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Students' errors in solving ethnomathematics word problems using the newman procedure: A perspective from learning styles

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Abstract

Some students had difficulty solving ethnomathematics word problems, indicating the need for further research to address this issue. This study aims to identify the types of errors made and the factors causing them. It applies Newman's Error Analysis, which includes reading errors, comprehension errors, transformation errors, process skill errors, and writing errors in the final answer. It incorporates the role of ethnomathematics as an innovation in contextual learning that introduces Indonesian culture to students. This study uses a qualitative method with six eighth-grade students as research subjects. Data were collected through learning-style questionnaires, ethnomathematics story problem tests, and interviews. Subjects were selected using purposive sampling, and data analysis employed the Miles and Huberman model. The results of the study showed that students with a visual learning style made comprehension errors and errors in writing the final answer, students with an auditory learning style made comprehension errors, process skill errors, and errors in writing the final answer, and students with a kinesthetic learning style made comprehension errors and errors in writing the final answer. Factors contributing to errors among students with visual, auditory, and kinesthetic learning styles include a lack of attention to detail when processing information, rushing through tasks, and the carryover of errors from previous stages.

Keywords: ethnomathematics; learning styles; Newman's Error Analysis

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INTRODUCTION

Mathematics is one of the disciplines that plays a crucial role in education (Debi et al., 2020). As the foundation of the sciences, mathematics serves not only as a tool for problem solving but also as a means to develop students' critical, systematic, logical, and creative thinking skills (Irfan et al., 2022). Students' ability to solve problems in mathematics is closely related to their ability to identify relevant information, ensure the availability of necessary information, formulate mathematical problems, develop solution steps, and explain and justify the validity of the solutions found (Veronica et al., 2022).

Based on PISA 2018 results, Indonesia's literacy levels remain relatively low compared to the Organization for Economic Co-operation and Development (OECD) average. Meanwhile, the latest PISA 2022 data shows that Indonesia's reading literacy scores still lag far behind Singapore's, which ranks first with a score of 543 (OECD,

2023). Mathematical literacy can be defined as a person's ability to formulate, apply, and understand mathematics to solve problems arising in daily life (Ramadhan et al., 2023). One way to develop mathematical problem-solving skills is through mathematical literacy. Encouraging students to work on story-based problems is an effort to improve their literacy skills.

In mathematics education, word problems require students to solve mathematical problems in the context of everyday situations (Diva & Purwaningrum, 2022). For students, word problems are often seen as difficult due to a lack of practice and difficulty understanding the context. It takes longer to solve word problems because they require an understanding of the problem (Nailia et al., 2023).

To strengthen understanding of the relationship between culture and mathematics learning, an approach is needed that integrates cultural context into the educational process. Ethnomathematics is one approach that can bridge culture and education in learning, particularly in mathematics (Andzin et al., 2024). Ethnomathematics is defined as a contextual educational innovation in mathematics that develops within a specific cultural context (Pane & Sihotang, 2022). Ethnomathematics allows students to explore the connections between mathematics and daily life, appreciate the role of mathematics in cultural heritage, and explain how mathematical principles are manifested in that cultural heritage (Harun et al., 2024). Furthermore, ethnomathematics is closely related to students' error analysis, as contextual problems can reveal students' difficulties in understanding, transforming, and solving mathematical tasks, thereby providing insights into the sources of their errors.

Learning styles are chosen because they are among the characteristics students possess (Aini et al., 2025). A learning style is an approach that describes how a person learns—that is, the methods each person chooses to focus on the learning process and master challenging new knowledge from various perspectives. DePorter & Hernacki (1992) classified learning styles into three types: visual, auditory, and kinesthetic.

Students' errors in solving math problems serve as a reference for identifying their mistakes or misunderstandings, acting as a benchmark for improvement (Utami, 2020). Since mathematics is an abstract subject, it is natural for students to make mistakes or have difficulties in understanding it (Marasabessy et al., 2021). As mathematics educators, it is important to analyze students' errors and the causes of learning difficulties

(Rahastiana & Haerudin, 2023). A detailed error analysis is necessary to identify students' errors and the factors contributing to them. Newman's Error analysis was chosen because it can systematically identify students' errors at every stage of problem-solving, from reading the problem to writing the final answer (Paramarta et al., 2025). Unlike other, more common methods, this approach provides a more detailed analysis of students' thought processes, particularly when solving word problems. Therefore, this method is considered more comprehensive in identifying the types of errors and their causes as a basis for improving learning. Several previous studies have examined students' error profiles from various perspectives. Fitry et al. (2022) analyzed students' errors in solving mathematical word problems. Analysis of student errors in solving word problems using Polya's problem-solving stages (Pangestu et al., 2021). Error analysis in solving contextual math problems based on Newman's Error Analysis in terms of gender (Amin et al., 2021). Analysis of student errors in solving SPLDV word problems based on Newman's stages (Rahastiana & Haerudin, 2023). However, none of these studies have examined students' errors in solving ethnomathematics word problems based on Newman's procedure in terms of learning styles combining Newman's error analysis procedure with the grouping of students according to their learning styles, it is hoped that teachers will be able to identify the different types of errors and their causes.

Newman's error analysis is considered an effective method for identifying errors and their causes in the learning process (Singh et al., 2010). Previous studies have shown that Newman's error analysis enables researchers to gain deeper insights into the various types of errors students make, as well as the underlying factors that contribute to them. This study aims to describe students' errors in solving mathematical word problems and to analyze the underlying causes of these errors based on Newman's Error Analysis in the context of ethnomathematics problems.

METHODS

The research design of this study was a qualitative descriptive approach. Data were collected from six eighth-grade students at SMP Negeri 1 Kradenan. The research subjects were selected using purposive sampling, consisting of two students from each learning style category: visual, auditory, and kinesthetic. The selection of six subjects was deemed sufficient to represent each learning style group and to allow for in-depth analysis, a key characteristic of qualitative research. Additionally, this sample size

supports data triangulation, enhancing the validity of the findings. Research instruments included a learning style questionnaire, an ethnomathematics-based story problem test, and semi-structured interviews. The learning style questionnaire was used to classify students into visual, auditory, and kinesthetic categories. The test was used to identify students' errors in solving ethnomathematics story problems, while the interviews were conducted to explore the underlying causes of these errors in greater depth. All instruments were validated by three experts in their respective fields—two mathematics lecturers from the University of PGRI Semarang and a mathematics teacher—before data collection. Data were collected through the learning style questionnaire, the ethnomathematics story problem test, and interviews, and were then analyzed using Newman's Error Analysis to identify the types of errors and their underlying causes. The subject selection technique used purposive sampling, in which the sample was determined by considering specific factors for specific purposes (Sugiyono, 2023). Student results were analyzed using Newman's Error Analysis, with the observed error indicators presented in Table 1.

Table 1. Error analysis indicators for Newman's procedure

Error Type	Indicators
Reading Error	1. Students overlook important information in the question. 2. Students cannot correctly interpret the symbols. 3. Students can read the question but do not understand the meaning of the terms or symbols used in it.
Comprehension Error	1. Students are unable to provide the requested information. 2. Students are able to provide the requested information but are not entirely accurate. 3. Students are unable to identify the issue being asked about. 4. Students are able to identify the issue being asked about but are not entirely accurate.
Transformation Error	1. Students do not know the correct problem-solving strategy. 2. Students are unable to translate the information in the problem into a mathematical model. 3. Students are able to translate the information in the problem into a mathematical model but do so inaccurately. 4. Students make mistakes in choosing the method, arithmetic operation, or mathematical symbol used to solve the problem.
Process Skill Error	1. Students are unable to apply mathematical rules correctly. 2. Students are unable to follow procedures correctly. 3. Students are unable to perform calculations. 4. Students are unable to analyze the solutions to the problems further.

Encoding Error	1. Students are unable to write down mathematical units. 2. Students are unable to write down the final answer requested in the question. 3. Students are unable to express the final answer in mathematical form. 4. Students can express the final answer in mathematical form, but do so incorrectly.

The data analysis techniques used in this study follow the Miles and Huberman approach, which includes data collection, data reduction by organizing and classifying data based on students' learning styles and types of errors in accordance with Newman's procedures, narrative data presentation to describe patterns of student errors in solving problems, supported by student work and interview excerpts, as well as drawing and verifying conclusions by identifying error patterns, analyzing their causes, and comparing them with previous studies. The researcher acts as the primary instrument, and data validity is ensured through triangulation.

The data collection phase involved gathering questionnaire results, results from the ethnomathematics story problem test, and interviews with research subjects. During data reduction, the researcher classified the data by students' learning styles. In the data presentation stage, students' errors are described narratively to illustrate the process they experienced while working on ethnomathematics story problems, following Newman's procedure. In the final stage, conclusions are drawn from the patterns identified in the data and compared with findings from previous studies.

In this study, the researcher served as the primary instrument, responsible for research planning, data search, data collection, data analysis, and conclusion, all of which must be conducted meticulously. To ensure data validity, this study employed source triangulation to verify data accuracy by comparing information from multiple sources. This procedure was implemented by conducting interviews with two subjects representing each learning style. Data was deemed valid if there was significant consistency between the written test and the information provided during the interview process.

RESULTS AND DISCUSSION

Based on the results of the learning style grouping, two students were selected as research subjects. Each subject was then asked to complete an ethnomathematics story

problem test, and their answers were analyzed to identify the types and causes of errors using Newman's Error Analysis. The research subjects are presented in Table 2.

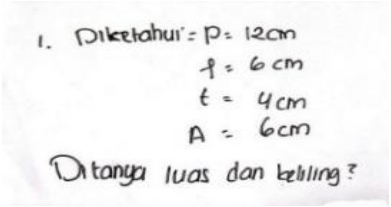
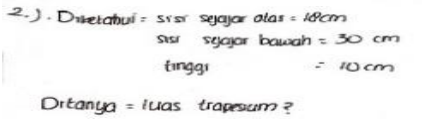
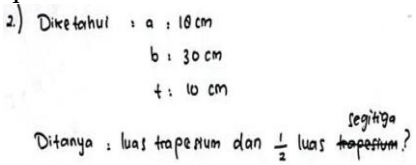
Table 2. Selected subjects based on learning styles

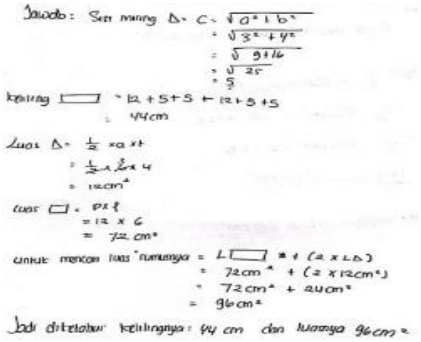
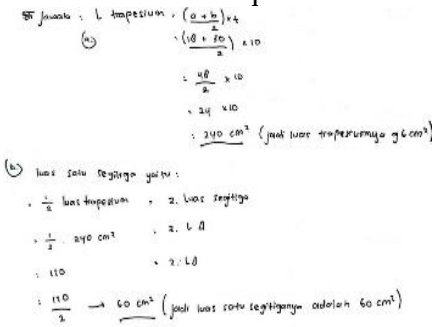
Learning Styles	Subject's Number	Subject's Code
Visual	1	SV-1
	2	SV-2
Auditory	1	SA-1
	2	SA-2
Kinesthetic	1	SK-1
	2	SK-2

Students with a visual learning style

The results for students with different learning styles were analyzed using a triangulation method to assess the validity of the data. Table 3 presents the triangulation results for students with a visual learning style.

Tabel 3. Triangulation for the visual learning students' response

Error Type	SV-1	SV-2
Reading Error	Subject SV-1 did not omit any important information from the question.	Subject SV-2 did not omit any important information from the question.
Comprehension Error	Subject SV-1 didn't accurately address the question in question 1.  The subject is not quite appropriate for describing what is known and asked in question 2.  R: "Why didn't you write it on the answer sheet?" S: "I didn't check it again earlier, so something's missing."	Subject SV-2 is not quite correct in stating what is asked in question 2.  R: "Take a look at your answer sheet. Did you write down the information shown above?" S: "Number two is wrong, teacher. It should be the area of a triangle" R: "Why didn't you write that on your answer sheet?" S: "I made a mistake and didn't check it again, teacher."

Transformation Error	Subject SV-1 can translate the information in the question into a mathematical form.	Subject SV-2 can translate the information in the question into a mathematical form.
Process Skill Error	Subject SV-1 can perform calculations correctly.	Subject SV-2 can perform the procedure correctly and make accurate calculations.
Encoding Error	The subject is not quite appropriate for writing a conclusion that aligns with the intent of question number 1.  R: "Why didn't you write out the full answer?" S: "I didn't read the question again while writing the answer."	The subject was unable to write the conclusion for question 2.  R: "Why didn't you write it down according to your calculations?" S: "I wasn't careful enough."

The results of the data analysis in this study indicate that students with a visual learning style did not make any errors during the problem-reading stage, as subjects were able to read the words and symbols in the questions.

Misunderstandings occur when the subjects fail to grasp the intent of the question. This aligns with the research by Murtiyasa & Wulandari (2020), which found that misunderstandings occur when students fail to write down what is known and what is being asked, fail to provide complete information, and are unable to comprehend the problem presented in the question. In question number 1, subjects SV-1 and SV-2 were able to write down what was known in the question. SV-1 wrote down the problem asked in the question but was not entirely accurate, whereas SV-2 was accurate and correct. In question number 2, SV-1 and SV-2 were able to write down what was known, but both were inaccurate; SV-1 was also able to write down the problem asked in the question, but was not entirely accurate. This was because the subjects were not careful enough and were confused about understanding the problem within the question.

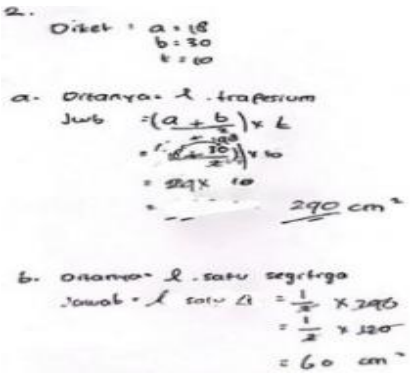
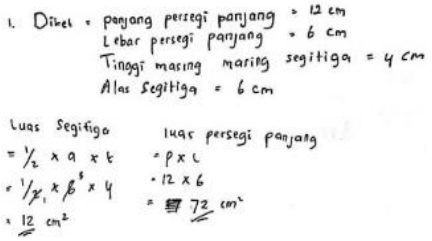
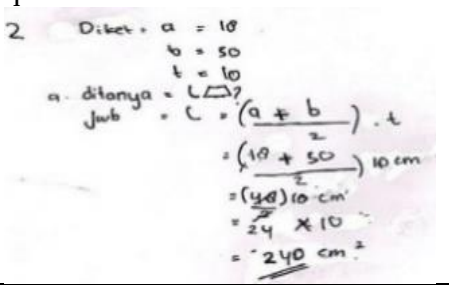
The third stage transformation for questions 1 and 2, SV-1 and SV-2, made no errors; the students were able to convert the problems into mathematical models. None of the subjects made any errors during the transformation stage, as they were able to write the mathematical models.

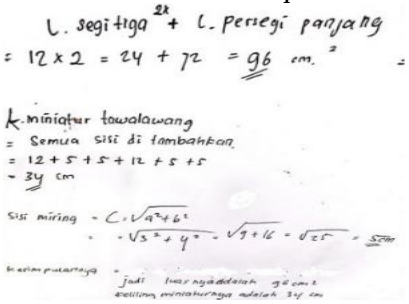
The fourth stage involves process skills in questions 1 and 2, where students can complete the calculation steps with accurate answers. According to Annisa & Kartini (2021), errors in process skills can occur when students are unable to identify the steps and perform the appropriate arithmetic operations. The final step is encoding. SV-1 was incorrect on question 1, while SV-2 was incorrect on question 2.

Students with an auditory learning style

The results for students with specific learning styles were analyzed using a triangulation method to assess the validity of the data. Table 4 presents the triangulation results for students with an auditory learning style.

Table 4. Triangulation for the auditory learning students' response

Error Type	SA-1	SA-2
Reading Error	Subject SA-1 did not omit any important information from the question.	Subject SA-2 did not omit any important information from the question and was able to state the known information.
Comprehension Error	Subject SA-1 did not accurately describe what is known in item 2. 	Subject SA-2 was unable to describe the problem asked in question 1.  The subject did not accurately describe what is known in question 2. 

Transformation Error	The subject was able to perform the procedure correctly.	Subject converts information into a mathematical model.
Process Skill Error	Subject SA-1 was unable to calculate the circumference in question 1.  R: "Why didn't you double-check? The process was correct, but the result was wrong." S: "Yeah, I didn't double-check earlier. I was confused."	Subject SA-2 had difficulty performing the calculation to find the circumference in question 1.  R: "Take a look at your answer for the circumference of the model. Is it correct?" S: "I made a mistake in my calculation, teacher." R: "Why didn't you double-check it? You followed the steps correctly, but the result is wrong." S: "Yeah, teacher, I didn't double-check it earlier."
Encoding Error	Subject SA-1 made a calculation error, which caused the student to also make a mistake in writing the final answer.	Subject SA-2 made an error in writing or calculating the final answer for question 1.

Based on the results of the description and analysis of subjects SA-1 and SA-2, neither subject made any reading errors on questions 1 and 2. Both were able to read every word and symbol in those questions.

The second stage is understanding the problem. For question 1, SA-1 was able to write down what was known and what was asked in the question. SA-2 was able to write down what was known, but was unable to write down what was asked in the question. Meanwhile, for question number 2, both SA-1 and SA-2 were able to write down what was known and what was asked in the question, but both were inaccurate because they were confused about the information in the question.

The transformation stage of this research analysis, for questions 1 and 2, neither subject made any errors, as the students were able to write down the formula or convert the problem into a mathematical model. According to Sulaiman et al (2023), errors at this

stage occur when subjects are unable to write down or state the appropriate formula or calculation.

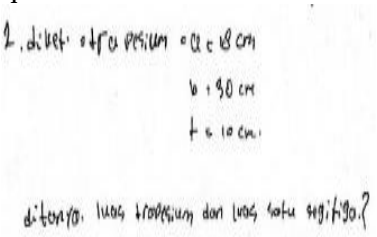
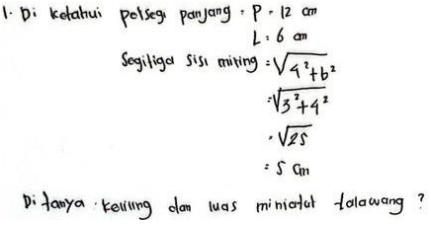
In the fourth stage of the process skills, for question 1, students in groups SA-1 and SA-2 made calculation errors due to a lack of attention to detail, whereas for question 2, students in both groups completed the task according to the steps and performed the calculations accurately. Students' lack of attention to detail led them to skip parts of the calculation process and to fail to double-check their work.

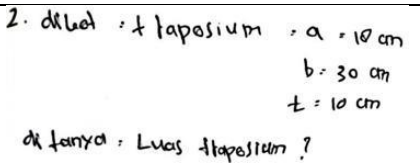
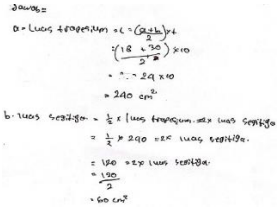
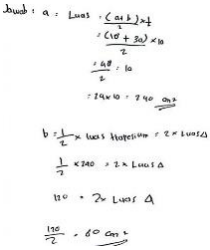
The final step, encoding the answer, is the last. In question 1, SA-1 and SA-2 failed to correctly write the final answer in the form of a conclusion. This was because the subject made errors in the calculation process and did not double-check their work. Errors in the final writing step were caused by mistakes made in the previous step. Students' errors in the previous step can lead to errors in the final answer.

Students with a kinesthetic learning style

The results for students with a kinesthetic learning style were analyzed using the triangulation method to assess the validity of the data. Table 5 presents the results of the triangulation for students with a kinesthetic learning style.

Table 5. Triangulation for the kinesthetic learning students' response

Error Type	SK-1	SK-2
Reading Error	Subject SK-1 did not omit any important information from the question.	Subject SK-2 can translate the information in the problem into a mathematical form.
Comprehension Error	The subject didn't accurately describe what is known in question 2. 	The subject was unable to write down what they knew about question 1.  The subject did not accurately state what was asked in question 2.

		 R: "Why didn't you write it down?" S: "I forgot to check it."
Transformation Error	Subject SK-1 is able to convert the information in the problem into a mathematical form.	Subject is able to convert the information in the question into a mathematical form.
Process Skill Error	SK-1 is able to perform calculations correctly and follow calculation procedures accurately.	SK-2 is able to perform calculations correctly and follow calculation procedures accurately.
Encoding Error	Subject was unable to write a final conclusion in accordance with the instructions question 2.  R: "Why didn't you write a conclusion?" S: "I was in a hurry earlier"	The subject was unable to write the final conclusion question 2.  R: "Why didn't you write the conclusion for number two?" S: "I was in a hurry"

Based on the results of the tests and interviews, the students did not make any reading errors on questions 1 and 2, subject able to read every word and symbol and process the information in questions 1 and 2.

The second stage involves understanding the problem in question 1: SK-1 made no errors, meaning subjects were able to write down what was asked and what was known in the question, whereas SK-2 made errors in understanding. Meanwhile, for question 2, both SK-1 and SK-2 were able to write down what was known and what was asked in the question, but both were somewhat inaccurate because they rushed to understand the information in the question.

The third stage is transformation for questions 1 and 2; both subjects were able to transform or write the questions into mathematical form. Next, the fourth stage is process skills, for questions 1 and 2, both subjects were able to complete the calculation steps with the correct answers.

The final stage is encoding: writing the final answer for question 1. Both subjects were able to write the final answer in accordance with the intended conclusion of the question. However, on question 2, both subjects made errors in writing the final answer due to carelessness and rushing.

Differences in error types stem from an underlying factor: learning style. Students with a visual learning style make comprehension errors and errors in writing the final answer; students with an auditory learning style make comprehension errors, process skill errors, and errors in writing the final answer; while students with a kinesthetic learning style make comprehension errors and errors in writing the final answer. The use of ethnomathematics in word problems acts as a dual factor. On one hand, this context brings mathematics closer to students' reality. However, the data indicate that cultural elements add to students' cognitive load. Students tend to focus on the cultural narrative, which leads them to fail at transforming everyday language into the appropriate mathematical model. This explains why errors frequently occur in the early stages of the Newman procedure. The validity of these findings is strengthened through source triangulation, with various sources revealing consistency between answer sheets and subjects' statements during interviews.

CONCLUSION

Based on the research findings, it can be concluded that the types of errors made by students in Class VIII B at SMP Negeri 1 Kradenan include misunderstandings of the questions and errors in writing the final answers, particularly among students with a visual learning style. The types of errors made by two students with an auditory learning style include comprehension errors in understanding the questions, process skill errors, and coding errors in writing the final answers. The types of errors made by two students with a kinesthetic learning style are comprehension errors and coding errors. Given the errors that occurred, teachers should incorporate ethnomathematics story problems into the learning process so that students become accustomed to them.

This study is limited to a single class with a small number of subjects and only examines students' errors in solving ethnomathematics story problems based on learning styles without considering other factors. This study contributes to the development of theoretical and methodological approaches in diagnosis by identifying types of errors and

their underlying factors. Given these limitations, future research could involve a larger sample and examine other factors, as well as the development of an ethnomathematics-based learning model. The analytical approach used in this study can serve as a model for future research in determining evidence-based diagnostic strategies.

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Author Contribution : HZR: Conceptualization, Drafting the Initial Manuscript; LH: Formal Analysis; S: Validation and Supervision.

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