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Integrating Local Wisdom: Innovative Assessment Instrument of Critical Thinking Skills in Science Learning

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ABSTRACT

Purpose- This research aims to develop a valid and reliable instrument for measuring students' critical thinking skills in learning integrated with local wisdom.

Methodology- The research addresses the need for culturally relevant assessment tools that align with modern educational goals and promote the appreciation of local heritage. Employing the ADDIE development model, the study follows a systematic approach encompassing five stages: analysis, design, development, implementation, and evaluation. The sample consisted of 56 seventh-grade students from MTSN 2 Ponorogo.

Findings- The research results show that data collection involved validity and reliability tests to ensure the instrument's effectiveness. Expert evaluations yielded an average validity score of 96%, categorizing the instrument as "very feasible." Reliability analysis using the Quest program revealed that nine out of ten question items achieved INFIT MNSQ scores within the ideal range of 0.71 to 1.40, demonstrating their suitability and alignment with established measurement criteria. However, one item fell outside this range, indicating a need for further refinement.

Significance- The conclusion of this research shows the instrument's potential to assess critical thinking skills while accurately incorporating cultural values. Integrating local wisdom, specifically through educational practices that connect learning to traditional cultural elements, enhances students' critical thinking abilities and fosters an appreciation for cultural heritage. This research is significant for educators, curriculum developers, and policymakers seeking to balance modern pedagogical practices with cultural preservation.

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INTRODUCTION

The progress of a country is highly dependent on its human resources. Therefore, the government's success in building and developing human resources is decisive in improving the country's welfare and progress. However, if efforts to improve human resources are not implemented optimally, various problems in various fields can arise. A strategic step is to build quality human resources supported by a resilient education system relevant to the times' needs (Nwachukwu, 2024; Nwachukwu G.O, 2019). 21st-century education provides a realistic picture of the current conditions as the best learning environment. The idealism in question refers to a representation of the student's experience through the learning process applied today, which prepares them to face future challenges. One of the main goals of 21st-century education is to develop students' critical thinking skills. This approach emphasizes the integration of relevant, real-world contexts into learning, including local wisdom, to ensure students not only acquire essential cognitive skills but also develop a deeper appreciation of their cultural heritage while addressing global (Mohamed, 2021; Sari et al., 2021).

Critical thinking is a deep and reflective way of thinking to analyze situations, evaluate ideas, and draw the correct conclusions in decision-making and problem-solving (Antonio, 2023). Critical thinking skills are thinking about a problem that encourages students to think reflectively through cognitive processes. Based on this presentation, critical thinking skills include a variety of abilities, including effectively conveying reasons, analyzing problems systematically, asking specific questions, solving problems, and reflecting in decision-making (Guamanga et al., 2024). Based on the Program for International Student Assessment (PISA) results, Indonesia achieved a literacy score of 382, ranked 64th out of 65 countries. The questions tested had six levels, with Level 1 being the lowest and Level 6 being the highest. The results show that students' critical thinking skills are still not optimal (Ismawati et al., 2023). The problems identified include: (1) students have difficulty solving problems with high cognitive levels (C4-C6); (2) many students have difficulty connecting concepts with real problems; and (3) many students have difficulty expressing their opinions during discussions (Abdullah et al., 2019). The study by Lodge et al. (2018) also revealed that most students were passive in group assignments, were not proactive in asking learning problems, and few were involved in responding to the problems presented. As a result, students have been unable to provide solutions to their problems (Khusniati et al., 2017; Saleh, 2019).

Developed countries have paid significant attention to the issue of developing critical thinking skills as a strategic step to improve these skills in education (Prayogi et al., 2022). The implication is that every effort and learning process in the classroom must be directed toward achieving critical thinking skills (Verawati et al., 2022). However, most teachers in Indonesia do not clearly understand what critical thinking is and how to integrate it into teaching. In addition, teachers in Indonesia still use traditional teaching methods, such as reading from textbooks, dictating, or writing on the whiteboard while students listen and take notes (Erikson, 2019). The research Septiany (2024) was conducted by 60 students who were tested for critical thinking skills; as many as 30 students were classified as very low. A total of 27 students were in the low category, and only three reached the medium category. No student has managed to reach the high or very high-level category.

Students who think critically can find relevant sources of information, utilize them, and draw conclusions in solving everyday problems (Nasihah et al., 2020). Students' critical thinking skills need to be trained and developed to solve various problems with a critical approach. Students with critical thinking skills are usually confident and try to find and offer the best solutions to their problems (Kusumastuti et al., 2019). Understanding the importance of a learning system that supports the development of students' thinking skills, it is necessary to have a more active learning method that involves students in the learning process, one of which is science learning. Science education is expected to foster students' logical, rational, analytical, and critical thinking skills, thereby supporting the advancement of science and technology (Aditya et al., 2023). Research Baysal (2022) also states that science is a field of science that is obtained through experiments and observations of events in the surrounding environment. Based on experts' opinions, Sciences is a critical process for finding cause-and-effect relationships between various phenomena that occur in the universe and its contents.

The integration of local wisdom is a crucial element in enhancing students' critical thinking skills. One effective way to achieve this is through learning strategies that incorporate local values and traditions, where the problems or questions posed to students are grounded in culturally relevant contexts. Several studies have shown that local wisdom-based learning can improve conceptual understanding and high-level thinking skills by linking learning materials to students' experiences and culture (Khusniati et al., 2017; Muslimahayati, 2020). In addition, research by Suprapto (2021) revealed that this approach can also help students develop reflective and solution-oriented thinking patterns towards problems relevant to their lives. Although various studies have highlighted the importance of critical thinking skills in education, the integration of local wisdom as a strategy to develop these skills has not been explored in depth. In addition, research that discusses the relationship between local wisdom and critical thinking skills is generally still limited to theoretical concepts without any assessment instruments to measure the effectiveness of this approach.

Local wisdom not only functions as additional material in learning but can also be a context that enriches students' critical thinking experiences. According to Khusniati (2017), local wisdom-based learning can help students develop analytical and evaluative thinking skills by linking scientific concepts to cultural phenomena they are familiar with. This approach allows students to analyze and solve problems while fostering a deeper appreciation for Indonesia's rich cultural diversity and heritage. For instance, integrating the process of creating traditional Ponorogo batik into learning activities not only sharpens students' analytical and problem-solving abilities but also instills pride in their cultural heritage, making education both meaningful, engaging, and impactful for long-term development (Muslimahayati, 2020).

Based on the results of interviews with science teachers, it was explained that students still struggle to analyze, evaluate, and formulate solutions to environmental problems. Many students tend to only memorize concepts without being able to relate them to real phenomena around them (Adawiyah et al., 2023). To overcome this problem, this study offers a solution by developing an assessment instrument based on local wisdom that measures critical thinking skills and connects them to cultural contexts familiar to students. Local-based approaches have also been shown to increase student engagement in learning and strengthen the relevance of science to their daily lives (Suprapto et al., 2021).

Based on this background, this study aims to develop and test the validity and reliability of students' critical thinking skills instruments by integrating local wisdom. A valid and reliable instrument is expected to be an effective measuring tool in identifying the level of students' critical thinking skills and strengthening the relationship between learning and meaningful local contexts.

METHODOLOGY

The method employed in this study is Research and Development (R&D), following the model proposed by Dick and Carey (1996). This model, widely recognized in educational research, provides a systematic approach to designing, developing, and evaluating instructional materials. However, in this study, the Dick and Carey model has been adapted and modified to meet the specific needs and objectives of the research. The modifications were implemented to align the research with the unique requirements of measuring critical thinking skills while integrating local wisdom. This integration is particularly focused on the traditional art of Ponorogo batik, which holds cultural significance in the local community.

The primary goal of this study is to develop an innovative learning tool that connects students' understanding of environmental pollution in Sciences with local cultural practices. This approach is intended to enhance students' critical thinking skills by encouraging them to analyze and evaluate environmental issues within the context of their cultural heritage. This research involved 56 grade VII students from MTSN 2 Ponorogo as research subjects. These students served as the subjects for evaluating the effectiveness of the developed instructional materials.

To achieve these objectives, the research methodology involved several stages. First, the research identified specific needs related to environmental pollution and its connection to local wisdom. This stage included analyzing the curriculum, assessing students' prior knowledge, and identifying gaps in their understanding of critical thinking. Based on these findings, the study designed instructional materials

incorporating local wisdom elements, particularly the traditional practices of making Ponorogo batik. These materials were integrated into the subject matter of environmental pollution, offering students a hands-on, culturally relevant learning experience. The flow of this study can be seen in Figure 1.

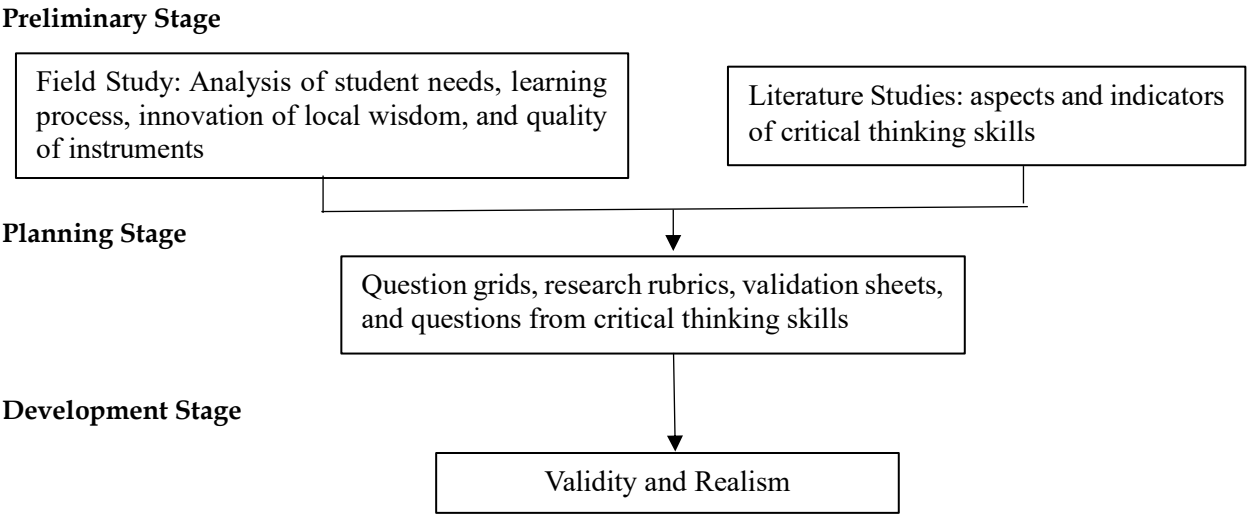

Figure 1. Research Flow

The research methodology employed in this study was carried out systematically through three main stages: the Preliminary Stage, the Planning Stage, and the Development Stage. Each stage played a critical role in ensuring that the instructional materials were academically robust, culturally relevant, and effective in enhancing students' critical thinking skills.

In the Preliminary Stage, the research began with an extensive needs analysis to identify the core issues surrounding teaching environmental pollution in Sciences. This included observing the current teaching methods, reviewing the curriculum, and gathering input from educators and students. Additionally, the researchers conducted a literature review to explore the integration of local wisdom, explicitly focusing on the traditional art of Ponorogo batik as a context for learning. This stage also involved initial data collection through interviews and questionnaires to assess students' baseline knowledge and attitudes toward environmental issues and their critical thinking ability.

The next step, the Planning Stage, involved translating the findings from the preliminary analysis into a detailed design framework for the instructional materials. The researchers set specific learning objectives to foster critical thinking while promoting cultural awareness. This stage also included designing a prototype for the instructional materials, which incorporated activities such as analyzing the environmental impact of traditional batik-making processes and proposing sustainable solutions. The researchers developed assessment tools, including rubrics and tests, to evaluate students' progress in critical thinking and their understanding of environmental concepts.

Finally, the instructional materials were constructed and iteratively refined in the Development Stage. This stage began with creating the prototype, which was tested in a limited trial involving a small group of students. The feedback from this trial was used to identify areas for improvement, such as simplifying complex instructions or adding more examples to link scientific concepts with cultural practices. After revisions, the materials were tested on a larger scale with the full sample of 56 seventh-grade students from MTSN 2 Ponorogo. The results of this field test were analyzed to measure the effectiveness of the materials in achieving the research objectives. Expert validation was also conducted during this stage, involving subject matter experts and educators who provided input on the materials' content accuracy, instructional design, and cultural relevance.

The systematic flow of these stages is visualized in Figure 1, which outlines the iterative process of designing, testing, and refining the instructional materials. This figure highlights how each step contributes to achieving the research goals, from identifying initial needs to producing a final product that integrates critical

thinking and local wisdom. The seamless integration of cultural practices, such as Ponorogo batik, into the curriculum, enhances students' critical thinking skills and fosters a deeper appreciation for their cultural heritage, ultimately creating a more holistic and meaningful learning experience.

This flow is designed to ensure that the resulting instruments meet the criteria of validity and reliability and are suitable for use in learning.

FINDINGS

The stage of developing instruments to measure critical thinking skills integrated with local batik wisdom begins with a comprehensive needs analysis. This foundational stage is crucial to ensure that the developed instruments are relevant, effective, and aligned with the research objectives. The needs analysis involves multiple steps, starting with identifying clear learning objectives that reflect the integration of critical thinking and cultural heritage. It also includes examining student characteristics, such as age, cognitive development, and familiarity with critical thinking concepts and the traditional art of batik. Additionally, this stage addresses the specific assessment needs required to accurately evaluate students' critical thinking skills while embedding local wisdom elements.

To ensure the instruments are grounded in established theoretical frameworks, the analysis is based on theories from experts in critical thinking, including Facione (2011), Fisher (2011), and Emily R. Lai (2011). These theories are synthesized into five core indicators of critical thinking skills: interpretation, which involves understanding and categorizing information; analysis, the ability to break down information and identify its components; evaluation, which focuses on assessing the credibility and relevance of information; conclusion, involving logical reasoning and decision-making; and explanation, the capacity to communicate reasoning effectively. These indicators serve as the foundation for designing assessment tools that are academically rigorous and culturally relevant.

The next stage is the development of instrument products, which includes the preparation of question grids, assessment rubrics, validation sheets, and essay questions to measure critical thinking skills integrated with local batik wisdom. Each question item is arranged based on indicators of critical thinking skills that have been determined with the content of batik local wisdom that refers to the cognitive level in Bloom's taxonomy, namely C4 (analysis), C5 (evaluation), and C6 (creation). The selection of this level is based on the need to develop student's critical thinking skills so that they not only understand the concept of environmental pollution but can also relate it to the social, cultural, and economic contexts around them. This instrument is designed to cover aspects of critical thinking skills, such as clarity of meaning (interpretation), testing of ideas and arguments (analysis), evaluation of the quality of arguments (evaluation), making logical conclusions (conclusions), and delivering results systematically (explanation). The preparation of this instrument is based on local wisdom, especially the process of making batik, which is relevant to materials for environmental pollution. The content in the instrument is designed to reflect aspects of the process of making Ponorogo batik, including its potential impact on the environment, so that it is in harmony with the theme of environmental pollution. The matrix of the critical thinking skills instrument with the integration of local wisdom is presented in Table 1.

Table 1. Instrument Matrix

Indicators of Critical Thinking Skills	Question	Bloom's Taxonomy
Interpretation, Inference	Identifying human activities that cause changes in the environment in the process of making batik	C4
Analysis	Explain the various impacts of environmental pollution on the batik-making process.	C4
Evaluation	Explain efforts or solutions from environmental pollution in the batik-making process.	C5
Explanation	Explain the various impacts of environmental pollution on the batik-making process.	C6

Later, in developing the scoring rubric for this instrument, the steps taken refer to the principles put forward by Wolf & Stevens (2007) and are adjusted to the needs. This rubric assesses students' critical thinking skills through 10 essay questions. Scoring is carried out based on the correctness of the answers and the reasons given by the students. A score of 4 is given if the answers and reasons are correct, reflecting a deep and comprehensive understanding. For example, if asked about the impact of batik waste on aquatic ecosystems, an answer that scores four must include an explanation of how synthetic dyes' chemicals can disrupt the ecosystem's balance, reduce oxygen levels in the water, and affect the food chain. A score of 3 is given if the answer and the reason are also correct but it is less specific or not detailed enough. For example, students answered that batik waste can pollute water and damage ecosystems without mentioning the chemicals that play a role or the scientific impact (Eva Ervia et al., 2024). A score of 2 is given in two conditions: first, if the answer is correct but the reason given is wrong, and second, if the answer is wrong but the reason given is correct, which indicates the existence of thoughts despite errors in the answer. For example, students answer that batik waste pollutes water but argue that natural dyes are more dangerous than synthetic dyes without supporting scientific evidence. Second, suppose the answer is wrong, but the reason is correct. In that case, students state that batik waste does not pollute water but correctly explains how chemicals can react with the environment. A score of 1 is given if the answer and the reason are wrong, even though the student responds. This scoring rubric aims to provide an accurate, objective, and reliable assessment of students' critical thinking skills and ensure that the assessment covers the key aspects of critical thinking skills.

After the instrument is developed, valid experts validate it to ensure its feasibility. This validation includes content validity tests to assess the suitability of indicators with question items and ability tests to measure instrument consistency. This validation is carried out by experts in the field of education, especially those who possess competent critical thinking skills.

The results of the validation test of learning instruments conducted by two experts showed an average of 96%, which was in the very feasible category. This assessment reflects a high level of conformity between the items in the instrument and the indicators that have been formulated, both in terms of content relevance and the integration of the instrument structure.

The next step in this study is to conduct a reliability test on the test questions to ensure the instrument's consistency in measuring the variables studied. The data obtained from the instrument test results were then analyzed in depth using Quest. The results of the reliability analysis are presented in Figure 2**.**

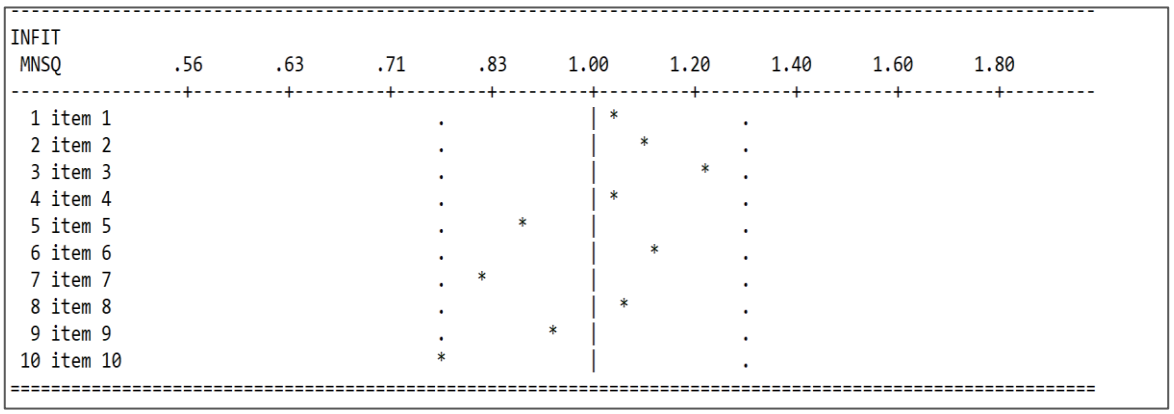

Figure 2. Reliability Analysis

The analysis results show that nine items fit questions with the Rasch model, indicating that most questions consistently measure students' abilities according to the variables studied. However, item number 10 does not fit because the difficulty level of the question is too high or the question statement is ambiguous, thus affecting the student's response. For example, the question may contain terminology that is unfamiliar to students, has unclear context, or requires more complex thinking skills than other items. In addition, the question structure or answer choices may not fully align with students' level of understanding, potentially leading to incorrect answers. These findings are based on Rasch's measurement theory, which states that the

ideal instrument should have an INFIT MNSQ value in the ideal range (0.71 to 1.40) to ensure measurement consistency.

DISCUSSION

Based on the research and development steps carried out, the final product is a set of critical thinking skills instruments for students that are integrated with local wisdom. The success of this product is measured through validity and reliability tests that show the consistency and suitability of the instrument in measuring the variables studied.

Critical thinking can be interpreted as an integrated process in which a person can evaluate various elements such as evidence, assumptions, logic, and the language that underlies the thoughts of others. This process involves the ability to understand information and includes attitudes and skills in giving reasons verbally, analyzing existing arguments, and thinking about potential hypotheses. In addition, critical thinking also involves the ability to consider possibilities and uncertainties and make informed decisions in solving the problems at hand (Andreucci et al., 2023).

In further study, various methods can be used to develop this critical thinking ability. One is an explicit approach, where critical thinking is taught directly to students. On the other hand, critical thinking skills should be integrated into specific subjects so that students can apply them in a broader context. Effective learning strategies to hone critical thinking skills include various activities, such as argumentative discussions, peer assessment, concept mapping, and contextual learning based on real problems. Through these instruments, the primary focus is on analytical skills, argument evaluation, and logical decision-making. All of this is in line with the goals of 21st-century learning, where students are expected to have knowledge and qualified critical thinking skills to face future challenges (Fitriah, 2022).

Integrating local wisdom in learning tools provides a valuable opportunity for students to elaborate and improve their critical thinking skills. In the face of increasingly complex challenges brought about by globalization, there is a growing need to preserve and maintain the values of local wisdom by incorporating them into science and education. This approach ensures that cultural heritage remains relevant in modern contexts while fostering deeper learning outcomes. By embedding local wisdom into the learning process, students gain a better understanding of the material being taught and experience a richer and more meaningful learning journey. Including cultural context makes the learning process more relatable, engaging, and impactful (Hunaepi et al., 2020).

Using science learning tools based on local wisdom, each step in the learning process is carefully designed to encourage students to think critically. This is achieved by presenting them with real-world problems or cases that require analytical thinking, evaluation, and problem-solving. For instance, students might analyze the environmental impact of traditional practices such as batik-making, which allows them to connect scientific concepts with cultural practices. Studies have shown that this case-based learning approach is highly effective in fostering critical thinking skills. It engages students actively, helping them solve problems and apply their knowledge in real-life situations, thus bridging the gap between theoretical learning and practical application (Suprapto et al., 2021).

In addition to enhancing critical thinking, this approach aligns with the goals of 21st-century education, which emphasizes the development of skills such as problem-solving, creativity, and adaptability. Research conducted by Ridho (2021) reinforces the idea that learning tools integrated with local wisdom are valid and well-received by both teachers and students and are highly effective in improving critical thinking abilities. Students find the content more relevant and practical by contextualizing learning materials within familiar local settings. This relevancy motivates them to engage actively with the learning process, as they see a direct connection between their cultural heritage and the subject matter.

Moreover, integrating local wisdom into the curriculum fosters a sense of identity and pride in students. It helps them appreciate their cultural heritage while preparing them to face global challenges. For example, by studying the environmental impact of traditional practices such as Ponorogo batik-making, students learn to analyze its effects on ecosystems, evaluate the sustainability of these practices, and propose innovative

solutions. These activities promote critical thinking and encourage students to become environmentally conscious and culturally aware. In conclusion, integrating local wisdom into learning tools is a powerful strategy for enhancing critical thinking skills. It provides a culturally enriched educational experience, prepares students to address real-world challenges, and ensures that the values of local wisdom are preserved and passed on to future generations.

Local wisdom-based learning can be practically applied in the classroom by integrating activities that challenge students to think critically and solve real problems, for example, by analyzing videos and case studies on pollution caused by batik waste. After that, they can discuss in groups to identify the type of pollution that occurs, evaluate the methods used to overcome the problem, and design solutions based on local wisdom, such as using natural dyes or more environmentally friendly waste processing systems. In addition, the application of this instrument in 21st-century education also has the potential to be applied on a broader scale as a local-based learning model that can be developed for various subjects. By adopting this approach, other regions can integrate their local wisdom into the curriculum to improve student's critical thinking skills through more relevant and meaningful contexts. Suppose this local wisdom-based learning model improves students' critical thinking skills. In that case, it can be further developed through education policies, teacher training, and collaboration with local communities to be applied more widely at various levels of education.

The novelty discovered in this study, namely the development of critical thinking skills assessment instruments based on local wisdom, directly contributes to solving the problems identified in the introduction. By integrating local wisdom into the assessment instrument, this study not only helps students understand the concept of environmental pollution more contextually but also trains them to think critically in solving problems based on the reality around them.

CONCLUSION

They show excellent quality based on the analysis of the validity and reliability of critical thinking skills integrated with local wisdom. Validation by two experts resulted in an average rating of 96%, which is classified as very feasible, and the results of the analysis using Quest nine out of ten question items showed an INFIT MNSQ score in the ideal range (0.71 to 1.40), while item number 10 was outside that range. The questions may use terminology that is less familiar to students and have unclear context. Revisions can be made by simplifying the language used and adjusting the difficulty level to align with other items in the instrument. Thus, the tested instruments are valid and reliable in improving students' critical thinking skills after application, especially in learning that integrates local wisdom.

Teachers can adapt this instrument to other relevant materials, such as environmental pollution due to local industries. This approach can be applied more broadly to improve students' critical thinking skills in various learning environments.

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