Madura Batik Ethnomatematics: Mathematical Reasoning in Plane Figures

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Abstract

The ethnomathematics approach can simplify mathematical reasoning for students while introducing cultural knowledge. Mathematical concepts in culture are discovered through mathematical reasoning. This research is important to conduct because Madurese batik motifs contain the concept of flat shapes and mathematical reasoning which have the potential to become a source of contextual mathematics learning based on local culture.The purpose of this study is to describe students' mathematical reasoning in Madurese batik ethnomathematics, particularly in plane geometry, through mathematical reasoning indicators. This study adopted a qualitative descriptive research method. The researcher selected 20 participants as subjects and grouped them into high, medium, and low groups based on the results of the reasoning test answers that had the same tendency in writing steps and answers. Therefore, the interview process used two students per group. Data processing was carried out through descriptive analysis and triangulation analysis based on the test results, interviews, and field notes. The results were then reduced, followed by data presentation and conclusion drawing. The results of the study showed that the achievement of mathematical reasoning indicators with all students being able to make assumptions about problems, 16 students being able to prepare mathematical steps, 16 students being able to make conclusions about answers, and 3 students being able to provide arguments/reasons as truth. In addition, at high mathematical reasoning ability, students were able to fulfill all mathematical reasoning indicators. At medium mathematical reasoning ability, students were able to fulfill two mathematical reasoning indicators. At low mathematical reasoning ability, students were not able to fulfill the mathematical reasoning indicators.These results suggest that implementing ethnomathematics can facilitate students' mathematical reasoning. This research has implications for the development of ethnomathematics-based contextual mathematics learning that can enhance mathematical reasoning while preserving Madurese batik culture.

Keywords: Ethnomathematics, Mathematical Reasoning, Planar Figures.

Introduction

Mathematics education in Indonesia is still in the underperforming category. Mathematics lessons are often avoided because they are difficult and boring (Anditiasari, 2020). This can be anticipated through the use of an ethnomathematics approach to learning. Ethnomathematics is learning that makes use of local culture or wisdom that contains mathematical concepts and all types of mathematical activities that have developed throughout society (Wulandari, 2019; Zayyadi, 2021). Mathematics learning using an ethnomathematical approach can make it easier for students to reason mathematically while also introducing them to cultural knowledge. Madura batik is a cultural icon that combines various motifs and patterns, making it a suitable medium for introducing abstract geometric concepts such as lines, angles, symmetry, shapes, and similarity, which can be directly demonstrated to students (Sari et al., 2021; Sudirman et al., 2024).

Mathematical concepts are discovered through the process of mathematical reasoning. Mathematical reasoning is the skill to understand mathematical information more deeply, observe and find hidden information, and make estimates, steps, as well as conclusions through logical reasoning. Students' mathematical reasoning abilities influence their cognitive learning outcomes (Chusna, 2024; Nirmalasari et al., 2025).

Preliminary observations of eighth-grade students suggest that plane figure learning still emphasizes procedural problem-solving and the use of formulas, resulting in students' mathematical reasoning not yet developing optimally. Students struggle to explain the rationale for their chosen solution methods, connect plane figures, and relate concepts to everyday life. Furthermore, students are unable to analyze geometric shapes, patterns, and relationships in depth. This situation suggests the need for further research analyzing students' mathematical reasoning through an ethnomathematics approach based on Madurese batik on plane figures

Mathematical reasoning skills have also received significant attention since 2020 and continue to be studied in general areas such as Java and Bali, particularly in geometry and algebra in eighth-grade junior high schools (Ariati & Juandi, 2022). In previous research, it was found that the Sidomukti batik motif contains flat triangular and quadrilateral shapes, which can be used to prove the Pythagorean Theorem (Nirmalasari et al., 2025). Another study revealed that Madura batik ethnomathematics, when combined with e-modules in mathematics, can provide foundational understanding and enhance students' reasoning abilities (Fachrur et al., 2021;Marsitin & Sesanti, 2024). Another study mentions that students who can only make assumptions through mathematical manipulations but cannot verify the truth of their opinions and are unable to draw conclusions from statements are considered to have low mathematical reasoning skills (Kunfiana et al., 2024).

Previous research has emphasized mathematical reasoning skills in geometry and algebra, with the use of batik motifs and e-modules specifically on Madurese batik ethnomathematics being limited. Previous research has focused more on conceptual and procedural aspects, while reasoning through conveying reasons or arguments has not been widely analyzed. This study makes a novel contribution by examining Madurese batik motifs as a local cultural context in mathematics learning, developing innovative learning methods, and exploring various aspects of mathematical reasoning. Furthermore, the integration of Madurese batik motifs with geometry and the potential for cross-subject integration with other subjects, such as algebra, patterns, and symmetry, is expected to provide more contextual learning.

Method

The research approach used is descriptive qualitative, which provides a description of everything that happened during the research. According to Saleh (2021), qualitative descriptive research is the basis of the problem that guides the research to explore or document the social situation being studied in a broad, deep, and comprehensive manner.

The subjects were selected based on the results of the students' tests. The instrument used was a mathematical reasoning test with ethnomathematics consisting of two questions on plane figures. The instrument was developed based on mathematical reasoning indicators. The indicators used are mathematical reasoning indicators, which can be reviewed in Table 1.

Table 1. Mathematical Reasoning Indicators.

No	Indicator	Sub Indicator
1.	Make assumptions about the problem	Identify the problem
		State the questions in the problem
2.	Planning mathematical steps	Determine the steps/strategies to solve the problem
3.	Providing arguments or reasons for the correctness of the answer/solution	Using the steps/strategies determined to solve the problem Providing an explanation of the relationship between the steps/strategies used in solving the problem
4.	Making conclusions/generalizations	Obtaining answers/solutions from the steps/strategies applied in solving the problem Providing conclusions from the answers/solutions obtained in solving the problem

Adaptation (Marsitin & Sesanti, 2023)

The research instruments were consulted and validated by validators to ensure that they were valid and usable. After that, a written test was administered to the 20 students, who were then grouped into high, medium, and low mathematical reasoning groups based on the results of the mathematical reasoning test.

Validation was conducted to determine whether the test was valid and suitable for use in research. The test components validated were the test items, solution steps, and assessment rubric. The instrument was validated by two validators, both mathematics education lecturers. The validation results of the test items, solution steps, and assessment rubric using the mathematical reasoning stages indicated that the test items, solution steps, and assessment rubric could be used with minor revisions.

Next, the written test results were analyzed using mathematical reasoning indicators. Data processing analysis used descriptive analysis, which included checking the results and grouping similar data based on score ranges and tendencies in writing steps and answers, with the total score (n) divided into high ($25 \leq n < 40$), medium ($15 \leq n < 25$), and low ($0 \leq n < 15$) groups. Two students from each group were then interviewed to provide additional data for triangulation purposes. The triangulation process was carried out by comparing the test results with interviews and field notes, followed by analysis. The data obtained were then subjected to data reduction, followed by data presentation and conclusions.

Results and Discussion

The analysis and correction results were obtained from 20 students who took the test, with 13 students scoring above average and 7 students scoring below average. The students' scores are shown in Table 2.

Table 2. Groups Based on Score Criteria

No	Subject	Interval Score	Description
1.	MRM, CF, RDR	$25 \leq n < 40$	High
2.	MK, ND, NDS, VKP, LF, ADL, RR, AAN, AAK, DCU, AF, AVS, AFR	$15 \leq n < 25$	Medium
3.	MA, AVS, RAS, FA	$0 \leq n < 15$	Low

Analysis of the results of interviews participated in by two students from each group. Interviews with MK, RDR, AAN, ND, MA, and RAS obtained data on mathematical reasoning abilities in solving ethnomathematics problems in plane geometry based on the mathematical reasoning indicators described in Table 3.

Table 3. Analysis Interview Results Based Mathematical Reasoning Indicators

Code Subject	**Mathematical Reasoning Indicator**	**Question Number**	
		1	**2**
MK (High)	Make assumptions about the problem	√	√
	Planning mathematical steps	√	√
	Providing arguments or reasons for the correctness of the answer/solution	√	√
	Making conclusions/generalizations	√	√
RDR (High)	Make assumptions about the problem	√	√
	Planning mathematical steps	√	√
	Providing arguments or reasons for the correctness of the answer/solution	√	√
	Making conclusions/generalizations	√	√
AAN (Medium)	Make assumptions about the problem	√	√
	Planning mathematical steps	√	√
	Providing arguments or reasons for the correctness of the answer/solution	-	-
	Making conclusions/generalizations	√	√
ND (Medium)	Make assumptions about the problem	√	√
	Planning mathematical steps	√	√
	Providing arguments or reasons for the correctness of the answer/solution	-	-
	Making conclusions/generalizations	√	√
MA (Low)	Make assumptions about the problem	√	√
	Planning mathematical steps	-	-
	Providing arguments or reasons for the correctness of the answer/solution	-	-
	Making conclusions/generalizations	-	-
RAS (Low)	Make assumptions about the problem	√	√
	Planning mathematical steps	-	-
	Providing arguments or reasons for the correctness of the answer/solution	-	-
	Making conclusions/generalizations	-	-

The results of the analysis from the interviews with MK, RDR, AAN, ND, MA, and RAS, along with the subject's responses from the previous reasoning test, were reanalyzed using mathematical reasoning indicators. These indicators include making assumptions about problems, which involve identifying and starting problems, preparing mathematical steps to solve them, providing arguments or reasons as the correct answers or solutions, and drawing conclusions or generalizations.

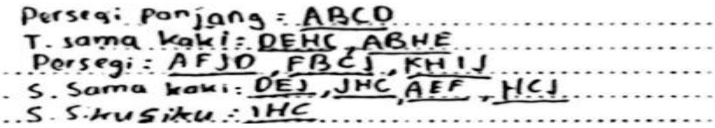
Making Assumptions and Identifying Problems

The first mathematical reasoning indicator is making assumptions and identifying problems in questions 1 and 2. In the interview, all students were able to identify and describe the problems. The analysis of students' ability to make assumptions and identify problems is presented in Table 4.

Table 4. Analysis of the interview results and the test answers to make assumptions about the problem

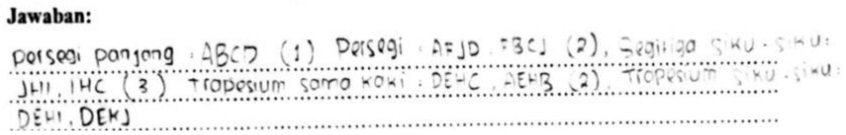
Code Subject	Mathematical Reasoning Indicators	Sub-Indicators Of Mathematical Reasoning	Interview Results Question Number		Reasoning Test Answers Question Number	
			1	2	1	2
MK (High)	Make assumptions about the problem	Identify the problem	√	√	√	√
		State the questions in the problem	√	√	-	-
RDR (High)	Make assumptions about the problem	Identify the problem	√	√	-	-
		State the questions in the problem	√	√	-	-
ND (Medium)	Make assumptions about the problem	Identify the problem	√	√	-	-
		State the questions in the problem	√	√	-	-
AAN (Medium)	Make assumptions about the problem	Identify the problem	√	√	-	-
		State the questions in the problem	√	√	-	-
MA (Low)	Make assumptions about the problem	Identify the problem	√	√	-	-
		State the questions in the problem	√	√	-	-
RAS (Low)	Make assumptions about the problem	Identify the problem	√	√	-	-
		State the questions in the problem	√	√	-	-

The results of the answers from all students showed this, with only MRM recording the information. This lack of information is evident in Pictures 1, 2, and 3.


Persegi Panjang : ABCD
T. sama kaki : DEHC, ABHE
Persegi : AFJO, FBCJ, KHIJ
S. Sama kaki : DEJ, JHC, AEF, HCJ
S. Siku siku : IHC

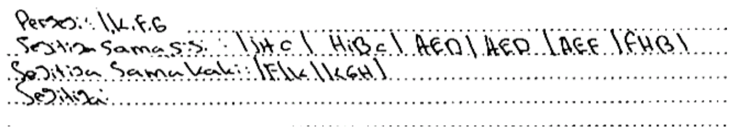
Picture 1. RDR's Test Answers

Observations of RDR's answers simply write down answers without mentioning what was known or asked, but the results of the RDR's interview activities able to understand the meaning of the questions. Then, triangulation was carried out, resulting in the conclusion that RDR was able to satisfy the indicator of making assumptions about problems.


Jawaban:
persegi panjang : ABCD (1) Persegi : AFJD . FBCJ (2), Segitiga siku - siku : JHI, IHC (3) Trapesium sama kaki : DEHC , AEHB (2), Trapesium siku - siku : DEHI, DEKJ

Picture 2. AAN's Test Answers

Reviewing the results of AAN's answers, he just wrote down the answers without mentioning the known and asked questions, but the AAN interview results found that he understood the questions, so triangulation was conducted, and it was found that AAN could do the indicators to make assumptions about the problems.



Picture 3. RAS's Test Answers

Looking at the RAS's answers, he just wrote down the answers without mentioning the known facts or questions, but RAS's interview results showed that he understood the questions, so we did some triangulation and found that RAS could meet the indicators for making assumptions about problems. All the answers had the same tendency, which was not mentioning the known facts and questions, but answering the questions correctly.

This indicates that the subjects can make accurate problem assumptions despite deficiencies in writing. Students are considered capable of identifying problems when they can rewrite the information in the question and provide detailed explanations when answering interview questions (Nisa et al., 2024). Additionally, students who can understand problems by correctly and accurately expressing the data obtained at the known and questioned stages are then able to formulate and prove their assumptions (Maryanti & Qadriah, 2021; Rohati et al., 2023). Therefore, all students can meet the indicators for formulating problem hypotheses. This is demonstrated by all students being able to provide complete information about the question and answer the questions during the interview.

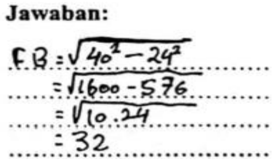
Planning mathematical steps

The second type of mathematical reasoning indicator is planning mathematical steps by determining the steps/strategies used to solve problems in Numbers 1 and 2. Students with high and medium mathematical reasoning abilities were able to explain the steps/strategies used in the interview activity. The analysis of students' abilities in planning mathematical steps is presented in Table 5.

Table 5. Analysis of interview results and test answers in preparing mathematical steps

Code Subject	Mathematical Reasoning Indicators	Sub-Indicators Of Mathematical Reasoning	Interview Results		Reasoning Test Answers	
			Question Number		Question Number	
			1	2	1	2
MK (High)	Planning mathematical steps	Determine the steps/strategies to solve the problem	√	√	√	√
RDR (High)	Planning mathematical steps	Determine the steps/strategies to solve the problem	√	√	-	-
AAN (Medium)	Planning mathematical steps	Determine the steps/strategies to solve the problem	√	√	√	√
ND (Medium)	Planning mathematical steps	Determine the steps/strategies to solve the problem	√	√	-	-
MA (Low)	Planning mathematical steps	Determine the steps/strategies to solve the problem	-	-	-	-
RAS (Low)	Planning mathematical steps	Determine the steps/strategies to solve the problem	-	-	-	-

The results of the answer sheet corrections are only MRM that include patterns in the solution process. However, the interview results indicate that MRM, CF, RDR, MK, ND, NDS, VKP, LF, ADL, RR, AAN, AAK, DCU, AF, AVS, and AFR students can provide information about the patterns used in solving the problem. This confirms that high-performing and average-performing students on test results can meet the second criterion, which is preparing mathematical steps. Conversely, four students cannot explain the strategies or steps used, as seen in response to test question Number 2 MA on Picture 4.



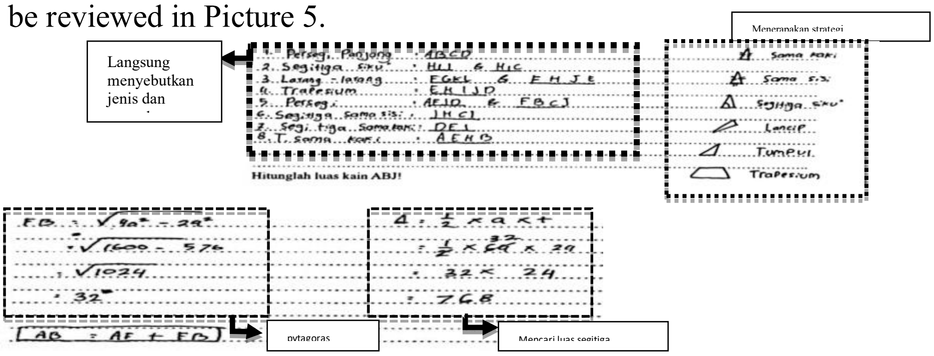
Picture 4. MA's Test Answers

The MA subject wrote down the steps to find the length of FB in answer to question 2. However, MA did not include information on the question, steps/strategies, and final solution. The interview results showed that MA understood the problem. However, MA was unable to design and implement a strategy to solve the problem.

The indicator for planning mathematical steps is achieved if the student can explain the strategy used to solve the problem (Dadan et al., 2025). Additionally, a student is considered capable of planning steps by exploring the problem by describing patterns or tables from the problem and drawing conclusions based on the tables or patterns created (Siswanto & Meiliasari, 2024).

Providing arguments or reasons for the correctness of the answer/solution

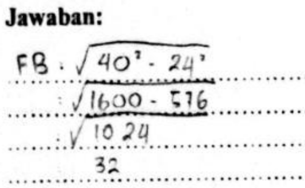
Based on interview results, MRM, CF, and RDR students were able to clearly explain how to apply the strategies/steps/concepts used to solve problems. The same results can be seen in the analysis of answers to questions 1 and 2, where MRM, CF, and RDR students wrote down the strategies/steps/concepts used when solving problems, which can be reviewed in Picture 5.



Picture 5. MRM's Test Answers

Based on the results of questions 1 and 2, MRM was able to calculate correctly. However, MRM only wrote AB = AF + FB as a step in finding the base of triangle ABJ. In addition, MRM didn't write down the knowns, unknowns, and the complete solution process. The interview results showed that MRM understood the question and could use strategies to solve the problem. Furthermore, the subject MRM used a systematic and correct solution process. However, the subject MRM forgets to include the complete solution process.

Conversely, when interviewed, students MK, ND, NDS, VKP, LF, ADL, RR, AAN, AAK, DCU, AF, AVS, and AFR couldn't explain the strategy/steps/concept clearly, but the answers were obtained by predicting the image in the question. They didn't write down the strategy/steps/concept used to solve the problem until it was finished. The deficiency in writing down the steps can be seen in answer to question number 2 by AAN, presented in Picture 6.



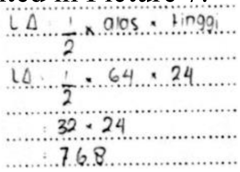
Picture 6. AAN's Test Answers

An analysis of answer Number 2 found that subject AAN wrote down the steps to find FB using Pythagoras and triangle area calculations. However, subject AAN didn't write down what was known, asked, the complete steps, or the strategy used. The interview results showed that subject AAN could understand the question and design a strategy to solve it. However, AAN couldn't implement the strategy.

Students are considered capable of providing arguments when they can write down and explain the relationship between the steps/strategies used in solving the problem during the interview (Marsitin & Sesanti, 2023). Additionally, students are considered to meet this indicator if they can apply concepts or formulas in presenting the problem-solving process (Pradestya et al., 2019). Therefore, it can be concluded that only students in the MRM, CF, and RDR groups achieved the indicator in providing arguments or reasons as the correct answer.

Making conclusions/generalizations

The indicator for drawing conclusions/generalizations can be seen through the clear writing of the results and the explanation of the results obtained. The final answers to questions 1 and 2 by students MRM, CF, RDR, MK, ND, NDS, VKP, LF, ADL, RR, AAN, AAK, DCU, AF, AVS, and AFR have clear and correct final answers in solving the problems. Meanwhile, students of MA, AVS, RAS, and FA were unable to write down the results. Something similar can be seen in the interview results from students MRM, CF, RDR, MK, ND, NDS, VKP, LF, ADL, RR, AAN, AAK, DCU, AF, AVS, and AFR, who were able to explain the results they got well. However, in the interviews, MA, AVS, RAS, and FA students were unable to answer questions about the results received. The results of Test Number 2 for RAS are presented in Picture 7.



Picture 7. RAS's Test Answers

The RAS test answers didn't really get to the final answer or conclusion, so RAS couldn't really solve problem number 2. The same thing happened with the MA, AVS, and FA test answers. So, only the MA, AVS, RAS, and FA students couldn't meet the criteria for drawing conclusions or generalizations.

Students are considered capable of drawing conclusions or generalizations when they can arrive at answers/solutions based on the steps/strategies applied in solving problems and derive conclusions from the answers obtained in solving problems (Marsitin & Sesanti, 2023). Conclusions can also be made by understanding and summarizing the results of problem solving based on the strategies or data obtained. (Prima & Muhamad, 2023;Hjelte et al., 2020).

According to the results of the discussion above, in this study, all students were able to make assumptions about the problems from the questions given. In this case, all students could identify the problems and state the questions well during the interview but forgot to write them down on the previous answer sheet.

Mathematical Reasoning Ability

The results of the study related to students' mathematical reasoning abilities at high, medium and low levels of mathematical reasoning ability obtained data that at high levels of mathematical reasoning ability there were two students who could fulfill the mathematical reasoning indicators, namely being able to make predictions from problems by identifying problems and stating questions in the problem, being able to prepare mathematical steps by determining steps/strategies to solve problems, being able to provide arguments or reasons as the truth of the answer/solution and being able to draw conclusions. Additionally, students who can understand problems by correctly and accurately expressing the data obtained at the known and questioned stages are then able to formulate and prove their assumptions (Maryanti & Qadriah, 2021; Rohati et al., 2023). In the moderate mathematical reasoning ability, there are two students who can fulfill the mathematical reasoning indicators, namely being able to make guesses from problems by identifying problems and stating questions in the problem, being able to prepare mathematical steps by preparing mathematical steps but being less careful in completing the answers, and not being able to provide arguments or reasons as the truth of the answer/solution and not being able to draw conclusions. In the low mathematical reasoning ability, there are two students who can fulfill the mathematical reasoning indicators, namely being able to make guesses from problems by identifying problems and stating questions in the problem, but there are still some that are not quite right, being able to prepare mathematical steps by determining mathematical steps, but not being careful in solving the answers, and not being able to provide arguments or reasons as the correctness of the answer/solution and not being able to draw conclusions.The indicator for planning mathematical steps is achieved if the student can explain the strategy used to solve the problem (Dadan et al., 2025).

Students are considered capable of providing arguments when they can write down and explain the relationship between the steps/strategies used in solving the problem during the interview (Marsitin & Sesanti, 2023; Pradestya et al., 2019). Conclusions can also be made by understanding and summarizing the results of problem solving based on the strategies or data obtained. (Prima & Muhamad, 2023;Hjelte et al., 2020).

Conclusion and Suggestion

The results of the study concluded that the ability of students to perform mathematical reasoning when working on reasoning tests with Madura batik ethnomathematics was obtained by all students being able to make guesses from problems by identifying and stating problems, as many as 16 students were able to prepare steps or strategies used in the interview process but forgot to include these steps on the answer sheet, 16 students were able to conclude the answer correctly during the interview and include the final answer correctly, and 3 students were able to explain the application of the strategy that had been prepared in the interview process but forgot to include it on the answer sheet, and as many as. In addition, students with high mathematical reasoning ability can make informed guesses from problems, prepare mathematical steps, provide arguments or reasons to support the correctness of answers/solutions, and draw conclusions. Students with a medium mathematical reasoning ability can fulfill two indicators of mathematical reasoning, but this is often due to being less careful in completing the answer, resulting in the lack of arguments/reasons for the correctness of the answer/solution, and the failure to draw conclusions. Low mathematical reasoning ability, students have not been able to fulfill all the indicators of mathematical reasoning, which is caused by being less precise in making assumptions from problems and less careful in solving problems, so that they have not provided arguments/reasons for the correctness of the answer/solution and have not drawn conclusions. Based on the conclusions of the previous research, the researcher can provide the following recommendations: ensure that students understand and remember the material to be used in the research and encourage teachers to pay more attention to precision and improve the mathematical reasoning skills of students in solving mathematical problems.

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