibility, and originality. Each dimension was further broken down into several items that measure the different cognitive elements involved in creative thinking. Fluency is the cognitive ability to produce numerous ideas applicable to a specific task. In this tool, fluency is measured using items that stimulate respondents to provide several answers—alternative solutions. These items emphasize the number of ideas generated and not their quality (Runco & Jaeger, 2012). For example, items targeting fluency prompted the participants to list or generate as many ideas or approaches as possible within a given context.

Flexibility is the ability to consider different viewpoints or use different strategies to solve a problem. This component was processed through items asking respondents to consider problems using different viewpoints or strategies for the same situational problem. These items were designed to measure the respondents' ability to shift their thinking and move across different levels of abstraction (Sternberg & Lubart, 1993). Originality is the ability to generate ideas that are new, unusual, or infrequent in a statistical sense. Originality was measured using items designed to elicit responses that differed from typical or standard answers. In this sense, the items measured the level of originality and novelty in the responses and not their frequency (Plucker et al., 2004).

From the ten items developed, some were created to measure multiple facets of creativity simultaneously (e.g., Q1, Q3, and Q9, measuring fluency, flexibility, and originality), and some were made to focus more clearly on one or two specific facets. For example, items Q2, Q4, Q7, and Q8 targeted flexibility and originality, whereas items Q5, Q6, and Q10 targeted flexibility. This overlapping structure embodies the foundational belief that the dimensions of creative thinking are connected and are not completely separable.

To assess the level of each dimension, a Likert-type scoring rubric ranging from 0 to 4 was employed, where 0 indicated the absence of the attribute, and 4 represented a high level of the attribute. The use of this scale allowed us to capture the varying intensities of creative thinking across the dimensions. Consequently, items had different maximum scores (e.g., up to 12 for multidimensional items and up to four for single-dimension items), depending on the number of dimensions assessed within each item. The 10-item test is presented in Appendix 1. The assessment tool was constructed using known theoretical frameworks regarding creativity and underwent expert evaluation regarding the relevance, clarity, and comprehensiveness of the constructs (Kaufman & Beghetto, 2009). The expert evaluations suggested that the items were representative of the intended aspects. External evaluators scored the participants' responses based on a defined rubric. In terms of inter-rater reliability, Cohen's kappa yielded a value of 0.732, indicating substantial concordance, which affirmed the reliability of the scoring.

1.3. Procedure

As part of the data-gathering exercise, the researcher administered an open-ended (essay) test that was conducted by the participants under the researcher's supervision within a time frame of 90 minutes in a classroom environment. The participants were given a brief explanation of the research, their right to withdraw, and the measures used for privacy protection before taking the test. All participants expressed their consent and were aware

of the relevant ethical principles in psychological research (Field, 2017).

The respondents were asked to respond to a ten-item creative thinking scale that measured their most common cognitive patterns when engaged in creative activities. The scale items were described as open-ended questions so that the respondents could provide detailed answers. This format adequately addressed the fluency, flexibility, and originality of the respondents. It was ensured that the information was not identifiable; however, a few parameters were collected to assess the effects of different attributes on creative scores among various populations (Tabachnick et al., 2019).

1.4. Data Analysis

To evaluate the creative thinking scale, we employed a three-step data analysis approach, reliability testing, and validity testing through EFA.

1.4.1. Reliability Testing

A statistical technique used for the internal consistency of the scale was conducted using Cronbach's alpha (DeVellis, 2017). Cronbach's alpha was computed on a 0-10 scale to determine how well the items measuring of problem-solving and creativity associated within the scale. An alpha value of 0.604 was obtained, implying moderate reliability (Hair et al., 2013). The value obtained in this study is slightly less than 0.7, which is the commonly accepted rule of thumb. However, this value is deemed good for exploratory studies, especially during the later development of instruments (Field, 2017).

To inform common-sense models of total score calculations, item-totals showed correlations. Items with low or negative corrected item-total correlations were flagged for potential revision. The lowest correlations in the instrument indicated that they may not correlate with broader constructs (Plucker et al., 2004). This necessitates that some items must be refined or even replaced to enhance the scale's reliability (Kaufman & Beghetto, 2009).

1.4.2. Validity Assessment

Construct validity for creative thinking was verified using descriptive measures, inter-item correlations, and communalities, which represented the relationship between the scale and its theoretical constructs (Kline, 2015). Participants were asked to complete a creative thinking test, makes mean comparisons toward the multiple questions (which is called items) to assess performance variability measures conceptually related to the measurement, such as creative thinking's level, as per the test, by performing descriptive analysis (Field, 2017). An inter-item correlation matrix was used to uncover any correlations between the items to determine whether they had the same meaning (Guilford, 1967). Several diverse items in all probabilities had sufficient factors. Similarly, factor structures contribute to the form of constructs behind how items were or ought to be clustered (Tabachnick et al., 2019).

1.4.3. Exploratory Factor Analysis

EFA was performed on the Creative Thinking Test (CTT) to determine whether it had more constructs or bundles of patterns in the underlying structure of the scale. EFA is broadly defined as a quantitative investigation that seeks to identify the latent dimensions or structures underlying the constructs of instruments (Field, 2018). The analysis commenced with an examination of sampling adequacy using the Kaiser-Meyer-Olkin (KMO) measure, which had a score of 0.399. Although high literacy levels may be desirable when conducting factor analysis, this threshold is lower than the ideal 0.6 level—the adequacy of this sample is limited. Thus, the sample provided sufficient evidence to perform stable factor extraction, although it did not fully suffice (Hair et al., 2010).

Exploratory Factor Analysis (EFA) was conducted using Principal Axis Factoring (PAF) as the extraction method. PAF is considered appropriate for identifying latent constructs, particularly when data may violate normality assumptions. To enhance interpretability, Varimax rotation was applied, which maximizes the variance of factor loadings across components (Kline, 2015). The rotated component matrix indicated a three-factor structure corresponding to the constructs of fluency, flexibility, and originality.

2. FINDINGS AND DISCUSSION

This chapter details statistical tests performed on the 10-item scale for measuring creative thinking in three dimensions—fluency, flexibility, and originality—with specific attention on the scale's validity, reliability, and factor structure. The results and discussion focus on validity, reliability, and EFA while situating them in the context of the growing body of work on creative thinking.

2.1. Findings

The purpose of the statistical analysis was to assess the validity, reliability, and factor analysis of the 10-item scale measuring creative thinking and its

three dimensions: fluency, flexibility, and originality. The analysis considered from the results obtained how much the pairwise constructs agreed. This findings section presents an in-depth analysis of each statistical test—validity, reliability, and EFA—and interprets the results within the broader context of creative thinking assessment.

2.1.1. Reliability Analysis

Reliability, in the context of measurement instruments, refers to the ability of the instrument to yield the same measurement on the same construct on multiple occasions (Kline, 2015). The internal consistency for the ten creative thinking items was calculated using Cronbach's alpha, which is one of the most commonly used methods for estimating the reliability of psychometric scales (DeVellis, 2017). The alpha reliability coefficient for the creative thinking items was 0.604 indicating moderate internal consistency which is shown in Table 1. The standard criterion for established tools is an alpha reliability coefficient in excess of 0.7. In provisional, or exploratory, research, the bar is often placed at 0.6 for the purpose of developing new measurement scales (Field, 2018). This score, while indicating that the scale is reasonably reliable in measuring creative thinking, suggests that improvements to the scale can be made, possibly through an improved or greater number of items.

Table 1: Reliability Statistics.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.604	.548	10

Considering standardized items as the basis of measurement, the reliability analysis depicted an even lower Cronbach's alpha of 0.548, implying mild variation when utilizing different response scales between items. This variation implies that not all items were perfectly aligned in terms of measuring the same aspect of creative thinking. This led us to speculate whether certain items measure different constructs or are prone to response pattern biases. However, the average reliability coefficient indicated that the scale was stable, although further improvements are necessary to enhance the degree of internal consistency. The alpha value cross-tabulated on standardized items appeared to be lower on standardized items—it might be possible to enhance the overall reliability through modification or revision of the scale (Tabachnick & Fidell, 2019).

Table 2: Item-Total Statistics.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item test no 1	39.21	32.884	.480	.681	.518
Item test no 2	42.03	40.892	.212	.608	.592
Item test no 3	39.69	22.722	.780	.772	.365
Item test no 4	43.55	39.613	.285	.374	.577
Item test no 5	44.76	43.333	.061	.529	.620
Item test no 6	44.24	46.047	-.091	.517	.636
Item test no 7	44.21	39.956	.199	.595	.597
Item test no 8	42.41	42.323	.232	.767	.590
Item test no 9	39.17	39.005	.194	.691	.602
Item test no 10	44.97	40.249	.337	.769	.571

Item total statistics provide an idea of how an individual item affects the overall reliability of the scale. The item deducted from the total score is known as item-total correction, which indicates how strongly an item relates to the total score of the scale (DeVellis, 2017). Among the items analyzed, item 3 was noted to have the highest corrected item total correlation of 0.780—it is well predicted by the total scale score because it meets the objectives comprehensively. This also means that Q3 is one of the best predictors of the scale and hence increases the internal reliability of the instrument. However, Q5 and Q6 showed corrected item-total correlation values of 0.061 and -0.091 respectively which indicating a weak relationship with the overall scale. To some extent, these low correlations suggest that Q5 and Q6 did not fully meet the general construct of creative thinking on the scale, which could affect the reliability of the scale. Even the scale means and variance when the mean decreased suggest room for improvement. The potential of Q3 as a critical variable, such that with its omission, the scale would record a Cronbach's alpha of 0.365 for scale consistency. However, the deletion of Q5 or Q6 increased the overall Cronbach's alpha to 0.620 and 0.636, respectively—these items are likely to reduce

the overall reliability of the scale's consistency (Field, 2018).

The findings imply that the scale can be regarded as internally consistent because some items improve consistency reliability, whereas others may have to be modified, eliminated, or substituted. Some items that have low rates of corrected item-total correlations, such as Q5 and Q6, seem to impair the reliability of the scale, and thus should be dropped from the final scale (Hair et al., 2010). Nevertheless, items that perform exceedingly well, such as Q3, must remain because they serve the scale's measurement objectives (Kaufman & Beghetto, 2009).

2.1.2. Validity Analysis

Construct validity was assessed with respect to the fluency, flexibility, and originality of the scale. As noted by Kline (2015), construct validity is an important criterion for determining whether items in the constructed scale represent the intended dimensions of creative thinking. The analysis began with the aim of studying the distribution of each item using descriptive statistics, which, in turn, provided the construct validity of each item. The item means ranges from 2.17 (Q10) to 7.97 (Q9), indicating a high degree of variation in the different aspects of creative thinking, as expected (Table 3). High means for Q3 and Q9, for example, imply that these items are likely to produce much broader responses from more abstract aspects of creative thinking such as the generation of ideas or taking multiple perspectives (Runco, 2014). Low means with Q10 indicate that this item attempts a more specific or more difficult aspect of creative thinking instead of focusing on more flexibility in problem-solving under constraints.

Table 3: Item Statistics.

	Mean	Std. Deviation	N
Item test no 1	7.93	1.771	29
Item test no 2	5.10	1.235	29
Item test no 3	7.45	2.354	29
Item test no 4	3.59	1.268	29
Item test no 5	2.38	1.208	29
Item test no 6	2.90	.939	29
Item test no 7	2.93	1.462	29
Item test no 8	4.72	.882	29
Item test no 9	7.97	1.658	29
Item test no 10	2.17	1.037	29

The variance of each item further enhances the arguments made regarding its contribution to construct validity. Items such as Q3, which had the highest variance at 5.542, suggest a wider range of responses and, therefore, can discriminate effectively between participants who vary in their level of creative thinking (see Table 4). Usually, a high variance is beneficial because it indicates that the item has the ability to differentiate between people's creative performances, which can strengthen the construct validity of the scale (Plucker et al., 2011). However, items that are more homogeneous, such as Q6, imply that there is less variation in the responses provided by the respondents, which may suggest that the item does not measure creative thinking as well as it should or that the item is not worded well enough to separate ideas (Tabachnick & Fidell, 2019).

Inter-item correlation also represents construct validity, in that it shows the degree to which individual items are related. The correlations of the items on the Autonomous Motivation construct ranged from -0.374 to 0.641. Items are essentially tinctured with social emphases, placed within this category, and are interrelated. For instance, item Q1 measures the extent to which a person thinks they are contributing to teamwork, and Q3 measures the integration of thinking in creative ways, which seem to share some aspects of creative dimensional thinking (Guilford, 1950). Consequently, in addition to originality and fluency, which seem to be tightly modeled, the earlier items might have also measured a similar construct, which is inter-dimensional creativity, as modeled by Sternberg and Lubart (1996). Nonetheless, the negative associations of some items, such as with Q5 and Q6 (-0.374) triggers the thought of notions remaining invalid regarding the construct. Such a negative association may correspondingly suggest the use of resource items, but in this case, they are interpreted differently by the informants; therefore, they call but dislike the credibility of the overall construct added to the item separation scale (Field, 2017).

Table 4: Summary Item Statistics.

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.714	2.172	7.966	5.793	3.667	5.357	10
Item Variances	2.089	.778	5.542	4.764	7.120	2.068	10
Inter-Item Covariances	.276	-.645	2.675	3.320	-4.145	.404	10
Inter-Item Correlations	.108	-.374	.641	1.015	-1.717	.071	10

The inconsistencies between the inter-item correlations indicate a possible improvement in the scale such that all items are sufficiently suited to represent the constructs meant for measurement. While items that are strongly correlated are likely to promote construct validity, those that are weakly or negatively correlated should be amended to enhance the scale's internal consistency and conformity to models of creative thinking (Kaufman & Beghetto, 2009).

2.1.3. Exploratory Factor Analysis

The underlying structure of the newly developed 10-item scale was analyzed using the specified EFA for three main creative thinking parameters: fluency, flexibility, and originality. According to Field (2017), EFA is also important in determining whether the theoretically predicted constructs successfully represent items. The first evaluation step begins with an adequate picture of the sample and correlation structure through the KMO measure and Bartlett's Test of Sphericity respectively. In other words, even with a rather low KMO value of 0.399, as it falls below the recommended range of the minimum threshold value of 0.6, on which Hair et al. (2010) based their findings did not yield strongly inter-correlated results, such a finding has potential factors that yield effectiveness. However, these limitations of KMO can pass Bartlett' test, which further elucidates why the KMO value was low at a chi-square value of 116.459 ($df = 45$, $p < 0.001$): Whenever a test matrix is sampled, there is a chance that it is not an entire matrix, meaning that relationships between their items are sufficient for factor extraction. The KMO score, which was suggested to have a factor structure that was rather difficult to stabilize, had a notable Bartlett's test, which enabled us to proceed with the analysis.

Table 5: KMO And Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.399
Bartlett's Test of Sphericity	Approx. Chi-Square	116.459
	df	45
	Sig.	<.001

The extracted factors managed to explain, on average, between 40 and 88% of the variance of the item as measured by the communalities. Therefore, some items were better explained by factors such as Q3 (0.876), Q1 (0.736), and Q10 (0.735), in terms of items related to creative thinking (Tabachnick & Fidell, 2019). The case was different for four, where the extracted factors, as evidenced by the communality value of only 0.400, represented this item more poorly; hence, this item seemed less relevant in relation to the factor structure (Plucker et al., 2011). In general, the higher the communality, the more the items correlated with the extracted factors, which is consistent with the concurrent validity of the scale.

Table 6: Communalities.

	Initial	Extraction
Item test no 1	1.000	.736
Item test no 2	1.000	.633
Item test no 3	1.000	.876
Item test no 4	1.000	.400
Item test no 5	1.000	.666
Item test no 6	1.000	.640
Item test no 7	1.000	.610
Item test no 8	1.000	.650
Item test no 9	1.000	.697
Item test no 10	1.000	.735
Extraction Method: Principal Component Analysis.		

According to Kaiser's criterion (Kaiser, 1960), we commenced our factor analysis with the extraction of factors having eigenvalues greater than 1. A set of three factors was extracted and these ones accounted

for 66.4% of the overall variance. For the first component, it contributed 24.96% of the variance, followed by the second component at 24.23%, and the third component at 17.24%. This total variance explained however is not above the threshold of 60%, the inference being that the reserved factors contribute a reasonable percentage of the variation of the creative thinking scale factor measured (Hair et al., 2010). The scree plot, see Figure 1, showed even clearer the situation as it amply stood out after the third factor—the "elbow" rule, no more increases only minimum changes in the amount of variance that is explained and which is not important (Cattell, 1966). Additionally, this scree plot pattern explains the decision to retain three components in concordance with the three circa theoretical aspects of fluency, flexibility, and originality.

Table 7: Total Variance Explained (Extraction Method: Principal Component Analysis.)

Item	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.496	24.957	24.957	2.496	24.957	24.957	2.407	24.067	24.067
2	2.423	24.227	49.184	2.423	24.227	49.184	2.387	23.869	47.937
3	1.724	17.239	66.423	1.724	17.239	66.423	1.849	18.486	66.423
4	.957	9.567	75.990						
5	.772	7.719	83.709						
6	.656	6.561	90.270						
7	.492	4.919	95.190						
8	.255	2.554	97.743						
9	.142	1.417	99.160						
10	.084	.840	100.000						

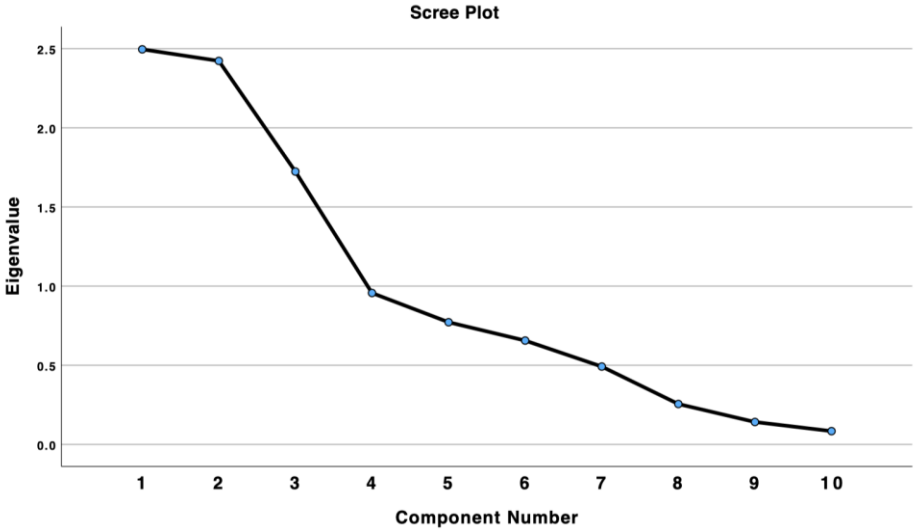

Figure 1: Scree Plot.

Factor loadings were further explained using Varimax rotation, a factor rotation technique that facilitates factor interpretation by maximally dispersing the variance of loadings across components (Kline, 2015), factor loadings were further explained. Based on the criteria and analysis requirements, the rotation was completed in five iterations, and a consistent and comprehensible answer was obtained. The rotated component matrix provided a clear interpretation of the items in relation to the three components. Component 1 had high loadings for items associated with both fluency and originality such as Q1 (0.850), Q3 (0.838), and Q9 (0.646)— these dimensions overlapped in the context of creative thinking. This kind of overlap supports the theoretical explanation that when many ideas have been generated (fluency), there is a chance that many new ideas (originality) will be generated as people look at a wider range of possibilities (Runco & Jaeger, 2012). This finding again demonstrates the fundamental unity of fluency and originality, which are sometimes described as events that occur during creative activities (Guilford, 1950).

Table 8: Rotated Component Matrix.

	Component		
	1	2	3
Item test no 1	.850	-.073	.090
Item test no 2	.521	-.157	.581
Item test no 3	.838	.378	-.172
Item test no 4	.489	.122	.382
Item test no 5	-.030	.353	-.735
Item test no 6	-.136	.101	.782
Item test no 7	-.067	.762	-.159
Item test no 8	-.041	.805	-.024
Item test no 9	.646	-.361	-.386
Item test no 10	.167	.840	.041
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 5 iterations.			

Component 2 reflected most aspects of flexibility, with Q7 (0.762), Q8 (0.805), and Q10 (0.840) exhibiting strong loadings. This clear separation of flexibility as a distinct factor supports the theoretical understanding of flexibility as an important feature of creativity, which conceives the ability to view things differently and formulate changes in solutions (Plucker et al., 2011). Strong loadings for flexibility suggest that the items measure what they are meant to measure, thus strengthening the argument that the construct is an important aspect of creative thinking (Sternberg & Lubart, 1996).

Component 3 captured the and secondary dimensions of measurement of creativity in terms of originality with items such as Q6 (0.782) and Q5 (-0.735) making significant loadings. This component measures slightly different degrees of originality, and in this sense, both incorporate ideas that are original at once and those that are original in the originality almost-beta form. The presence of Q6 and Q5 under this component acknowledges that originality exists in idea scanning, idea formation, and structural originality in the form of novelty combinations and refinements, such as formed thoughts (Kaufman & Beghetto, 2009). The negative loading of Q5 suggests that there are problems with the measurement of the construct, in which case, it appears that the items using this structure work against the construct, as many more alterations will be required for this item and for originality alone (Runco, 2007).

As a logical guideline, the component transformation matrix provides information on the dependencies between the components obtained through extraction. The matrix displayed moderate correlations among the three components—while the components measure different facets of creativity, they are not entirely separable. For example, the correlation between components 1 and 2 was as high as 0.907—originality/fluency and flexibility are highly related (Plucker et al., 2011). This correlation, in turn, gives credence to theoretical models that view creative thinking as a system in which differing facets of creativity are in constant interaction (Sternberg & Lubart, 1996). However, the correlation between components 1 and 3 was weaker and slightly negative (-0.159). This suggests a more complex association where primary fluency, originality, and secondary originality interact but are likely to engage different neural pathways (Runco, 2007). This distinction calls for an appreciation of the complexity of creativity as a construct and how its dimensions relate to one another.

Table 9: Component Transformation Matrix.

Component	1	2	3
1	-.149	.907	-.393
2	.976	.199	.089
3	-.159	.370	.915
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

The EFA results confirm that the ten-item scale has captured three facets of creative thinking. While independent, these facets are interrelated. The factors identified are associated with the components of fluency, flexibility, and originality; therefore, the scale defines creative thinking as a composite construct. However, in the next rounds, some items, particularly those with lower communalities or those with complex loadings in a factor, will need some changes to enhance construct validity and interpretability. The moderate correlation across components indicates that the construct is integrative

and that creative thinking involves a number of processes that are interrelated but also distinct (Runco, 2007). These results demonstrate that there is a solid foundation for the scale to be expanded and validated with the hope that the lower range of the scale to measure creative thinking across different contexts will be utilized.

2.2. *Discussion*

The aim of this paper is to assess the construct validity, reliability, and factor analysis of a ten-item scale measuring creative thinking in terms of fluency, flexibility, and originality. Findings of this study, in addition to the first psychometric evidence, continue the discourse on measuring multidimensional constructs of creativity and the implications for educational measurement, while contributing to the empirical findings of the current study. the current body of research, and considering creativity to be a construct, integrated or unintegrated, or in a loosely connected framework (e.g. Runco & Jaeger, 2012; Kaufman & Beghetto, 2009), this study conceptualizes creativity as a partially integrated model. The final part of this paper discusses the findings in relation to other studies, explains the theory of the findings, and suggest how to improve the instrument for educational purposes.

2.2.1. *Reliability of the Scale*

In the evaluation of psychometric instruments across various contexts, reliability has emerged as a construct that one cannot do without, most notably because it exemplifies the extent to which an instrument measures a given attribute within different contexts and possibly times (DeVellis 2017). In this study, the internal consistency of the creative thinking scale was evaluated using Cronbach's alpha. The analysis showed a Cronbach's alpha value of 0.604—the internal reliability of items on the scale was acceptable but not optimal (Field, 2017). This is generally in accordance with the recall by Hair et al. for most exploratory research, whereby alpha values of approximately 0.6, which are already deemed acceptable, should be used in pilot studies, especially those involving new instruments that are validated for the first time (Hair et al., 2010). However, if the scale were to be applicable over a wider range of usage, the accuracy with which it currently measures the components would have to be enhanced to the most conventional unit measure which is above 0.7 (Kline, 2015).

As moderate reliability was established in this study, the items of the scale measured the intended constructs reasonably consistently, leading to one or more varied response patterns. The differences are further highlighted by the value of the standardized Cronbach's alpha value, which is slightly lower at 0.548, and controls for the scale of the responses (Tabachnick & Fidell, 2019). The apparent disparity among the alpha scores suggests some problems in the way different items are transformed into a single scale, which could be due to differences in the items' wording, interpretation, and relation to the theoretical aspects of creative thinking (Johnson, 2013; Tavakol & Dennick, 2011).

The item-total statistics provided further insight into the reliability of the individual items. Items such as Q3 exhibited a strong corrected item-total correlation of 0.780—they were congruent with the general force of the scale and added to its overall consistency (DeVellis, 2017). Items Q5 and Q6 showed much lower corrected item total correlations—they may not be operating at the same construct level as expected, or that they may be poorly worded and the items confuse the respondents (Plucker et al., 2011). The fact that the removal of Q5 or Q6 would increase the value of the overall alpha to 0.620 and 0.636, respectively, means that the removal, amendment, or substitution of these items would improve the reliability of the scale. This corroborates the literature suggesting that this kind of instrument routinely and centrally requires multiple rounds of iteration for better item alignment and internal consistency (Kaufman & Beghetto, 2009).

Cronbach's alpha of 0.604 indicated moderate internal consistency, which aligns with the thresholds commonly accepted in exploratory and early-stage instrument development (Hair et al., 2010). However, compared to established creativity assessment tools that typically report reliability coefficients above 0.70 (Plucker et al., 2011; Runco, 2014), the current scale demonstrates room for improvement. Thus, while the instrument is suitable for preliminary research, it may not yet be sufficiently robust for high-stakes assessment contexts.

From a theoretical perspective, this moderate reliability can be partially explained by the inherently context-sensitive and domain-dependent nature of creative thinking, as emphasized by Sternberg and Lubart (1996) (see also Runco et al., 2010). Therefore, the extent of reliability attained in creative thinking assessments is usually low because performance is affected by factors such as the personal characteristics of the respondents, context, and the specific nature of creative tasks (Runco, 2014). Thus, educators and researchers should

interpret scores cautiously and consider complementing the scale with performance-based or open-ended assessments to capture a fuller picture of students' creative abilities.

2.2.2. *Validity Of the Scale*

It is crucial for the scale to be valid and capable of assessing three creative thinking dimensions: fluency, flexibility, and originality. In this study, construct validity was evaluated based on inter-item correlations, communalities and EFA factor loadings (Kline, 2015; Lim, 2024; Spinoni et al., 2024) Initial evidence of construct validation based on descriptive statistical analysis was made when factors means and variances revealed differences across the scale. Higher and lower means on an item, for example, giving a proportion of 84 for Q9, would capture general aspects of creative thinking, as would the theoretical definition of the motivation for fluency, which has been characterized in the literature as the generation of many ideas (Runco & Jaeger, 2012). Items such as Q10 that would presume low mean averages depict more specific abilities or less easy ones such as flexibility, which include adaptative thinking, but only in constrained situations (Plucker et al., 2011).

Diversity in item variance also reinforced the construct validity of the scale. The marked variation in items such as Q3 indicates that the functioning and definition of the items at the top are strong, as they can differentiate among respondents with varying levels of creative thinking (Field, 2018). Items such as Q6, which have low variance, seem useless in terms of classification and may require changes before they can broaden the range of responses captured to enhance the validity of the scale. (Tabachnick & Fidell, 2019).

The relationship between items in inter-item correlations also demonstrated the existence of a degree of relationship across items, be it a construct or an individual item misalignment. Items Q1 and Q3 shared a high positive correlation of 0.641, which is evidence that the two measures similar creative thinking dimensions: fluency and originality (Guilford, 1950). However, high negative correlation values, such as -0.374, which were obtained between Q6 and Q5, aroused suspicion of the possibility that the items measured different constructs, and each did not correlate with the intended factor for that item. Kline (2015) indicated that these items raised concerns about possible construct disentanglement. This finding highlights the critical need for constructing items such that they do not detract from other dimensions but enhance them, thus construct validation Kaufman, & Beghetto, (2009) argued that the items will have been tackled.

The EFA results further validated the construct by showing that three components which arose were consistent with the theoretical definition of creative thinking's three components which are fluency, flexibility and originality. This finding reinforces the multidimensional conceptualization of creativity that is widely supported in the literature (Guilford, 1950; Runco, 2007). These three factors collectively accounted for 66.4% of the total variance, further supporting the premise that creative thinking is inherently multidimensional (Runco, 2007). (Runco, 2007). The strong loadings of the items on their respective components also substantiated the construct validity of the scale. For instance, items Q1, Q3, and Q9 loaded strongly on Component 1, suggesting a close relationship between fluency and originality, as noted by Sternberg and Lubart (1996). Nonetheless, this overlap indicates that these constructs may not be entirely independent in practice but rather function as interdependent processes within divergent thinking. This aligns with Runco and Jaeger's (2012) argument that fluency often serves as a generative mechanism facilitating originality. Conversely, items Q7, Q8, and Q10 were strongly associated with Component 2, clearly representing flexibility as a relatively distinct cognitive process (Plucker et al., 2011).

Despite this, the presence of a third factor with Q5 and Q6 indicates that there are other aspects of originality that the current model does not address. This suggests that the model can be refined to include a more comprehensive understanding of originality. From this perspective, the model may open the question of what can be termed 'secondary originality', which encompasses not only spontaneous idea generation but also more intentional and evaluative kinds of originality. Such a perspective allows the model to encompass more than the existing concept of originality and points towards an idea that, in a broad sense, originality consists of varying degrees of cognitive complexity (Kaufman & Beghetto, 2009). Practically, these findings demand that educators and empirically oriented assessment designers create more tasks to measure these elements, especially those that assess the lower-level cognitive demand of idea generation (fluency) and its higher-level counterparts of transformation and evaluative judgment, which are critical to higher order sense of originality. The negative loading of Q5 also raises the question of whether it is a true measure of the construct; clearer revisions would ensure more construct

representativeness (Field, 2018).

2.2.3. Exploratory Factor Analysis and Factor Structure

The results of the EFA were central to determining the factor structure of the creative thinking scale. The EFA identified three factors with an eigenvalue greater than one, which corresponds to Kaiser's rule of one factor being extracted per retained factor (Kaiser, 1960). Collectively, these components contributed to 66.4% of the cumulative variance extracted from the analysis, indicating that this scale measures a greater portion of the creative thinking domain construct (Hair et al., 2010). The proportions of variance assigned to the components, 24.96% for Component 1, 24.23% for Component 2, and 17.24% for Component 3, indicate that a percentage of the total variance is distributed across these components, meaning that the factor structures are well shaped, which minimally meets the definitional structure of creative thinking (Runco, 2007).

Using varimax rotation, the variance of factor loadings is maximized, clarifying the factor structure of the component (Kline 2015). For instance, the items on fluency and originality overlap with items measuring Q1 (0.850), Q3 (0.838), and Q9 (0.646), indicating that Component 1 encompasses fluency and originality (Plucker et al. 2011). This result agrees with the theoretical model that states that originality is encouraged by fluency, as fluency allows a wide range of thoughts to be produced; hence, many new ideas can be produced (Runco & Jaeger, 2012). This also suggests, as do Components 1 and 2, which correlated at 0.907, that there is indeed a relationship between them, which leads to the conclusion that fluency and originality are indeed interdependent in many, but not exclusively, aspects, and are not absolutely separate (Sternberg & Lubart, 1996). This overlap may arise from the consideration that fluency, explained as the ability to produce many ideas, is a necessary condition for producing creative ideas; therefore, it is difficult to assess these dimensions separately (Guilford, 1950).

According to the analysis of the main components, the second component was mostly associated with flexibility, showing high loadings for items such as Q7 (0.762), Q8 (0.805), and Q10 (0.840). This factor's strong portrayal of flexibility is consistent with the theoretical approach that considers flexibility within creative thinking as a separate cognitive process that includes the ability to see the problem in different ways and use new or unusual solutions (Plucker et al, 2011). Flexibility's clear discrimination of its position as a component establishes that it hones down to one particular area of creativity: cognitive flexibility and cognitive openness (Sternberg & Lubart, 1996). The ingredients used to define this construct, clearly defined by the factor structure of the flexibility scale, imply that it is real. Furthermore, this construct comprises a moderate correlation between Components 2 and 1 — is a clear correlation between flexibility, fluency, flexibility, and originality, as the use of flexible thinking is bound to result in various thoughts and ideas (Runco, 2007).

Component 3, as claimed by other authors, incorporated supplementary facets of originality, with items such as Q6 (0.782) and Q5 (-0.735) loadings recording high marks. This component provides a broader scope definition of the originality base than its rate of occurrence based on structure. Kaufman and Beghetto (2009) referred to creativity as an imaginative act, classified as a spontaneous or purposeful action. Q6 and Q5 quantify a composite measure of originality and its aspects, which are anti-speed as the primary focus of creativity and the original concept with indentation.

The low score reported for Q5 contained useful information regarding the understanding or attachment of the item to the originality construct and may require further modification to ensure that the required dimension is better captured (Field, 2018). Such intricacy is consistent with the concept of originality being understood from a broader theoretical perspective as something that is not a single entity but is experienced in different ways — in the form of eureka moments or purposeful ideas (Runco, 2014). The explanation given in the component transformation matrices indicates that while there may exist a certain degree of correlation between fluency, flexibility, and originality, the correlation is not strong enough for them to be interpreted as independent constructs; the three components are interrelated. This finding is consistent with theories that regard creativity as a multifaceted phenomenon, in which each creative dimension is activated at different stages of the creative process (Sternberg & Lubart, 1996). The strong positive correlation of Components 1 and 2 (0.907) suggests that fluency and flexibility are often evident simultaneously in a wide range of creative performances due to the use of diverse ideas in problem-solving that are not rigid, thus expanding the solutions available (Plucker et al., 2011). However, the low but negative correlation between Components 1 and 3 (-0.159) suggests that primary fluency/originality and secondary originality are associated; however, different cognitive mechanisms

may underpin these two concepts. Primary and secondary originality both depend on related factors in real creativity. Fluency and initial originality are largely dependent on divergent thinking, while secondary originality might involve more convergent and evaluative thinking, which is an individual's more elaborate creativity (Runco, 2007).

The results of the EFA provide strong support for a theoretical model of creative thinking by viewing it as a multifaceted construct comprising three dimensions: fluency, flexibility, and originality. The three extracted components are in line with classical and well-established theories and provide a logical framework for measuring several dimensions of creative thinking. Noting the relatively low communality of some items, such as Q4 0.400-Ashton et al., there are areas for improvement. Such items can be revised or clarified to provide a scale with greater ability to detect creative thinking capabilities within an individual where variability is expected (Tabachnick & Fidell, 2019). In addition, the fact that secondary originality was regarded as an independent component indicates that there might be a basis for further examination of this factor, as this might be a different type of creativity that requires a different set of measurement items (Kaufman & Beghetto, 2009).

While the EFA results generally support the proposed three-factor structure, the low KMO value (0.399) indicates that sampling adequacy may be insufficient for stable factor extraction. Compared with the recommended thresholds (KMO > 0.60; Kline, 2015), this limitation suggests that the current factor structure should be interpreted with caution. Similar challenges have been reported in early-stage validation studies of creativity instruments, where heterogeneous item interpretations and limited sample sizes affect factor stability (Acar et al., 2023; Kline, 2015).

In conclusion, the Early Factor Analysis results are applicable in confirming the factor structure of the scale within the theoretical framework of creative thinking as a multi-faceted construct consisting of discrete, interrelated factors. The three-component structure is largely sufficient for the measures of fluency, flexibility, and originality, although some items could be improved for better accuracy in measurement.

The results also bring out the systems view of the creative process where several elements come together and act as one. This is typical of the creative process in ideation and problem solving (see de Villiers, 2022; Haavold & Sriraman, 2022). Therefore, future studies should focus on larger and more heterogeneous samples for improved generalisability of findings. Also, the Confirmatory Factor Analysis (CFA) provided important information on the stability (or instability) of the three-factor model and the acceptance of rival models (e.g., hierarchical or bifactor models of creativity). From an applied point of view, this is a limitation in that the current scale is more suited to exploratory diagnosis than to standardised measurement, particularly in educational contexts where the degree of measurement is high.

2.2.4. Practical Implications for Mathematics Education

The results demonstrate multiple strategies for assessing creative thinking in the field of mathematics. The first example considers the structure of teaching strategy assessment and the mathematics creative thinking framework in relation to the use of differentiated assessment approaches. These approaches can be designed to demonstrate flexibility (in terms of different strategies to solve the problems) and originality (in terms of novel approaches) rather than opt for more responses (in terms of number of responses).

The second example focuses on problematic items (i.e. Q5 and Q6) and reminds us of the importance of contextualized clear designs. As such, educators as well as test developers must ensure that the prompt is as clear as possible to the learners to the avoid context and element misalignment to the furthest extent possible. Given the moderate reliability, the final example leads one to realize the use of the scale should be limited to mini assessments (formative assessments) supporting instructional decisions rather than to finalize large assessment (summative assessments). The scale may also be used in conjunction with some digital tools (i.e. tasks designed with GeoGebra or AI to provide feedback) to capture the evolving dynamics of creative thinking more easily.

This study adds to the research on the assessment of creativity by presenting initial support for a three-dimensional framework of creative thinking and highlighting critical measurement issues. These findings suggest that beyond the multidimensional nature of creativity, some dynamically interdependent aspects demand measurement approaches that account for the divergence and integration of ideas. Future research should improve item quality, widen sampling, and determine the factor structure through confirmatory approaches. These activities are necessary for creating a rigorously developed and contextually relevant tool

to support research and practice in mathematics education.

3. CONCLUSION

This study created and evaluated a ten-item scale that assessed the creative ability of individuals in three aspects: fluency, flexibility, and originality. The recent shift in educational and business approaches has fostered the need for individuals to engage in innovative activities and solve complex problems; however, the assessment of creativity is limited because of its direct focus. The new measurement scale that has been outlined helps expand the boundaries of these issues by providing a reliable and valid measurement that captures different aspects of creativity while performing psychometric testing.

The results of this construct showed moderate internal consistency for the scale, as evidenced by a Cronbach's alpha value of 0.604, which is acceptable for exploratory research. This somewhat reliable finding indicates that the scale items were sufficiently relevant to the theoretical concepts of creative thinking, although further research is warranted to enhance the achieved level of consistency. The construct validity was supported by the results of descriptive statistics, inter-item correlations, and communalities, suggesting that more items were likely to comply with their expected dimensions of fluency, flexibility, and originality.

The results determined the scale to be multidimensional as three factors totaled 66.4% of the variance. This conclusion concurs with existing theoretical models that treat the creativity construct as one unified entity comprising of various interrelated components. From the Varimax rotation, fluency and originality were identified as key factors while flexibility stood alone. This means that fluency and originality go together as one generates multiple ideas while flexibility refers to the ability to shift and use different thinking styles in relation to the creative task at hand. Although the results were decent, the study identified areas of improvement. Items Q5 and Q6, for example, had low corrected item-total correlations and factor loadings which indicated that these items may be less relevant to the construct of creative thinking. Such modifications would improve clarity and increase the focus to the targeted dimensions. Additionally, the KMO of 0.399 indicated that the findings, owing to sample size restrictions, are not useful for a particular population and as such this limitation highlights the need for future research with larger sample sizes to evaluate the usefulness of the scale across different populations and contexts.

This research presents several advancements in the measurement of creativity. Firstly, it presents a measurement tool of greater flexibility and scope to cover more creatively defined ways of thinking, and address the current measuring instruments that are typically one-dimensional in nature. The psychometric properties of the instrument are applicable in the educational, institutional, and research domains, where there is a need for a more profound understanding of the construct of creativity. Secondly, this research exemplifies support to the multidimensional nature of creativity by supporting the scale's factor structure through EFA.

From an applied perspective, the scale offers measurement of validity that educators, psychologists, and leaders in organizations that are interested in measuring and stimulating creativity possess and need. With a well-defined measurement of fluency, flexibility, and originality, practitioners are better able to illustrate the creativity scores of people, and their deficiencies, in a way that provokes the right kind of stimulation and training interventions. To this end, one can use the scale to plan tasks in a classroom to promote uni-dimensional creativity, or one can use the scale to identify creative potential in employees and provide appropriate training interventions.

The limitations of this study should be pointed out. The decisive inter-item correlation coefficients and small sample size are conducive to the notion that the scale is overhauled, and more tests are needed to put it into practice. Further research should focus on the items that display low factor loadings so that they are modified or replaced, while the other direction should be to sustain the scale using CFA. Additionally, testing the scale in diverse populations and cultural contexts could provide insights into its broader applicability and reveal potential cross-cultural variations in the expression and measurement of creative thinking.

In conclusion, the goal of the research was successfully completed by developing, and discovering the ability of the scale, to assess the construct of creative thinking in several dimensions. Research results indicate the intricacy of the measurement of creativity and, thus, the extent of these business research implications, which warrant the measurement and monitoring of improvement and changes. Although the scale might have some shortcomings, it seems to provide a sufficient means to offer creativity measurement some advancement, and it ought to be applicable in a number of areas,

including education, research, and organizational improvement. Since the scale measures, in addition to fluency, a further degree of flexibility and originality, it adds to the comprehension of a number of creative dimensions, and how the same can be used to guide future inquiries, aimed at enhancing the structure and nurturing the creative processes in various areas.

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Appendix 1

Question 1 ***Traditional Dance of Jambi Province***

The Sekapur Sirih Dance is a traditional dance from the Jambi region. This dance is a type of welcoming dance for honored guests visiting Jambi and is performed by female dancers. Wearing traditional attire and accompanied by the sound of music, they dance gracefully while carrying a tray (cerano) as an offering.

The Jambi government will hold a mass performance of the Sekapur Sirih dance, with the number of dancers in each row following a numerical pattern. If the first row has 2 dancers, the second row has 5 dancers, and the third row has 7 dancers, determine the possible number of dancers in the next 3 rows following the pattern given. Provide at least two different methods of solving this.

Question 2 ***Icon of Jambi Province***

Jambi City officially became the capital of Jambi Province based on Law Number 61 of 1958. Jambi is known as "Bumi Melayu" with the motto "Tanah Pilih Pusako Betuah." Jambi City is divided by the Batanghari River, the longest river on Sumatra Island.

Here are some important days celebrated by the people of Jambi:

- January 6: Anniversary of Jambi Province
- September 10: Kerinci Lake Festival

- November 14: Batanghari Festival

If observed, these celebration dates form the pattern 6, 10, 14, … Determine if the date 30 is part of this pattern. Use at least two different methods to solve this question.

Question 3 ***Traditional House of Jambi***

The traditional house of Jambi is known as "Kajang Leko," designed as a stilt house. It has unique construction and decorative carvings. The roof structure is named "Gajah Mabuk," inspired by the designer's name, who created it while being "intoxicated by love." Unfortunately, he didn't receive the blessing from his parents. Meanwhile, the roof ridge is curved upward, resembling a boat, and is called "Jerambah" or "Lipat Kajang." The top of the roof, named "Kasau," is made from woven palm fiber, folded in two to prevent water from entering the house.

The traditional house of Jambi has windows with various patterns.

- The first traditional house has an odd number of window patterns less than 6.
- The second traditional house has an even number of window patterns between 5 and 11.

Determine the possible window patterns of the two traditional houses that can form a Fibonacci sequence. Use at least two different methods to solve this.

Question 4 ***Traditional House of Jambi***

The traditional house of Jambi stands on wooden pillars, consisting of main and additional pillars. The use of these pillars symbolizes the importance of structure and stability in the lives of the people of Jambi. These pillars not only physically support the house but also represent the support between community members and the strength of culture passed down through generations.

The traditional house of Jambi has two series of wooden pillars as follows:

- Main pillars = 7, 11, 15, 19, 23, …
- Additional pillars = 1, 10, 19, 28, 37, …

If both series continue, determine the next common number in both series. Use at least two different methods to solve this.

Question 5 ***Anniversary of Jambi Province***

The Provincial Government of Jambi will hold the 67th-anniversary celebration of Jambi Province on January 6. The committee has prepared the event to run solemnly and smoothly. Special invitations have been prepared for important guests who will be given VIP seats.

The organizing committee is asked to arrange 20 rows of seats. In the first row, there are 12 seats. In the second row, the number of seats increases by 2 to 14 seats. In the third row, the seats increase by another 2 to 16 seats, and so on, with each subsequent row adding 2 seats compared to the previous row. Determine the total number of seats that need to be prepared by the committee. Solve this problem using two different methods.

Question 6 ***Traditional Food of Jambi***

Tempoyak is a traditional Jambi dish made from fermented durian. It is usually consumed as a side dish mixed with sambal when eating rice. Tempoyak has a sour taste due to the fermentation process of durian flesh.

A tempoyak seller experiences a consistent increase in profits every month. The cumulative profit up to the fourth month is IDR 30,000, and the cumulative profit up to the eighth month is IDR 172,000. How much total profit does the seller earn in a year? Use at least two different methods and provide an explanation.

Question 7 ***Cultural Heritage of Jambi***

Muaro Jambi Temple is one of the relics of the Sriwijaya Kingdom, used as a place of worship and study of Buddhism. This temple is located in Muaro Sebo District, Muaro Jambi Regency, on the banks of the Batanghari River. It is the largest temple complex in Southeast Asia, covering an area of 3,981 hectares.

"Entrance Ticket Prices for Muaro Jambi Temple"

Every month, the entrance ticket price for Muaro Jambi Temple increases by a fixed amount. This increase is part of the tourism conservation effort to maintain its sustainability. Calculate the total revenue from entrance tickets to Muaro Jambi Temple over half a year if there is at least one visitor every month. Use at least two different methods and provide an explanation.

Question 8 ***Traditional Cake of Jambi***

Did you know?

Padamaran cake is a traditional Jambi cake made from rice flour and coconut milk, with a green pandan color and a layer of melted brown sugar at the bottom. The cake, shaped like a small rectangular boat made from banana leaves, has a soft texture and a sweet-savory taste. It is usually served at weddings, thanksgiving events, and other important occasions.

A banana leaf used to wrap the padamaran cake is cut into 2 parts, each part is then cut into 2 parts again, and this process continues. After each cut, the number of banana leaf pieces increases. Determine the total number of banana leaf pieces after 5 cuts. Use at least two different methods to solve this.

Question 9 ***Traditional Game of Jambi***

Marble game (kelereng) is a traditional Jambi game, made from glass, clay, or agate, with a typical diameter of ½ inch. The game begins when players throw marbles toward a pre-made hole, and the player who successfully lands a marble in the hole gets a chance to “attack” their opponents. An opponent's marble is considered "dead" if hit by an attack.

Andi has marbles that he has wrapped in 6 different bags, each with a different number of marbles. The first bag contains 3 marbles, the second bag has 6 marbles, the third bag has 9 marbles, and the fourth bag has 12 marbles. Determine the possible number of marbles in the next 3 bags, following the pattern. Explain your steps with at least two different methods.

Question 10 ***Traditional Musical Instrument of Jambi***

Kelintang kayu is a traditional Jambi musical instrument made from wooden pieces that produce different notes. It is played by striking it, and the resulting sound is a clear wooden tone. When played with the right notes, it produces melodious music.

A player strikes the kelintang kayu following a geometric sequence. The first strike produces 3 sounds, and each subsequent strike doubles the previous one. Determine the possible number of sounds produced in the next three strikes. Use at least two different methods to solve this.