DESCRIPTION OF STUDENTS' ERRORS BASED ON NEWMAN'S PROCEDURE IN RATIO AND PROPORTION WORD PROBLEMS

Arif Hidayat[1], Dian Nataria Oktaviani[2], Munadi[3]
123 Mathematics Education Study Program, Faculty of Teacher Training and Education, Universitas Pancasakti Tegal (INDONESIA)

[*]Corresponding author: arif22.hidayat@gmail.com

Abstract

This study aims to describe and analyze the types of errors made by students in solving mathematical word problems on ratio and proportion based on Newman's Error Analysis. This study employed a descriptive qualitative approach. The subjects were Grade VIID students of SMP N 2 Bantarsari selected based on the results of a diagnostic test. Data were collected through a written test consisting of word problems and semi-structured interviews. Data validity was established through technique triangulation by comparing the results of the written test with the interview results. Data were analyzed through the stages of data reduction, data presentation, and conclusion drawing. The results showed that students still made errors at all five Newman stages when solving ratio and proportion word problems. The percentages of student errors were as follows: reading error 0%, comprehension error 37.5%, transformation error 25%, process skill error 16.7%, and encoding error 83.3%. The most dominant errors occurred at the transformation and process-skill stages, where students had difficulty converting word-problem statements into appropriate mathematical models and made errors in fraction or ratio calculations.

Keywords: Student Errors; Newman's Error Analysis; Word Problems; Ratio and Proportion;

1 INTRODUCTION

Mathematics education plays a fundamental role in equipping students with logical, analytical, systematic, critical, and creative thinking skills. One of the objectives of mathematics learning at school is to enable students to solve problems, including the abilities to understand problems, formulate mathematical models, solve the models, and interpret the solutions obtained. A form of assessment frequently used to measure these problem-solving abilities is the word problem. Word problems present mathematical problems in everyday-life contexts, requiring students not only to be proficient in computation but also to be skilled in understanding the language and logic underlying the problems.

Ratio and proportion are among the essential mathematical concepts taught at the secondary-school level. The concepts of direct and inverse proportion are highly applicable to solving contextual problems. In practice, however, many students still experience difficulties in solving word problems involving these concepts. Such difficulties lead to various errors during the problem-solving process. Students are often confused when distinguishing situations that require direct proportion from those involving inverse proportion, or they fail to translate information from verbal statements into mathematical operations.

To identify in depth where students make errors, a systematic analytical tool is required. One comprehensive method for identifying students' errors in solving word problems is Newman's Error Analysis (NEA). Developed by Anne Newman, this method divides problem solving into five hierarchical stages. If a student makes an error at one stage, the student tends to make errors at subsequent stages or may be unable to continue the problem-solving process at all.

The five stages of Newman's Error Analysis are: (1) Reading, namely the student's ability to read words and symbols in the problem; (2) Comprehension, namely the student's ability to identify what is known and what is being asked; (3) Transformation, namely the student's ability to select the appropriate mathematical method or formula; (4) Process Skill, namely the student's ability to perform calculations correctly according to the required procedures; and (5) Encoding, namely the student's ability to write the final conclusion in accordance with what is asked in the problem.

2 METHODOLOGY

This study employed qualitative research with a descriptive approach. The purpose of this approach was to describe, analyze, and interpret in depth and naturally the data concerning students' errors in solving ratio and proportion word problems.

The study was conducted at SMP N 2 Bantarsari. The subjects were Grade VIID students who had studied ratio and proportion. Interview participants were selected using purposive sampling, in which the researchers selected several students whose test results showed the widest variety of errors based on Newman's indicators for further interviews.

The primary instrument in this study was the researcher, supported by a ratio-and-proportion word-problem test and an interview guide. The test consisted of eight word problems. The data-collection procedure began by administering the written test to all students in the class. After the students' answer sheets were scored and analyzed using Newman's error indicators, the researchers classified the types of errors. The next step was to interview the selected participants to obtain deeper information about the causes of the errors they made.

The data-analysis technique in this study referred to the interactive model of Miles and Huberman, which consists of three main stages: (1) Data Reduction: selecting, simplifying, and categorizing students' test responses and interview transcripts according to the five stages of Newman's errors; (2) Data Display: presenting organized information in the form of narrative text and percentage tables to identify overall error patterns; and (3) Conclusion Drawing: formulating the meaning of the presented data regarding the types and causal factors of students' errors and drawing an overall conclusion.

3 RESULTS

Based on the results of the written test administered to [Number] students, various response patterns were obtained, indicating errors made by students in solving ratio and proportion word problems. The students' answer sheets were then analyzed individually based on the five Newman error indicators. A summary of the percentages of student errors is presented in Table 1.

Table 1. Percentage of Student Errors

No.	Type of Error	Number of Errors	Percentage
1	Reading	0	0%
2	Comprehension	9	37.5%
3	Transformation	6	25%
4	Process Skill	4	16.7%
5	Encoding	20	83,3%

Based on the data above, the following is an in-depth description and discussion of each stage of Newman's errors identified in the study:

1. Reading Errors

   Reading errors occur when students are unable to read the meaning of words or recognize symbols in word problems. Based on the findings, the percentage of errors at this stage was relatively low, at 0%. Most students at the secondary level were already able to read sentences fluently.

2. Comprehension Errors

   Comprehension errors occur when students are able to read the problem properly but are unable to grasp what information is given and what the problem asks. At this stage, 37.7% of students were found to make errors. The main indicators of these errors were that students did not write the "Given" and "Asked" elements on their answer sheets, or they wrote them in a way that did not correspond to the intended meaning of the problem.

   Students often merely copied the problem statements without being able to reduce them to mathematical information. Many students failed to understand whether the context referred to

direct or inverse proportion, for example in problems concerning the time required to complete a project in relation to the number of workers.

3. Transformation Errors

   Transformation errors constitute a crucial stage at which the percentage of errors began to increase significantly, reaching 25%. These errors occur when students understand what is being sought but fail to determine the appropriate mathematical operation, method, or formula needed to solve the problem.

   In ratio and proportion problems, transformation errors were particularly evident when students reversed the construction of ratio equations. For example, in an inverse-proportion problem involving workers and time, instead of formulating a1 / a2 = b2 / b1, students used the ordinary cross-multiplication relationship for direct proportion, a1 / a2 = b1 / b2. This indicates that conceptually, students were not yet able to transform the real-world situation of "the more workers, the less time required" into an inverse-proportion mathematical model.

4. Process Skill Errors

   Process skill errors accounted for 16.7%. This type of error occurs when students have successfully constructed the correct mathematical model (correct transformation) but fail or make mistakes in carrying out the computational procedures.

   Common errors included: (1) lack of accuracy in multiplication or long-division operations; (2) errors in simplifying ratio fractions; and (3) basic computational errors, such as dividing a variable by an incorrect number, resulting in a final calculation that deviated from the correct result.

5. Encoding Errors

   Encoding errors represented the stage with the highest accumulated percentage of errors, reaching 83.3%. These errors occur when students do not write a final conclusion from the answer obtained, do not include the appropriate unit (for example, km, days, liters, or items), or write a final answer that does not address the main question in the problem.

   The main factor contributing to the high percentage at this stage is the hierarchical nature of Newman's stages. If students make errors at the transformation or process-skill stage, their final conclusions will automatically be incorrect, even though their calculations may be correct based on an incorrect formula. In addition, many interview participants stated that they were not accustomed to writing final conclusions (for example, "Therefore, the amount of fuel needed is ...") because they were accustomed to solving multiple-choice questions that do not require formal solution steps.

4 CONCLUSION

Based on the results of the data analysis and discussion concerning students' errors in solving ratio and proportion word problems according to Newman's stages, the following conclusions can be drawn:

1. Students made all five types of Newman errors in solving ratio and proportion word problems, although with varying levels of frequency.
2. The fewest errors occurred at the reading and comprehension stages. This indicates that students generally possessed adequate basic literacy skills.
3. The dominant errors made by students were concentrated at the transformation and process-skill stages. Students experienced substantial conceptual difficulties in translating verbal statements into appropriate mathematical forms, particularly in distinguishing the logic of direct and inverse proportion.
4. Encoding errors had the highest percentage because they represented an accumulation of errors from previous stages, combined with students' lack of practice in writing final conclusions together with the appropriate units.

The implication of this study is that mathematics teachers need to place greater emphasis on the transformation stage, train students to analyze the contextual logic of ratio and proportion before beginning calculations, and develop students' habit of writing structured solution processes in every learning assessment.

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