The Analysis of Student Errors
in Solving Algebraic Math Test Based on TIMSS

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Abstract

The low percentage obtained by students in solving TIMSS problems, especially in the algebra material domain, shows that there are several mistakes that students often make in solving TIMSS-type problems. This study aims to examine students' errors in completing algebraic mathematics tests using the TIMSS (Trends in International Mathematics and Science Study). This was a qualitative descriptive research project in which students of a state junior high school in Sinjai, Sulawesi Selatan, Indonesia, in class VIIIA were the subjects. The research's study instruments included diagnostic tests and interview protocols, and data analysis procedures were separated into three parts: data reduction, data presentation, and conclusion, which involves drawing or verifying. The researchers discovered four kinds of students' errors in completing algebra tests based on TIMSS that were connected to Newman's category: understanding question errors, transformation errors, process skill errors, and answer writing errors. Furthermore, the cause of errors in answering algebra questions based on TIMSS was that students do not pay more attention when writing information based on the following questions; they do not master the material related to the questions; they have a limited understanding of the material related to the questions; they also forget the concept of multiplication; they do not follow the procedures appropriately; and they do not re-check the answers. As a result, teachers must create TIMSS-based questions to help students improve their mathematical abilities.

Keywords: algebra, math test, TIMSS

INTRODUCTION

Education strives to cultivate critical thinking, cognitive reasoning, moral, and ethical ideals (Machfudh, 2017). Mathematics is one of the disciplines taught from elementary school to university (Listiana & Sutriyono, 2018). Most people, however, see mathematics as a tough subject (Widyantari & Yunianta, 2016; Subaidah et al., 2017).

Mathematics plays a critical part in resolving everyday difficulties. The capacity to think critically is employed in the process of examining and assessing a situation to make the best conclusion while addressing challenges (Unaenah & Rahmah, 2019). Critical thinking is essential for coping with challenges in everyday life (Ridho et al., 2020). As a result, persons with inadequate critical thinking abilities are unable to analyze the activities or decisions that have been taken (Restiaji, 2021).

The major source of students' poor critical thinking abilities is a lack of instruction in problem-solving skills and applying what they have learned to new situations. Furthermore, students are not self-sufficient, similarly, their mathematical reasoning skills (Wahyudi et al., 2020).

Error analysis is a procedure used to analyze students' errors in solving mathematical questions. The purpose of the carelessness analysis in this study is to describe the errors and reasons for students' faults in problem-solving. According to Nasser & Carifio (1993), for many years, errors in mathematics particularly in Algebra are considered a form and faults in mathematics, especially in algebra, which are seen as a type of procedural or computational error.

Students' errors in responding to questions, according to Toha, Mirza, & Ahmad

(2018), include misunderstandings, operational errors, and thoughtless errors, with misconceptions being the most prevalent. Fractional material and algebraic forms are examples of math errors made by students (Suhady et al., 2019; Cindy & Sutriyono, 2018).

The Trends in International Mathematics and Science Study (TIMSS) performs a cross-country study every four years. TIMSS is held every four years and attempts to determine the development of mathematics and science learning in the school curriculum (Pratiwi et al., 2016). According to the findings of the 2015 TIMSS Indonesia examination, Indonesia was rated 44th out of 49 nations, with an average score of 397, whereas the international average score was 500 (Hadi & Novaliyosi, 2019). The content domain and the cognitive domain are the two domains of TIMSS. According to the percentage data, the domain of algebraic material has a very low proportion. TIMSS questions are generally substantially contextual problems, demanding reasoning, argumentation and creativity in solving them. TIMSS questions can be used as a tool to measure students' ability levels, ranging from knowledge of facts, procedures, and concepts, to using them to solve simple problems to problems that require high reasoning (Taroreh & Noviyanti, 2019). In the cognitive dimension of reasoning, TIMSS questions include the ability to analyze, integrate, evaluate, draw conclusions, generalize, and justify (Supriana & Rahmat, 2022).

Based on the findings of an interview with one of the mathematics teachers at a state junior high school in Sinjai, Sulawesi Selatan, Indonesia, students frequently make errors when solving mathematical questions, particularly in algebraic material, because they lack counting techniques and do not understand the definitions of variables, coefficients, and constants. Several research results addressed student math problem-solving errors, one of them is research conducted by Subaidah, Erik, & Evi (2017) showing that students have mathematical literacy in solving PISA problems, content, space and form. Cahyani &

Sutriyono (2018) in their research results show that there are three types of mistakes made by students, namely concept errors, operation errors, and careless mistakes. In addition, the results of research conducted by Syahruddin (2019) show that several other factors cause students' errors in solving mathematical problems, namely not having the ability to know and ask things in the problem, rushing to solve the problem, and not having the ability to write down what is known and asked in the question. According to Fatahillah (2017), the sorts of student errors based on Newman's error analysis are reading errors, misunderstandings of issues that result in problem transformation, skill errors, calculation errors, and conclusion errors. Therefore, this study analyzed students' errors in solving TIMSS-based algebra math problems. This research can give information on the features of students' algebraic thinking abilities and activities, which may then be utilized as a reference to develop algebraic thinking skills via mathematics learning.

METHOD

This research approach used qualitative data collection to examine the type of student error and the perception of each student in solving TIMSS-type algebra questions based on Newman's error theory. The type of research used was descriptive-qualitative using diagnostic test data collection. This research was conducted at a state junior high school in Sinjai, Sulawesi Selatan, Indonesia, involving 19 students who took diagnostic tests and 4 interview subjects who were selected based on the type of error. Furthermore, the data analysis techniques in this study consist of data reduction, data presentation, and conclusion drawing or verification (Moleong, 2010).

RESULT AND DISCUSSION

Class VIII students at the school made multiple errors when answering TIMSS questions; on average, 18.94 percent of those who made errors in understanding difficulties were in questions 4, 5, 7, and 9. On average, 14.21 percent of those who experienced

transformation errors were in question numbers 3, 4, 6, and 10, 14.21 percent of those who experienced process skill errors were in question numbers 1, 2, 7, and 8, and 13.16 percent of those who experienced answer writing errors were in question numbers 4, 5, 7, and 9.

According to Newman's error theory, the student's error in solving a TIMSS-based algebraic question is as follows:

Question 1

Question number one, on the other hand, only discovered problems in the process's narrowness. Question 1 is on the summing operation of algebraic forms, and 5 students out of 19 make process skills errors while the rest answer the problems properly. Figure 1 is an example of a student's response to question number 1 due to a process-skill error.

Figure 1. The Example of a Process Skill Error for Question Number 1

In Figure 1, it can be seen that students do not master the inequality concept $12x - 7 < 8x + 5$ after the two segments are reduced by $8x$ and added by 7, which changes to $12x + 8x < 5 - 7$. Whereas, the correct answer is: when the inequality is less than $8x$ and multiplied by 7, it becomes $12x - 7 < 8x + 5$ $12x + 8x < 5 - 7$ $12x - 8x < 5 + 7$.

Question 4

Question 4 is a problem involving the multiplication of algebraic shapes. In this question, 13 participants were recognized as having misunderstood the problem, 7 as having made a transformation error, and 5 as having made an answer-writing error. Figure 2 is an example of an error in question number four.

Figure 2. The Example of an Error for Question Number 4

According to Figure 2, students write down answers that have been identified as having three types of errors based on Newman theory, namely, they are incorrect in determining the thing asked the question and they are incorrect in determining mathematical formulas where students use a pattern plus 4 for each ceramic while the correct pattern is black ceramics using an odd multiple pattern and gray ceramics using a pattern plus 4. Finally, students are unable to conclude because they put down the total number of ceramics utilized when the proper ones are the number of black ceramics and the number of gray ceramics.

Question 5

The fifth question is on the use of algebraic forms in real-world issues. In this question, ten people were identified as having misunderstood the problem, and six people were identified as having written the solution incorrectly. In question number 5, Figure 3 is an example of an answer that was flagged as having an error.

Figure 3 shows that the students write down responses that have been detected as having an error in grasping the problem, particularly their inability to write down facts that are known and asked in the questions.

Furthermore, students made errors in writing replies with improper indications in the conclusion, such as writing 7 without being followed by gram units as beam weight units.
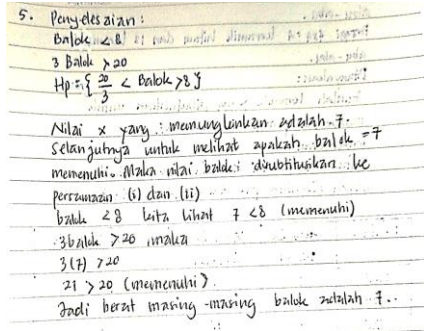

Figure 3. The Example of an Error on Question Number 5

Question 7

Question 7 is about the application of algebraic forms to real-world problems. Seven students were recognized as having falsified their process abilities in this question, and five people were identified as having written replies. In question number 7, Figure 4 is an example of an answer that was flagged as having an error.
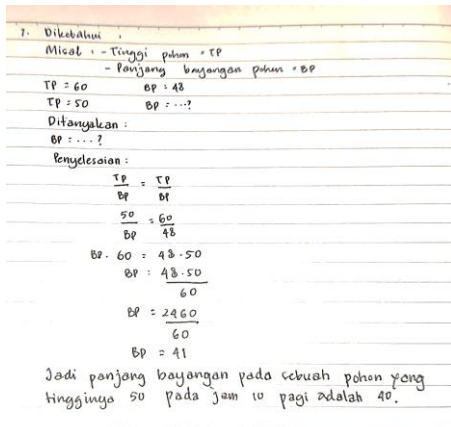

Figure 4. The Example of an Error on Question Number 7

According to Figure 4, the students write down numbers that have been detected as having process skills faults, such as $48 \times 50 = 2460$, while the right result is 2400. Furthermore, students were detected as having an inaccurate response with the improper indicator in concluding due to the absence of cm units.

Question 9

The ninth question is about the concept of algebra. In this question, 8 students were recognized as having misunderstood the problem, and 9 people were identified as having written the answer incorrectly. Figure 5 is an example of an incorrect response with the number 9.
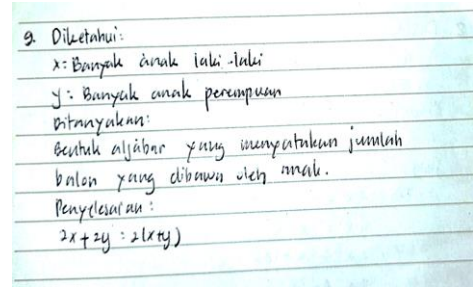

Figure 5. The Example of an Error on Question Number 9

Based on Figure 5, the students are recognized as having an inaccuracy in comprehending the drawing of inferences, with the evidence indicating students are unable to put down the conclusions of the responses.

Furthermore, the researchers conducted interviews with four students, one representing each sort of error that happened, to go deeper and learn more about the reasons why students made the errors. When answering questions based on Newman's hypothesis, each of the four students who took part in the interview made an error.

Interviews were performed with respondents who made errors in comprehending the question (S9), transformation errors (S6), process skills errors (S12), and answering writing errors to determine the reason for the error (S7). The following are the specifics of the interview results:

Interview with S9 (error in understanding the questions)
R : Could you please read question number 8?
S9 : Fira's math test score is 15 points higher than Fara's math score; if Fara's test score is x, then specify the number of their test scores in x!

R : Can you describe and solve the question?

S9 : Yes, I can; it is known that the value of Fira's math score is Fara's score minus 15. (The respondent described it based on the answer sheet.)

R : Are you sure?

S9 : Yes, I am pretty sure.

R : Pay attention to the question; the answer must be in the following way: Fira's score = Fara's score + 15.

S9 : Yes, that is it; I should add +15, not minus 15. I answered it incorrectly.

R : Why did you answer it in the wrong way?

S9 : I am careless.

R: Okay, can you answer the questions correctly?

S9 : It looks like this is about Fara's score.

R : Why did you not write it?

S9 : I am in a hurry, so I answered it in the wrong way.

According to the findings of the interview with respondent S9, it appears that the subject can declare the known information in the question, except for Fira's score, which is inaccurate, i.e. Fira = Fara + 15, when the proper response is Fira = Fara - 15. The reply may not provide any material that is erroneously related to the following inquiry. Furthermore, the findings on the respondent's (S9) answer sheet imply that the student misunderstands since he did not write down what he knew and categorized it in response to the question. The error is the result of carelessness and a quick response to the question.

Subject Interview S6 Results (transformation error)

R : Could you please mention the formula used for the number 10?

S6 : The formula used is the rectangular area pattern, which is $L = p + l$.

R : Why do you use that pattern?

S6 : It is based on the question below, which asks about the width.

R : Okay. Do you think that is the correct way to answer that question?

Q6 : Yes, I do.

R : Don't you think that the $p \times l$ formula is the correct one?

S6 : I don't think so. It is because $p \times l$ is the formula for the perimeter.

R : Your answer is incorrect. You should understand that the correct rectangular area formula is $p \times l$.

S6 : I see. Yes, it is.

According to the findings of the respondent's (S6) interview on the transformation error, the respondent committed the error because he could ascertain the formula employed but could not appropriately turn the formula into the question. Furthermore, the respondent's work (S6) demonstrates that he committed a transformation error because he can correctly utilize the formula but was unable to reform it appropriately. The component producing the transformation error is a lack of comprehension of fundamental principles in accurately applying formulas to the question.

Interview with S12 (process skills error)

R : Could you please describe the steps involved in answering question number 2?

S12: We can just directly substitute the values of A and B into the problem equation.

R : Then, what is the next step?

S12: It can be calculated into a simple form.

R : Could you please solve the following pattern, $-\left(10x - 2x^2\right) - 10x - 2x^2$?

S12: We can directly remove the brackets.

R : Don't you think that it must be multiplied by the operation mark?

S12: I don't think so because this question is only about addition and subtraction operations.

According to the findings of the respondent's interview (S12) about process skill errors, it appears that the respondent is not capable of suffering errors while altering the form of an operation. As a result, the student experiences processing issues. A lack of knowledge of the notion of algebraic operations is the cause of the student's process skill errors.

Interview with S7 (answer writing error)

R : What do you think about the answer to question number 7? Is it correct?

S7 : Yes, it is.

R : Could you please recheck the answer? Is the calculation process correct?

S7 : It is miscalculated; the value must be 48 x 50 = 2400.

R : Why do you make miscalculations?

S7 : I have missed it. I am careless.

R : Okay, what can be inferred from the question?

S7 : The conclusion is that the length of the tree's shadow is 40 cm at 10 o'clock.

R : Why don't you write the unit in conclusion?

S7 : I am sorry; I forgot it.

R : Why do you miss it?

S7 : I'm in a hurry and don't have time to double-check the answer.

Based on the findings of the interview with student S7 regarding writing errors, it appears that the student made an error in writing the answer because the student was incorrect in the calculation process and obtained the incorrect final result, and the student could conclude but the final answer was incomplete. According to the passage of the respondent's approach (S7), the factor producing the error in writing the answer was not comprehensive in the calculating process, was rushed, and did not re-examine the answer. Thus, Table 1 summarizes the sorts of errors seen by students when answering algebra questions using TIMSS, as well as the causes of the errors.

Based on Table 1, it is found that there are four types of errors made by students in solving TIMSS-type algebra problems. Lestari (2019) stated that comprehension error occurs when (a) students do not know what is known from the question, (b) students do not know what is asked from the question, (c) students cannot write correctly what they know based on the following question, (d) students cannot write correctly what is asked from the question, and (e) students cannot identify information on the question properly.

Table 1. Various Types of Errors and the Causes

No.	Types of Errors	Factors of Error Occurrence
1.	Understanding question error	Lack of thoroughness and haste
2.	Transformation Errors	Not understanding algebraic concepts
3.	Process skill errors	Lack of understanding of concepts
4.	Errors in Answer Writing	Lack of thoroughness in the calculation process, rushing, and not double-checking the answers

CONCLUSION

Based on the research results, the following conclusions have been reached: (1) according to Newman's theory, when answering TIMSS-based mathematics problems, students experience four sorts of errors: understanding question errors, transformation errors, process skills errors, and answer writing errors; (2) the causes of TIMSS-based algebra problem errors are that students are careless in writing information from the questions, do not master the material related to the questions, lack understanding of the material related to the problem, forget the concept of multiplication, are less thorough, and the finishing procedures used are ineffective. They are also negligent in their computation and do not double-check their results.

The following suggestions may be provided through this study: (1) for students who make mistakes in solving a TIMSS question, they must grasp TIMSS content so that it is easy to solve issues, and they must be accustomed to performing questions with complete completion processes; (2) the teacher must educate the students on how to do the work step by step; and (3) choose subjects that create a variety of errors for other reviewers who perform research connected to the examination of students' errors in answering TIMSS-based math questions.

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