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Development of a Local Culture-Based Creative Thinking Instrument in Science Education using the Rasch Model

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Abstract

Creative thinking skills are important in 21st-century science education, but the availability of contextual and empirically tested assessment instruments is still limited, especially for material on substances and their changes. This study aims to develop an instrument for creative thinking skills in the form of essay questions integrated with local culture in Semarang. The instrument was developed based on four indicators of creative thinking, namely fluency, flexibility, originality, and elaboration, and consisted of seven contextual questions. Content validity was assessed by five experts using Aiken's V index, which produced an average Aiken's V value of .92, indicating a very high level of item suitability. The instrument was then tested on 175 junior high school students and analyzed using the Rasch Model. The analysis results showed item reliability of .98, indicating extreme stability in the items' difficulty hierarchy. All items were declared fit for the model with outfit and infit mean square values within the accepted criteria range. The response category structure analysis showed a monotonically increasing observed average pattern and sequentially ordered category thresholds, although some threshold differences were outside the ideal range. Overall, the developed instrument has good measurement quality and is suitable for assessing creative thinking skills in science within the local culture.

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INTRODUCTION

Twenty-first-century learning positions creative thinking as a key competency within the 4C framework, a set of competencies students need to respond to the rapid development of science and technology (Mahrunnisya, 2023; Saputri et al., 2023). However, in the practice of science learning at the junior high school level, particularly in the subject of substances and their changes, students' creative thinking skills have not been optimally developed. One factor contributing to this condition is the limitation of assessment instruments specifically designed to measure creative thinking skills in the context of science learning (Syaifullah et al., 2024). The available instruments generally do not fully represent the demands of divergent and contextual thinking inherent in creativity. As a result, the assessment process still tends to focus on mastery of concepts, while students' ability to produce diverse responses to everyday phenomena remains inadequately assessed.

Conceptually, creative thinking skills are understood as an individual's ability to generate, develop, and refine new ideas that are valuable and applicable (Vincent-Lancrin et al., 2019). This ability encompasses four leading indicators, namely fluency, flexibility, originality, and elaboration (Torrance, 1965). In the context of science education, these four indicators require learning experiences and assessments that enable students to relate scientific concepts to the realities they face. Challenges arise when the tide of globalization and technological developments expands the penetration of global culture, with the potential to indirectly displace local culture in learning practices. In fact, local culture contains values, customs, and ways of life that are relevant as an authentic context for fostering and measuring students' creative thinking (Fatonah et al., 2024).

In science learning, integrating local culture into creative thinking tools can provide a more contextual and meaningful assessment experience. Local culture not only serves as a learning background but can also be positioned as a source of authentic problems that encourage students to construct and develop ideas creatively (Azizah & Wulandari, 2024). The local cultural context allows students to generate diverse ideas based on their daily experiences (fluency), review science concepts from various perspectives (flexibility), and express ideas that are relatively unique to their background (originality). In addition, connections to community practices and traditions help students elaborate on ideas in more detail and with greater meaning (elaboration). Thus, the integration of local culture into assessment instruments not only increases the relevance of the questions but also has the potential to foster students' appreciation of their local cultural identity (Galingging et al., 2024); Sukiastini et al., 2024; Sumarni et al., 2024; Tumbularani et al., 2025).

One form of local culture rich in a scientific context is the local wisdom of Semarang, such as Lawang Sewu, lumpia, bandeng presto, Semarang batik, and various historical buildings and cultural practices. These phenomena represent physical and chemical processes relevant to matter and its changes, and thus have the potential to serve as contexts for questions that require students' creativity. Culture-based learning and assessment are also reported to increase learning motivation because the material feels closer to students' daily experiences (Hikmawati et al., 2025). However, most previous studies still utilize local culture as a medium or approach to learning, rather than systematically integrating it into the development of science assessment instruments. In addition, the availability of specific instruments to measure students' creative thinking skills in the subject matter of substances and their changes is still very limited (Putra & Wahyuni, 2025; Setiani et al., 2024).

On the other hand, research that develops science-based creative thinking instruments explicitly and analyzes their quality using the Rasch Model remains relatively limited (Athiyyah et al., 2022; Rohmatika et al., 2025). In fact, the Rasch Model provides a strong measurement framework for evaluating item quality, measurement consistency, and scoring category functions in polytomous data instruments. Therefore, this study focuses on developing an instrument to measure creative thinking skills through essay questions on substances and their changes, integrated with Semarang's local culture. The instrument's quality was analyzed using the Rasch Model, especially the Andrich Rating Scale Model,

which is suitable for uniform scoring categories (Bond & Fox, 2015). Through this development and analysis, the study is expected to provide a contextual, valid, and reliable assessment instrument while supporting science assessment practices better aligned with the demands of 21st-century learning.

RESEARCH METHODS

This study employed a quantitative Research and Development (R&D) approach to develop an instrument for assessing creative thinking ability among junior high school students. The development model used is ADDIE (Analysis, Design, Development, Implementation, and Evaluation) as proposed by Branch, as cited in Weldami & Yogica (2023). This model was chosen because it provides a systematic framework for designing, developing, and evaluating the quality of assessment instruments on an ongoing basis. The stages of instrument development according to the ADDIE model are shown in Figure 1. Each stage is carried out sequentially to ensure consistency between the measurement objectives, instrument design, and the quality of the development results.

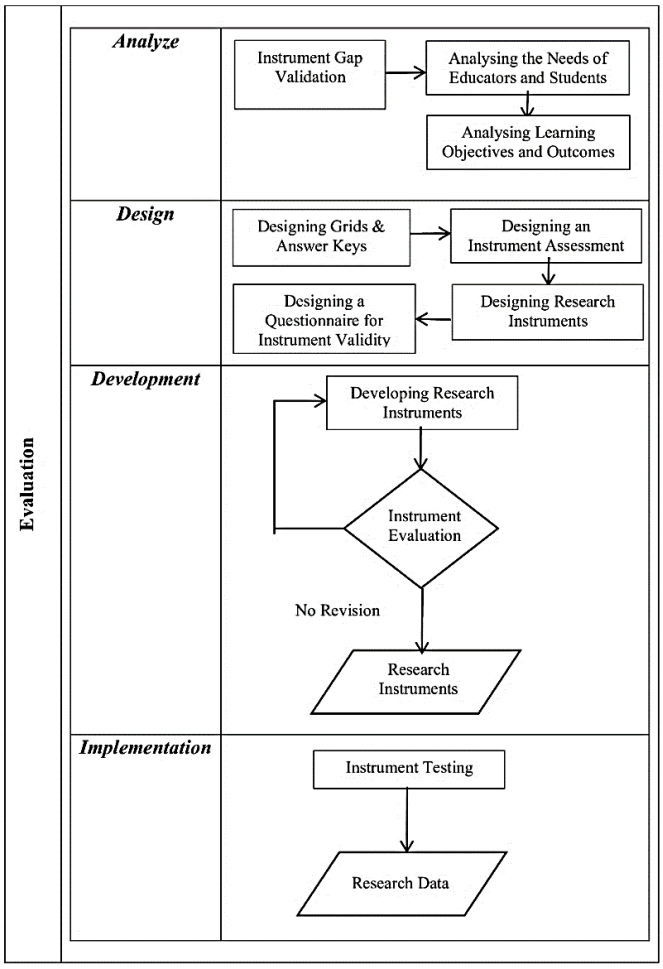

Figure 1. ADDIE Design Instrument for Creative Thinking Skills

The study was conducted at SMP Negeri 3 Semarang in the 2025/2026 academic year. The study population consisted of all 320 seventh-grade students across 10 classes, with a relatively balanced distribution. The sample was selected using a cluster-random sampling technique, with classes as the sampling units. Based on the Krejcie & Morgan (1970), a sample

of 175 students was selected, which was considered representative for the instrument's psychometric analysis. This technique was chosen to maintain population representativeness while adjusting to the existing class structure.

The instrument developed was an essay test on substances and their changes, integrating the local cultural context of Semarang. This instrument consists of seven questions designed to measure indicators of creative thinking skills, namely fluency, flexibility, originality, and elaboration. Each question is related to local cultural phenomena, such as Lumpia Semarang, Lawang Sewu, Bandeng Presto, Es Cong Lik, and Batik Tugu Muda, which represent the processes of physical and chemical changes in everyday life. The cognitive level of the questions ranges from C3 to C6 with a moderate level of difficulty. The design of this instrument is intended to encourage students to express their ideas openly, diversely, and contextually.

Student answers are scored on a 0–5 polytomous scale, applied consistently across all questions. A score of 0 is given if the student does not provide an answer, writes 'do not know', or provides a response without a relevant explanation. A score of 1 is given if the student can express only one relevant idea, but with an explanation that is unclear, incomplete, or not relevant to the context. In comparison, a score of 2 represents the ability to express one relevant idea with an explanation that is still very limited in terms of variety of perspectives, novelty, and depth of elaboration.

A score of 3 is given if the student produces two relevant ideas with general explanations and begins to show limited variation in perspective and novelty. A score of 4 indicates strong creative thinking skills, characterized by the ability to produce three relevant ideas with clear, coherent explanations, the use of diverse perspectives, and ideas that are relatively unique compared to most other students' answers. The highest score, 5, is given if the student produces more than three ideas that are relevant to the explanation, which are very clear and in-depth, demonstrate high flexibility of thought through the integration of various perspectives, and present detailed, mutually supportive elaboration of ideas.

The data generated are polytomous and are analyzed using the Rasch Model, specifically the Andrich Rating Scale Model. This model is designed for ordinal data with uniformly applied scoring categories across all items. (Bond & Fox, 2015). Rasch analysis includes instrument reliability estimation, analysis of item fit to the model, analysis of item difficulty, and evaluation of response category functions and threshold order (Amelia et al., 2023; Chong et al., 2022; Fadhilah et al., 2023). All stages of the analysis were carried out to ensure that the instrument met strong psychometric criteria and was suitable for measuring the creative thinking abilities of junior high school students. This approach also allows for a more accurate and tiered interpretation of the measurement result.

RESULTS AND DISCUSSION

The development of instruments for creative thinking ability began with the preparation of a grid containing indicators of fluency, flexibility, originality, and elaboration, which were then translated into instrument specifications, answer keys, and assessment

rubrics. The instruments were developed as seven contextual essay questions based on Semarang's local culture to ensure that the creative thinking requirements are relevant to students' daily experiences. Content validation was carried out by five experts, comprising assessment and subject-matter experts, to assess the suitability of each item to the construct of the creative thinking skills being measured. The analysis using Aiken's V index yielded an average value of 0.92, indicating that all items had a very high level of suitability and adequately represented indicators of creative thinking skills (Kurniawan et al., 2025). These findings confirm that, conceptually, the instrument meets content validity requirements and is suitable for proceeding to the empirical testing stage.

Although content validity showed strong results, item revisions were still made based on expert input to improve the clarity of the stimulus and the accuracy of the response requirements. The revisions focused on reducing ambiguity in the wording and sharpening the context of the problems so that the variety of answers that emerged truly reflected students' creative thinking abilities, rather than difficulties in understanding the questions. Examples of improvements in the wording of items before and after revision are presented in Table 1, particularly in item 4, which clarifies the context of a culinary specialty of Semarang, Es Cong Lik, by emphasizing its flexibility. In the initial version, the use of the phrase ‘in various ways’ was considered too general and could lead to differences in interpreting the cognitive demands of the question. This condition risked obscuring the focus of creativity measurement and reducing the accuracy of interpreting students' responses.

Through the revision process, the wording was clarified by emphasizing that students were asked to devise as many alternative solutions as possible to prevent the ice cream from melting quickly, accompanied by an explanation of the changes in the form or properties of the substances underlying each solution. This clarification made the demands for divergent thinking and conceptual reasoning more explicit, so that the responses produced were expected to better reflect students' thinking flexibility. This refinement was carried out without changing the local cultural context, but by clarifying the problem's focus and the expected cognitive demands. This step is important because the quality of the stimulus has a direct influence on the quality of responses in assessing creative thinking abilities, as well as determining the extent to which the instrument can measure the construct accurately and consistently (Sumintono & Widhiarso, 2015)

Table 1. Revision of Creative Thinking Instrument Items based on Expert Validation Results

Item 4 (Before Revision)	Item 4 (After Revision)
	
Es Cong Lik is a traditional ice cream from Semarang. One challenge with selling Es Cong Lik is that it melts easily in hot weather. If the	Es Cong Lik is a traditional ice cream from Semarang. One challenge with selling Es Cong Lik is that it melts easily in hot weather. If the

Item 4 (Before Revision)	Item 4 (After Revision)
seller cannot keep the ice cream cold, its texture becomes more liquid, mushy, and unpleasant to eat. Imagine you are asked to help the Es Cong Lik seller prevent the ice cream from melting too quickly on a hot day. Design various methods that can be used to make the ice cream last longer before melting. For each method, explain the change in form or change in properties of the substance that makes the method work!	seller cannot keep the ice cream cold, its texture becomes more liquid, mushy, and unpleasant to eat. Imagine you are asked to help the Es Cong Lik seller prevent the ice cream from melting too quickly on a hot day. Design as many ways as possible to make the ice cream last longer before melting. For each method, explain the changes in form or properties of the substance required for the method to work!

The revised instrument was then tested on 175 students and analyzed using Andrich Rating Scale Models to empirically evaluate measurement quality. The analysis showed an item reliability of .98, which is in the exceptional category because it exceeds the .94 threshold. Within the Rasch framework, this very high item reliability value indicates that the estimated item difficulty levels are structurally consistent and stable. In other words, the difficulty hierarchy between items has strong resistance to sample variation, so that the resulting difficulty parameters have the potential to be replicated when the instrument is applied to groups of students with comparable characteristics. These findings confirm that the quality of the instrument at the item level has met the prerequisites for valid and model-based measurement interpretation (Bond & Fox, 2015; Sumintono & Widhiarso, 2015).

In addition to reliability, the empirical quality of the instrument was also reviewed through item fit analysis and item difficulty levels as presented in Table 2. Based on the outfit and infit mean-square values, all items met the Rasch Model criteria of .5 < MNSQ < 1.5, indicating they were fit for the Rasch Model. The absence of misfit items indicates that the students' response patterns align with the model's expectations and that each item consistently measures the construct of creative thinking ability. Thus, there are no items that show measurement distortion or deviant response behavior, so that the instrument empirically meets the model suitability criteria required for further Rasch analysis (Kassiavera et al., 2024; Putri et al., 2024).

Table 2. Summary of Item Analysis According to the Andrich Rating Scale Model

Item Number	Item Fit		Item Difficulty (logit)
	Outfit MNSQ (logit)	Infit MNSQ (logit)	
1	.98	1.04	-.75
2	.86	.81	-.03
3	.71	.77	-.09
4	.74	.79	-.01
5	.91	.95	.19
6	.84	.84	.54
7	.89	.97	.80

In terms of difficulty parameters, the item difficulty values in Table 2 range from −.75 to .80 logit, indicating that all items fall into the moderate difficulty category. This range reflects variations in cognitive demands between items, although it does not include extreme levels of difficulty. This condition shows that the instrument is relatively accessible to most students, allowing them to express their creative ideas without excessive barriers to understanding the questions. However, the concentration of items at a moderate level of difficulty implies that the sensitivity of the measurement of very low and very high abilities is still limited. In line with Meijer & Tendeiro (2017), the distribution of difficulty levels centered on the middle category needs to be interpreted carefully, especially when the instrument is used with a population with a wide range of abilities.

A further evaluation of the scoring category structure was conducted using the Andrich Rating Scale Model, as presented in Table 3. The analysis shows that the average value increases monotonically across response categories, indicating that each category reflects a gradual, sequential increase in creative thinking ability. This pattern shows that students with higher category scores consistently have higher ability estimates than those in lower categories. In addition, the infit and outfit MNSQ values for all categories were below the 1.5 limit, indicating that each category functioned adequately and did not cause measurement distortion within the Rasch Model framework. Thus, the polytomous scoring system used met the basic criteria for response category functionality (Bond & Fox, 2015).

However, analysis of the threshold distances between categories shows that not all threshold differences fall within the ideal range of 1.4–5.0 logits. Some categories, particularly those transitioning from low to medium, have relatively narrow threshold distances, indicating that their boundaries are not yet fully optimal at distinguishing between closely related ability levels. This condition shows that although the category structure has functioned empirically, the scale's stability can still be improved by refining category descriptors or adjusting the scoring rubric to make the differences between response levels more distinct. These findings are in line with previous research emphasizing the importance of adequate threshold distances to improve measurement sensitivity on polytomous scales (Amelia et al., 2023).

Table 3. Categorization of the Andrich Rating Scale Model

Category	Observed Count (%)	Observed Average	INFIT MNSQ	OUTFIT MNSQ	Andrich Threshold	Thresholds between categories (width)
0	200 (14)	-1.33	.70	.64	NONE	
1	83 (6)	-.75	1.01	.88	-.12	Category 0-1 (-.12)
2	197 (14)	-.25	1.15	1.23	-1.50	Category 1-2 (-1.38)
3	496 (35)	.00	.97	.92	-1.15	Category 2-3 (.35)
4	352 (25)	.50	.97	.98	.56	Category 3-4 (1.71)
5	80 (6)	.63	1.46	1.20	2.20	Category 4-5 (1.64)

Overall, the results of the study indicate that the Semarang local culture-based creative thinking ability instrument has good measurement quality, as demonstrated by high content

validity, very strong Rasch reliability, item suitability to the model, and relatively stable response category functions. These findings directly address the issues raised in the introduction regarding the limitations of contextual and empirically tested science creativity assessment instruments. However, this study has limitations, particularly in the distribution of item difficulty levels, which remain concentrated in the intermediate category, and in the limited scope of the trial to one school and one learning material, namely substances and their changes. These limitations affect the instrument's ability to distinguish between students with very low and very high abilities, so generalizing the results needs to be done with caution.

The dominance of items with medium to relatively great difficulty levels indicates that the instrument is more sensitive in measuring the creative thinking abilities of students with medium to high abilities. Consequently, the measurement precision for students with low abilities remains limited because the instrument does not yet fully provide stimuli that capture the variation in responses at that level. Therefore, further development is recommended to increase the variety of item difficulty levels, expand the test context to other science subjects, and test the instrument on a more diverse sample so that students' creative thinking abilities can be mapped more comprehensively and accurately.

CONCLUSION

This study developed an instrument to measure creative thinking skills in the subject sustances and their changes, contextualized through the integration of local Semarang culture, and analyzed using the Rasch Model. Overall, the development and testing process demonstrated that the instrument had a clear conceptual basis, a consistent measurement structure, and adequate empirical support for measuring students' creative thinking skills. Thus, this study confirms that creative thinking skills in science learning can be systematically measured using contextual descriptive instruments without ignoring the complexity of the construct being measured. The existence of this instrument makes an important contribution to strengthening science assessment practices, particularly by providing a measurement tool that better aligns with the demands of 21st-century learning and students' socio-cultural context. The developed instrument can be used by educators to obtain a more comprehensive picture of students' creative thinking abilities and to serve as a foundation for designing more adaptive learning and assessment strategies. However, there is still room for improvement, particularly by expanding the material's scope, equalizing the difficulty of the items, and testing with a more diverse population. These efforts are necessary so that the instrument is not only accurate in a limited context but also has broader utility and scope in measuring creative thinking skills in science.

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