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Analysis of Students' Critical Thinking Skills in Solving Ethnomathematics Problems

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Abstract

Mathematics has an important role in the development of critical and logical thinking skills. However, the results of the PISA survey show that the mathematical literacy of students in Indonesia is still low. One approach that can be applied to improve critical thinking skills in mathematics learning is ethnomathematics. Ethnomathematics connects mathematical concepts with cultural elements, thus making learning more contextual and engaging. This study aims to analyze students' critical thinking skills in solving ethnomathematics problems. Based on the results of observations and interviews, it was found that most students still tend to memorize without understanding or critically analyzing information. The implementation of ethnomathematics in learning is expected to help students understand that mathematics is not only abstract but also related to daily life and culture. This study highlights the importance of the application of ethnomathematics in improving mathematical literacy and critical thinking of students, by taking the example of a tobacco warehouse in Jember Regency as one of the cultural objects that can be integrated in mathematics learning.

Keywords: Ethnomathematics, critical thinking, mathematical literacy, contextual learning, mathematics and culture

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INTRODUCTION

Mathematics education provides basic knowledge and skills, which help students' intellectual development (Skovsmose, 2020). With regard to proper grammar and rules, the definition and proof of mathematics as a form of formal system. Avigad, (2024), explains that mathematics is an agreed representation of systems, symbols, rules, and grammar. In contemporary technological advancements, mathematics serves as a universal science because it can be applied in a variety of other fields of science, such as natural sciences, engineering, medicine, medical, and social sciences, such as economics and psychology (Wahyuni, S., & Kusaeri, 2024). This requires the next generation to learn mathematics and get used to mathematical literacy. Mathematics has a role in the formation of reasoning, creative, logical and critical thinking skills.PISA survey results (Programme for international student assessment) in 2018 got a score of 379, but in 2022 the result dropped by 13 points, getting a score of 366. These results show that students in Indonesia are still less than the average of the survey participants in terms of mathematical literacy (Farah et al., 2024). The empirical data shows that students in Indonesia have mathematical literacy skills that are less than average. There are still many students who are not able to think critically in mathematics learning, students are more likely to memorize so they are not able to analyze information or existing problems.

PISA survey results (Programme for international student assessment) in 2018 got a score of 379, but in 2022 the result dropped by 13 points, getting a score of 366. These results show that students in Indonesia are still less than the average of the survey participants in terms of mathematical literacy (Farah et al., 2024). The empirical data shows that students in Indonesia have mathematical literacy skills that are less than average. There are still many students who are not able to think critically in mathematics learning, students are more likely to memorize so they are not able to analyze information or existing problems.

Thinking ability is one of the abilities that every individual has in an effort to find an answer or solve a problem (Pratama & Mardiani, 2022). The thinking ability that needs to be used and honed by every individual is the ability to think critically. One of the most important skills in the 21st century where the flow of information is very dynamic, is the ability to think critically (Wahyuni, S., & Kusaeri, 2024). Critical thinking skills are very important because there is a possibility of getting information from various sources that sometimes cannot be guaranteed to be true. With critical thinking skills, a person will be more likely to seek the truth, be very curious, be able to analyze problems well, and think systematically.

Critical thinking is expected to help improve low math literacy. Improving students' ability to think critically is a very important goal in an ever-changing educational environment. The entry of technology into educational practices can be used as an opportunity to build innovative learning models that focus on improving critical skills (Schultz, P., et al., 2024). Students who learn mathematics not only have numeracy skills, but they also need to be able to think critically and use these skills to complete tasks and learn new concepts that they will encounter in the future (Janah et al., 2019). Wahyuni, S., & Kusaeri (2024) stated that there are four indicators of critical thinking skills that will be used, namely, interpretation, analysis, evaluation, and inference.

Based on the results of initial observations and interviews conducted by the researcher with the informant, namely one of the mathematics teachers at Nurul Wafa Junior High School, it showed that almost all students in grade VIII were not able to analyze and develop the knowledge provided by their teachers. They only have the ability to memorize and recall the information. However, not with the ability to critically analyze problems. One way of critical thinking is to analyze and develop the information provided by the teacher. Thus, this study aims to describe and analyze how students' critical thinking skills in solving ethnomathematics problems.

Learning whose orientation is related to mathematics and culture is referred to as ethnomathematics. Ethnomathematics is a field that investigates how mathematical concepts or practices are used in various cultural activities that demonstrate the relationship between mathematics and culture (Akbar et al., 2024). D'Ambrosio describes ethnomathematics as the art or technique of understanding mathematics in its various sociocultural manifestations and mathematical knowledge that grows and develops and adapts to the culture of a country (Pradana et al., 2022). Ethnomathematics can be applied to students in learning so that there is an understanding that mathematics can be applied and practiced to a cultural element.

In essence, mathematics is a symbolic technique developed in cultural skills or environmental activities (Wahyuni, S., & Kusaeri, 2024). A person's cultural background has an impact on their mathematical patterns, as what they do is based on what they see and hear. Mathematics learning based on ethnomathematics has several effects, such as: 1. making mathematics learning fun and contextual; 2. changing the view that mathematics is difficult to become more fun and relevant to all life activities; 3. increase awareness of one's own culture and the culture of others; and 4. be part of a regular effort to preserve culture, starting with the educators themselves (Soebagyo & Haya, 2023).

In Indonesian culture, there are many elements that are part of the culture, both buildings and other objects, which contain the concept of building flat and building space. One of the cultures in Jember Regency, East Java is the warehouse or tobacco house. A tobacco warehouse

is a building used to store the harvest of tobacco leaves (Akbar et al., 2024). Tobacco warehouses have their own uniqueness when viewed in terms of the shape of the building. Each element of a tobacco warehouse building has a shape related to mathematical concepts. Such as the concept of geometry building space, flat building, lines, number patterns, angles, and so on. So, this can be a mathematics learning material for students based on ethnomathematics using critical thinking skills.

Research on ethnomathematics has shown its potential in improving students' mathematical understanding. However, there is still little research that focuses on the analysis of students' critical thinking skills in the context of ethnomathematics, especially on geometry materials. This research aims to fill this gap by analyzing students' critical thinking skills in solving ethnomathematical problems based on tobacco warehouses in Jember.

METHOD

Design and Research Subjects

This research is a descriptive research with a qualitative method. Descriptive research is a type of research that aims to obtain an objective and clear scientific understanding of the situation (Masyhud, 2021). Research with qualitative methods is research that emphasizes more on the aspect of an in-depth understanding of a problem than looking at the research problem as a whole (Masyhud, 2021). The qualitative descriptive method aims to analyze students' critical thinking skills in solving ethnomathematical problems. Ethnomathematics in the study took the Gayasan Jember tobacco warehouse as the topic of the problem. This research was conducted at SMP Plus Nurul Wafa which is located in Krajan Hamlet, Tamansari Village, Mumbulsari District, Jember. The subjects of this research are as many as 3 out of 30 students of SMP Plus Nurul Wafa who represent the high, medium, and low problem solving categories.

Participants

Subedi (2021) states that in a qualitative narrative, a sample size between 1–20 participants can be justified, depending on the depth of information required and the context of the study.The research subjects were selected using purposive sampling, aiming to obtain rich information from representative cases in each category of critical thinking skills (high, medium, low). Inclusion criteria include: grade VIII students at the school where the research is located, taking a complete ethnomathematics test and interview, having a stable attendance, and giving consent to participation. Exclusion criteria: students who are absent or have incomplete answers. Of the 30 students, the scores of the Mathematical Ability Test (TKM) were used to categorize: 80–100 (high), 60–79 (medium), 0–59 (low). From each category, one subject was selected that met the criteria to be analyzed in depth through tests–interviews–observations. This strategy is consistent with a qualitative descriptive design and supports in-depth analysis rather than statistical generalization.

Instrument Lineup

The preparation of test instruments to measure the level of students' ability requires a clear instrument design and in accordance with the reference of the indicators that have been adjusted. The design of the instrument in this study is as follows:

Table 1. Instrument Design

No.	Critical Thinking Indicators	Sample Questions
1.	Interpretation	1. Identify any flat shapes that appear in the picture! 2. What is ABC called flat build?
2.	Analysis	1. Sketch a line by giving it a symbol or number! 2. If BC = 10 m, AC = 16 m, What is the height B cutting right at the AC line? (Use triple Pythagoras)

3.	Evaluation	1. Calculate the circumference of the ABCD rectangle!! Description: Length = 2 times width 2. Find the angle formed between figure 1 and figure 2!
4.	Inference	1. The area of a rectangle shown in the picture is 2 m². Determine the area of the ABCD rectangle! 2. What is the name of the angle formed and how big is the angle?

Data Collection Techniques

The data collection techniques in this study are interview, observation and documentation techniques. The interview technique is a data research technique used to collect subjective data related to the opinions, behaviors and attitudes of the interviewees on a phenomenon being researched (Hansen, 2020). The interview technique is used to strengthen the test results given to the informant, the researcher can conclude the data obtained later. Observation techniques are the systematic observation process of human activities and the continuous physical regulation of natural activities (Hasanah, 2017). Observations made by the researcher are in the form of a cultural-based mathematical question test (ethnomathematics) that will be tested on the research subject.

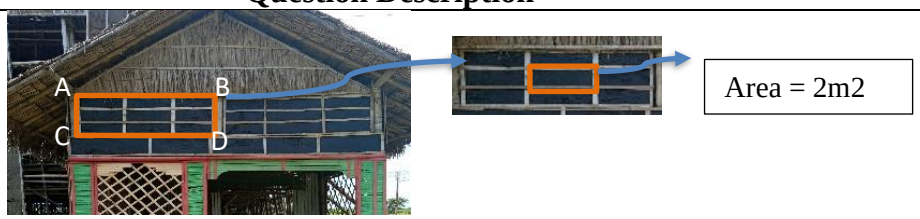
In collecting data, the researcher used primary sources. Primary sources are data obtained directly from respondents about the case or problem they are interviewed (Yusri, 2020). The data that will be collected by the researcher will use technical tests and interviews. The test that will be used is in the form of description questions with flat building materials in the Gayasan Jember tobacco warehouse building. The following are the test instruments that will be used in the research:

Table 2. Test Instruments

No	Question Description
	Build Flat
	Take a look at the photo below of the Tobacco Store! For questions number 1 and 2.

Picture 1. Wuwung Tobacco Warehouse

1	Identify any flat shapes that appear in the picture!
2	Sketch a line by giving it a symbol or number!
	Take a look at the photo below of the Tobacco Store! For questions number 3 and 4

No	Question Description
	 **Picture 2. ABCD Rectangle on Wuwung**
3	The area of a rectangle shown in the picture is 2 m². Determine the area of the ABCD rectangle!
4	Calculate the circumference of the ABCD Rectangle!! Description: Length = 2 times width
	Take a look at the following picture of the roof of the tobacco warehouse! For questions 5 and 6  **Picture 3. Tobacco Warehouse Roof**
5	What is ABC called flat build?
6	If BC = 10 m AC = 16 m What is the height B that cuts right on the AC line? (Use triple pytagoras)
	Corner
	Take a look at the picture below! For questions 7 and 8  **Picture 4. Tobacco Warehouse Drain Side**
7	Find the angle formed between figure 1 and figure 2!
8	What is the name of the angle formed and how big is the angle?

Data Analysis Techniques

Data analysis is carried out so that the information and research results obtained are easy to understand and valid. The researcher analyzed the data using the data analysis technique of the Miles and Huberman method (in Sri Annisa & Mailani, 2023). The steps that must be taken are data reduction, data presentation, and drawing conclusions. *First*, data reduction requires the ability of researchers to think sensitively, have the highest intelligence, breadth,

and depth of insight (Wahyuni, S., & Kusaeri, 2024). Researchers can carry out activities using data reduction independently to get data from the answers to the questions that the researcher prepares. The research subjects were selected using *Nonprobability Sampling* technique *purposive sampling*, which means subjects are sorted by highest to lowest scores. Next, the subjects were divided into three groups: the high group, the medium group, and the low group.

Second, the presentation of descriptive data is the result of the reduction of the data used in the research (Akbar et al., 2024). At the presentation stage, the data collected for the research is categorized into groups that are systematically related to the focus of the research and to facilitate conclusion making. The results of the subject's work and the findings of the interview are then analyzed to identify errors and their causes, so as to answer the research problem. The presentation of data uses narrative stories, which is an elaboration of how to think critically in solving ethnomathematical problems.

Third, the conclusion was drawn by analyzing the results of the answers to the test questions and the results of interviews with the respondents. The researcher will compare and adjust to the indicators of critical thinking so that the researcher can draw a conclusion. The classification of students' mathematical ability level is shown in Table 2 as follows (Wahyuni, S., & Kusaeri, 2024):

Table 3. Classification of Mathematical Ability Level

Yes	TKM Score	Information
1.	80 – 100	Tall
2.	60 – 79	Keep
3.	0 – 59	Low

Classification of scores Mathematical ability level in Table 3. used as a reference for researchers in grouping the results of the respondents' answers. The researcher used critical thinking ability indicators to describe the abilities of grade VIII students of Nurul Wafa Junior High School. The following are indicators of critical thinking skills (Rohim & Rofiki, 2024):

Table 4. Critical Thinking Indicators

Yes	**Indicators**	**Indicator Description**
1.	Interpretation	Students are able to understand/write down the information known in the question. Able to write/communicate the data asked correctly.
2.	Analysis	Able to make models of problems appropriately. Able to plan the right strategy, according to the problems faced.
3.	Evaluation	Able to calculate accurately. Able to solve problems correctly.
4.	Inference	Able to give reasons for the answers given.

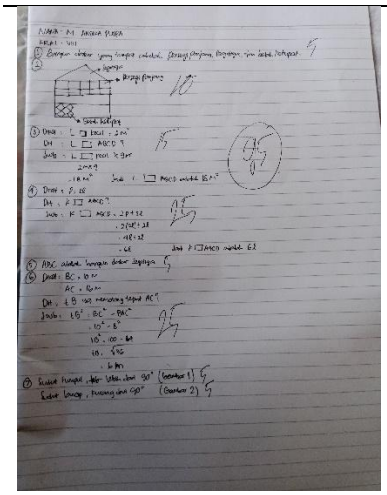
RESULTS AND DISCUSSION

The results of the critical thinking ability research carried out in grade VIII at Nurul Wafa Junior High School, found a group of subjects with different levels of students' abilities. From the test results, three levels of students' abilities were obtained in the high, medium, and low categories. Subjects with high ability had a test score between 80-100, a student with moderate ability had a test score ranging from 60-70, and research subjects with low ability had a score of 0-59. The researcher will describe the results of the test and research in detail as follows.

Subject Category High Ability

The results of the completion of test questions in the research subjects with a high category were represented by MAP who obtained a score of 95. Table 5 describe the results obtained. Of all the questions, MAP was able to answer all questions correctly. In answer number 6 there is a slight reduction in the score because there is a series of missed answers, but overall MAP has answered systematically. MAP meets all critical thinking indicators. MAPs with high ability categories can understand the problems in the questions, write the answers correctly, and be able to make conclusions related to the existing problems.

Table 5 MAP Completion Results

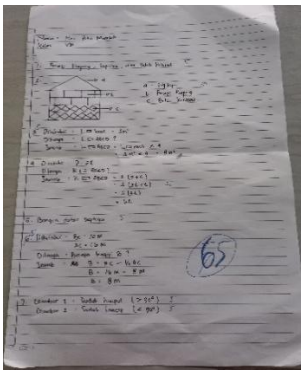
Solution Overview	Interview Results	Description of Critical Thinking Indicators
	Q: How do you understand the problem in each of these questions? MAP: I understand it by reading the questions one by one repeatedly and trying to understand what is instructed in each question Q: What information do you know from questions 1-7? MAP: In questions 1, 2, 5, and 7, it is asked to determine what geometric elements and angles are found in the tobacco warehouse. In questions 3, 4, and 6, they are asked to calculate the area, circumference, and height of a predetermined geometric shape. Q: What did you do to solve the problem? MAP: I pay attention to each question, pay attention to the commands, pay attention to the pictures, and work on the questions. For question numbers 3, 4 and 6 I need to calculate using the correct formula. Q: What are the next steps to solve the problem? MAP: In question numbers 1, 2, 5, and 7 I looked at the drawings one by one and answered the geometric elements that were asked. In question numbers 3, 4, and 6, the formula of rectangular area, rectangular circumference, and Pythagorean is used.	MAP can be said to be able to answer by understanding the information provided in the question. Analyze the problem and model solve the problem appropriately. Able to calculate accurately. Able to give reasons for what MAP wrote.

Subject Category Medium Ability

The results of the completion of test questions in the research subjects with a high category were represented by MPM who obtained a score of 65. Table 6 describe the results obtained. Of the 7 questions that existed, MPM subjects were able to answer 5 questions

correctly and in detail, namely in question numbers 1, 2, 4, 5, and 7. The questions in numbers 3 and 6 of the MPM answers are not correct, but they have answered by including steps and according to the instructions stated in the question. MPM meets 3 out of 4 critical thinking indicators. MPM with the medium ability category can understand the problems in the question and write down the intent of the command in the question.

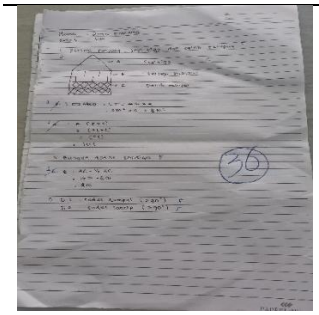
Table 6 MPM Completion Results

Solution Overview	Interview Results	Description of Critical Thinking Indicators
	Q: How do you understand the problem in each of these questions? MPM: I understand the questions by reading the questions carefully, and trying to answer each question. Q: What information do you know from questions 1-7? MPM: In questions 1, 2, 5, and 7, it asks to identify the geometric elements and angles shown in the image of the tobacco warehouse. In questions numbers 3, 4, and 6, they are asked to calculate the area, circumference, and height. Q: What did you do to solve the problem? MPM: I started by understanding the meaning of the question, then I paid attention to every detail of the picture given. After that, I look for a suitable concept or formula to solve the problem Q: What are the next steps to solve the problem? MPM: In questions 1, 2, 5, and 7, I identified the geometric elements based on the available drawings. In question number 4, I calculated the circumference by adding up all the sides of the rectangle.	MPM is able to answer by using the information provided in the question. Analyze the problem and the right solution model, and be able to provide the reasons for the answers that have been given.

Subject Low Ability Category

The results of the completion of test questions on the research subjects with a high category were represented by DP who obtained a score of 36. Table 7 will describe the results obtained. Of the 7 questions that existed, the DP subjects were able to answer 4 questions correctly, namely on question numbers 1, 2, 5, and 7. In question numbers 3, 4, and 6, the DP has not been able to answer the question correctly. The questions on the number require a more critical analysis. The results of the DP answer show that they have met 2 out of 4 critical thinking indicators. DP with a low ability category can understand the instructions given and do 4 out of 7 questions correctly.

Table 7 DP Settlement Results

Solution Overview	Interview Results	Description of Critical Thinking Indicators
	Q: How do you understand the problem in each of these questions? DP: By reading the questions carefully and understanding the commands given. Q: What information do you know from questions 1-7? DP: Questions 1, 2, 5, and 7 relate to geometric elements and angles in a tobacco warehouse Q: What did you do to solve the problem? DP: Understand the problem, look at the picture, and use the appropriate formula to complete the calculation Q: What are the next steps to solve the problem? DP: Identify the geometric elements for questions 1, 2, 5, and 7,	DP is able to find information in images, digest the information presented, reinforced by the answers that appear in the images.

DISCUSSION

The results showed that subjects with high, medium, and low abilities tended to have indicators of critical thinking. First, subjects with high abilities can correctly identify and communicate known and queried data. They are able to build a model of the problem appropriately, design an appropriate solution strategy, calculate correctly, and provide a clear reason for each answer. Second, subjects with moderate ability can also identify and communicate data correctly. They are able to devise appropriate solution strategies, but still experience errors in solving problems and difficulties in drawing conclusions. Third, subjects with low ability can communicate data that is known and questioned, but are not able to design problems appropriately. They are also unable to implement appropriate solution strategies, often provide inappropriate answers, and have difficulty drawing conclusions from the problems they face.

The results of this study confirm that ethnomathematics plays an important role in fostering students' critical thinking skills. Subjects with high categories showed the ability to connect information with solution strategies, while medium and low subjects still faced difficulties at the evaluation and inference stages. These findings are in line with international research by Rosa & Orey (2016), which states that ethnomathematics provides an authentic context to develop conceptual understanding while training students to think critically. In addition, Barton (2021) emphasizes that integrating cultural context in mathematics learning can enrich students' reflection processes as well as help them develop more meaningful problem-solving strategies. These results are also strengthened by the research of Fernandes et al. (2020), who found that culture-based mathematics learning improves students' ability to analyze, evaluate, and build logical mathematical arguments. Ethnomathematics-based mathematics learning is highly recommended because it can improve students' critical thinking skills. In solving problems, students follow systematic resolution stages, which helps them

analyze problems and recognize patterns, which ultimately allows them to solve problems more precisely. This is in line with the research of Martyanti & Suhartini (2018), which states that the ethnomathematical approach in mathematics learning can develop students' critical thinking skills, especially in solving problems related to daily life and culture. In addition, Indriani et al. (2024) also argue that the development of ethnomathematics modules (based on Jam Gadang architecture) has proven to be effective in improving students' critical thinking skills in flat building materials. Students follow logical and systematic problem-solving steps, so as to understand patterns and concepts in depth.

The limitation of this study lies in the limited number of subjects, i.e. only three students with different skill levels, as well as a specific focus on local contexts. Therefore, the results of this study are not intended to be generalized to a wider population, but rather to provide an in-depth and contextual understanding of students' critical thinking processes in culture-based mathematics learning. The qualitative descriptive approach used, with purposive selection of subjects and multi-layered data collection, shows the efforts of researchers in exploring data thoroughly albeit on a limited scale. The practical implications of this research lead to the need for an active role of teachers in accompanying students' critical thinking processes**.** Teachers can ask questions that encourage students to make inferences and evaluate the solutions they create. In addition, teachers need to provide appropriate *scaffolding* at the evaluation and conclusion stages, especially for students with medium and low abilities, so that they can formulate arguments and make decisions based on logical reasons. Thus, the results of this study not only contribute to the development of ethnomathematical literature, but also provide a practical picture for teachers in designing mathematics learning that is contextual, meaningful, and able to develop students' critical thinking skills gradually.

CONCLUSION

Based on the results of the study, it was found that students' critical thinking skills in solving ethnomathematics problems varied according to the level of ability of each individual. Subjects with high abilities are able to understand and communicate information correctly, build appropriate problem models, and provide logical reasons for solving problems. Moderately capable subjects can recognize problems and devise solution strategies, but still have difficulty drawing conclusions. Meanwhile, subjects with low abilities still face difficulties in implementing problem-solving strategies and have not been able to draw conclusions properly. The research findings support the potential of ethnomathematical tasks as a means to generate and develop students' critical thinking behaviors. By integrating cultural elements in math problems, students are encouraged to not only complete calculations, but also understand context, interpret information, and formulate logical reasoning. These kinds of tasks facilitate students in conducting the analysis, evaluation, and conclusion drawing which is a core part of critical thinking.

Ethnomathematics-based mathematics learning has proven to be effective in creating contextual, engaging, and meaningful learning experiences. By connecting mathematical concepts with local cultures, students not only improve critical thinking skills, but also develop mathematical literacy that is relevant to their real lives. The practical implications of these findings are the importance of designing ethnomathematical problems tailored to the types of items that drive high-level thinking processes, such as problems that demand reasoning, context interpretation, and argument formation.

In addition, a structured scaffolding strategy is needed, especially at the evaluation and conclusion preparation stages, to help students with medium and low abilities to be able to develop critical thinking processes gradually. Thus, ethnomathematics-based learning not only enhances students' critical thinking skills, but also connects mathematics to real life and local culture. This emphasizes that this strategy is relevant to be applied in schools, especially in the context of low mathematical literacy in Indonesia.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Eric Dwi Putra (Corresponding Author)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Ahmad Maulana Akbar	✓	✓	✓	✓	✓	✓		✓		✓				

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no known financial or personal conflict of interest that could have influenced the work reported in this paper.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author, Eric Dwi Putra, upon reasonable request.The raw data are not publicly available as they contain information that could reveal the identity of research participants (students) and confidential interview materials. However, derived anonymized data (behavioral codes, observation transcripts, and critical thinking analysis sheets) may be shared upon reasonable request for verification or further research purposes.

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