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Analysis of Student Errors in Solving Mathematics Problems Based on Newman Procedure and Providing *Scaffolding*

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Abstract

This error analysis can help teachers identify errors often made by students and provide appropriate solutions to overcome these errors. By knowing and understanding the mistakes students make, ways can be found to minimize or find the right solution to reduce these mistakes. This research aims to describe how students make errors based on Newman's procedural error analysis in solving SPLDV questions and providing *Scaffolding* based on the cause and type of error to reduce these errors. This research is a qualitative descriptive study. The research subjects were 9 class VIII students at SMPN 15 Bandung. Three data analysis techniques are used: reducing data, presenting data and drawing conclusions. Triangulation techniques were used for the validity of the data. The research results show that most students who make mistakes in solving SPLDV questions are at the transformation stage, amounting to 76%. The forms of *Scaffolding* given are types one, two and three; the processing stage is 55%. The forms of *Scaffolding* provided are type two and type three; the encoding stage is 67%, and the form of *Scaffolding* provided was type two. Meanwhile, the Stage where students made the fewest mistakes was the reading stage at 24%; the form of *Scaffolding* given was type two, and the understanding stage was 40%; the *Scaffolding* given was type one and type two.

INTRODUCTION

Mathematics is a subject that is often considered difficult by most students, so students often experience errors in solving mathematics problems. Error is a form of deviation from the actual answer that is systematic [1]. Mistakes are something fundamental and positive in the learning process [2]. However, errors in solving mathematical problems, such as calculation errors in solving problems with flat circular figures, cannot be tolerated because errors in solving mathematical problems indicate that the learning objectives have not been achieved optimally [3].

One topic that often becomes an obstacle for students in studying mathematics is Systems of Linear Equations in Two Variables (SPLDV) [4]. This is in line with the results of interviews with teachers and several class IX students at SMPN 15 Bandung, who said that SPLDV is one of the learning materials that is difficult for students, so they often make mistakes in solving SPLDV questions. SPLDV is an essential topic in mathematics because it is widely used in everyday life in economics, engineering, and science [5]. Studying SPLDV material requires a

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good understanding of concepts and problem-solving skills so errors do not occur when solving questions [6]. However, many students experience difficulties in completing SPLDV. This can be seen from the low student learning outcomes in completing SPLDV [7]. Therefore, it is necessary to analyze student errors in completing SPLDV so that the factors causing student errors can be identified and can provide appropriate solutions to improve students' understanding of SPLDV material.

The way to discover students' mistakes on SPLDV questions is to analyze the errors that appear [8]. One error analysis method that can be used is Newman Error Analysis [9]. The Newman procedure can analyze students' errors in solving mathematics problems, especially essay questions [10]. According to Clement (Susilowati and Ratu), there are five types of errors based on Newman's theory, including (1) reading errors are a form of error that occurs due to students' incorrect understanding of symbols, words or critical information about the problem; (2) errors in understanding the question (comprehension error), namely errors resulting from misunderstanding the information and not understanding what is asked in the question; (3) problem transformation error (transformation error) is an error due to students not being able to convert the problem into a mathematical model; (4) process skill errors are a form of error because students do not understand the procedures used when working on questions and are not careful when carrying out algebraic operations; (5) an error in writing the final answer (encoding error) is an error caused by the student making a mistake or not being correct in determining the final answer [11].

This error analysis can help teachers identify errors often made by students and provide appropriate solutions to overcome these errors. By knowing and understanding the mistakes students make, ways can be found to minimize or find the right solution to reduce these mistakes. One solution is by providing *Scaffolding*. *Scaffolding* is a learning technique where students are given a certain amount of assistance, then slowly, the assistance is reduced, and the students are responsible for carrying out the learning that has been determined. This kind of learning system is designed to support the student learning process, which is related to assisting students in learning and solving problems in the form of questions [12]. According to Priyati & Mampouw, the large number of mistakes made by students prompted assistance in the form of learning support for students at an early stage, which was provided in a more structured manner and then gradually required students to become independent in learning. The provision of *Scaffolding* is adjusted to the type of error the student makes [13].

Scaffolding use: (a) Level 1, environmental provisions, namely the arrangement of the learning environment, allows learning to occur without the teacher's direct intervention. The level at this stage is meant by structuring the learning environment, such as forming study groups, providing structured assignments, and providing learning aids to students to build an understanding of the problems given; (b) Level 2, explaining, reviewing and restructuring, namely providing explanations, reviewing and strengthening students' understanding. This level means that teacher interaction is increasingly directed at students being able to find problems correctly, asking students to find mistakes they have made, asking students to improve their work, and providing learning assistance to students by focusing on aspects that students are still lacking in mastering, and asking students to rephrase the correct answer. To fix a problem; (c) Level 3, developing conceptual thinking, namely, thinking concepts [14]. This level means teacher

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interaction is directed at developing concepts that students have previously mastered by asking students to find alternative answers to solve problems. The level of *Scaffolding* provided depends on each individual [15].

Several studies regarding the analysis of student errors in solving mathematical problems based on the Newman procedure have been carried out with research subjects of elementary school students, middle school students and high school students, one of which is research conducted by Purnama et al. The focus of the research is the analysis of student errors in solving mathematical problems, where the research results are that the errors of students with a high level of ability are encoding errors, and the errors of students with a medium level of ability are processing and encoding errors. In contrast, the errors of students with a low level of ability are errors in transformation, processing, and encoding [16]. Several other studies also focus on providing *Scaffolding*.

Based on the description above, the researcher wants new research to analyze errors based on the Newman procedure with a different method, namely combining error analysis with *Scaffolding* as a solution to minimize these errors. What is described is not only the error analysis but also the form of *Scaffolding* provided. This is done because error analysis and *Scaffolding* are interconnected. Based on these considerations, indicators based on the Newman procedure are suitable for use in this research. Therefore, researchers will examine the error analysis of class VIII students at SMPN 15 Bandung in completing SPLDV based on Newman's Error Analysis and *Scaffolding* Forms. Researchers will discuss the concept of SPLDV, Newman's Error Analysis method, the results of analysis of student errors in completing SPLDV, factors that cause errors and forms of *Scaffolding* to reduce these errors. Hopefully, this article can provide insight and solutions for teachers and students overcoming difficulties in completing SPLDV.

METHODS

Qualitative descriptive research will be used. This research aims to describe students' errors in solving mathematical problems based on Newman's error analysis, factors causing errors, and appropriate forms of *Scaffolding*. This research has four questions on Systems of Linear Equations in Two Variables (SPLDV). This research was carried out at SMP Negeri 15 Bandung. To obtain data on student errors in solving SPLDV questions, researchers gave research subjects a written test in the form of 4 SPLDV questions. Tests are an assessment tool for student success in specific abilities [16].

The answers to the questions are then analyzed based on Newman's error analysis procedure. Furthermore, to increase the validity of the analysis results, researchers also conducted interviews with subjects regarding the answers to the questions given. The interview was an unstructured type of interview, namely an interview that was not based on a question sheet, but the wording of the questions could be changed according to existing conditions [17]. From the results of the answer sheets and interviews, mistakes and the causes of mistakes made by students will be found. The next stage is to reduce data from written test results and interview results by analyzing the mistakes made by students based on Newman's error analysis. Furthermore, from the overall results, a solution can be provided to minimize errors by providing suitable and appropriate *Scaffolding*. The following are the error indicators:

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Table 1. Student Error Analysis Indicators

Newman Procedure	Error Type Code	Error Indicator
Reading	K_1	Errors in reading sentences, numbers, units or notation
Comprehension	K_2	What is known and asked is not stated correctly or is incomplete.
Transformation (transformation)	K_3	Errors in the transformation process according to the context of the question and not being able to state the appropriate formula correctly
Process Skills (Processing)	K_4	- Mathematical operations or solution procedures are not specified correctly - The completion process of the calculation process was not carried out correctly or was incomplete - Calculation errors made by students
Conclusion (Encoding)	K_5	In concluding the final answer, students did not write it correctly or incompletely.

The data validation technique used by researchers is triangulation. This method is carried out by comparing written test results and interview results to obtain the relevance of data on two questions with the same difficulty level. In addition, data presentation is carried out by describing student errors at each stage based on Newman's error analysis. Conclusions are drawn by describing the results previously obtained as an answer to the problem formulation that will be formulated.

The formula used to analyze the number of errors made by students at each stage is based on the following equation:

$$K_1, K_2, K_3, K_4, K_5 = \frac{n}{N} \times 100\%$$

Information :

K_1 = reading stage
K_2 = comprehension stage
K_3 = transformation stage
K_4 = processing skills stage
K_5 = encoding (Stage of writing the final answer)
n = number of students making mistakes
N = total number of students

To see the level of student errors, this research uses the error percentage categories presented in the following Table 2:

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Table 2. Student Error Percentage Category

Percentage	Category
$K < 10\%$	Very small
$10\% \leq K < 25\%$	Small
$25\% \leq P < 40\%$	Enough
$40\% \leq P < 55\%$	Tall
$\geq 55\%$	Very high

Next, to conclude that the student made a mistake based on the analysis of the Newman procedure, the error was in the very high category.

RESULTS AND DISCUSSION

Results Error analysis was carried out on the results of the SPLDV test questions, which consisted of four essay questions by class VIII students at SMPN 15 Bandung. Interviews were also conducted with students to confirm answer sheets. The results of the analysis are presented in Table 3:

Table 3. Student Error Analysis Results

Error Type	Question Number					Average
	1	2	3	4a	4b	
Reading Stage	0%	22%	11%	44%	44%	24%
Stage of understanding	56%	33%	11%	56%	44%	40%
Transformation stage	78%	33%	67%	100%	100%	76%
Process skills stage	22%	33%	44%	89%	89%	55%
Stage of writing the final answer	100%	89%	44%	56%	44%	67%
Average	51%	42%	35%	69%	64%	

Table 3 shows that, on average, most mistakes made by students were at the transformation stage at 76% due to students' lack of understanding in forming mathematical models. The following most common errors were at the encoding stage at 67% because students tended not to write the correct answer after proper processing or did not check again whether the question had been answered. The fewest mistakes students make are at the reading and understanding stage. Based on the question numbers, the mistakes students made most were in questions 4a and 4b, 69% and 64%, respectively, where these questions were at a problematic cognitive level. Next, the errors made by students at each stage will be described one by one based on Newman's error analysis.

Various factors cause mistakes students make, including mistakes from the students themselves, the learning process, learning support media, and so on. This can be minimized according to the type of error and characteristics of the student, for example, by providing appropriate *Scaffolding*. As discussed previously, three levels of *Scaffolding* can help reduce student errors at each stage of the Newman procedure analysis. The following explains the types of errors, the causes of errors and suitable forms of *Scaffolding* to reduce these errors:

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1. Student Mistakes at the Reading Stage

Reading stage errors include errors in reading sentences, notation, numbers, etc., which are fundamental skills that students need to master in solving questions. Overall, class VIII students at SMPN 15 Bandung made the fewest mistakes at the reading stage, namely 24%. The following are examples of answers from students who made mistakes at the reading stage:

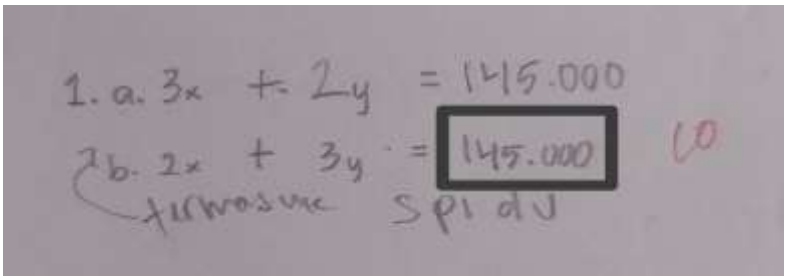

Figure 1. Answer Sheet for Students Who Make Reading Mistakes

The student's answer to the picture is the answer to question number 1, which is about determining whether an illustration is SPLDV. Based on the analysis of the student's answer, it appears that the student made a mistake at the reading stage because the student was wrong in writing the price known in the question. The price should have been 130,000 (circled in the picture), while the student wrote 145,000, meaning the student could not correctly write/interpret the sentences and symbols in the questions. Satoto stated that reading errors occur when students cannot read the questions' words, symbols or keywords [18]. Because the errors are at a fundamental stage, the consequences are fatal because students will also make mistakes in subsequent stages.

After conducting interviews, it was found that students made these mistakes because they were not careful or careless. To reduce these errors, providing suitable *Scaffolding* is level 2 *Scaffolding*, namely explaining, reviewing, and restructuring, providing explanations and reviewing and strengthening students' understanding. The form of *Scaffolding* given to students for these errors is by providing instructions and commands to read again carefully and providing questions and commands so that students look again at the information provided in the problem so that students can understand and solve the problem in question.

2. Student Mistakes at the Understanding Stage

Understanding stage errors includes understanding or writing down what is known and what is asked in the question. Overall, class VIII students at SMPN 15 Bandung also made a few mistakes at the understanding stage, namely 40%. The following are examples of answers from students who made mistakes at the understanding stage:

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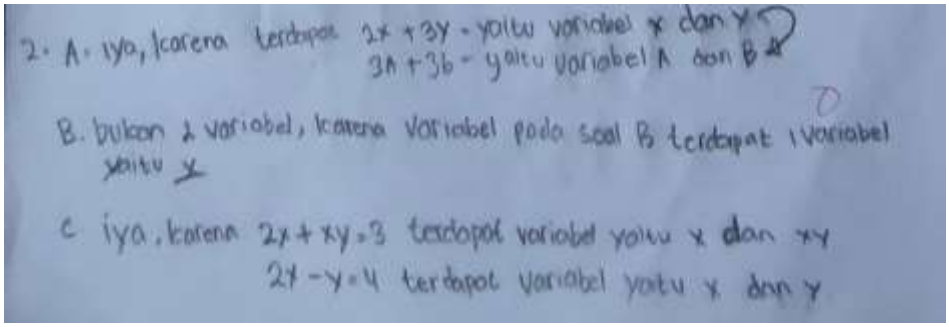

Figure 2. Answer Sheet for Students Who Make Misunderstandings

The student's answer in the picture is the answer to question number two, which is about classifying what is and is not an example of SPLDV. Based on the analysis of the student's answer, the student made a mistake at the understanding stage; namely, the student made a mistake in interpreting or deciphering the meaning of the question, so the answer given was also wrong. From the picture, it can be seen that the way students write answers is by analyzing the equations in the question one by one, but students do not understand the meaning of the question, so the answer does not match what the question asks. Jha and Singh stated that comprehension errors are caused by students being unable to understand the meaning of the entire question, write down and explain what is known, and ask about the question [19].

Based on interviews, students made mistakes due to their lack of understanding of the concept of SPLDV. Students thought that SPLDV was the same as PLDV, so students studied the existing equations one by one, whereas SPLDV was related to several equations at once, so the conclusions obtained were different. The *Scaffolding* that can be provided is type two: explaining, reviewing and restructuring, providing explanations, and reviewing and strengthening students' understanding. The form of *Scaffolding* given by the question is assistance in the form of an explanation, namely by explaining the meaning of the question given to students, reviewing, namely by providing examples or non-examples so that students can better understand and understand the problem being asked. Exists and restores understanding by rebuilding students' knowledge to solve problems.

3. Student Mistakes at the Transformation Stage

Transformation stage errors include determining the correct formula and forming the correct mathematical model. Overall, the transformation stage is where class VIII students at SMPN 15 Bandung make the most mistakes, namely 76%. The following are examples of answers from students who made mistakes at the transformation stage:

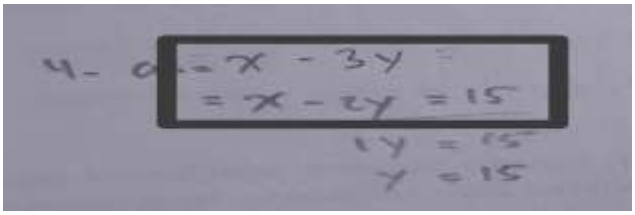

Figure 3. Answer Sheet of Students Who Make Transformation Errors

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The student's answer in the picture is the answer to question number 4a: the story question of determining age. Based on the analysis carried out on students' answers, as in the picture, students made mistakes at the transformation stage, namely when changing the form of the problem to a mathematical model. Students make mistakes, as in the picture. It should be in the mathematical modelling of the addition operation. This is because students are unable or cannot change the form of the problem into a mathematical model, so students also have difficulty identifying operations or determining formulas and solution methods that suit their needs in solving problems.

Based on interviews conducted with students, the factors that cause students to make mistakes are that students do not understand the concept of SPLDV in story problems or story problems that are not routine, so students are confused or cannot form a mathematical model from the problem, besides that students' understanding of the concept is also lacking and students unable to link old knowledge to new knowledge. Thus, the *Scaffolding* that can be provided is type 1, 2, and 3 *Scaffolding*. Type one form of *Scaffolding* is building a more enjoyable learning environment, having group discussions, and providing learning aids that build an understanding of the problems in the questions. The second type of *Scaffolding* that can be given is explaining in detail, reviewing and reconstructing the knowledge that has been obtained. Type 3 *Scaffolding* develops students' thinking concepts or ways of thinking so that they are not monotonous and so that students can solve non-routine problems.

4. Student Errors at the Processing Stage

Errors at the processing stage include errors in carrying out calculations, errors in completion steps, etc. Several processing stages were also carried out by class VIII students at SMPN 15 Bandung, namely 55%. The following are examples of answers from students who made mistakes at the processing stage:

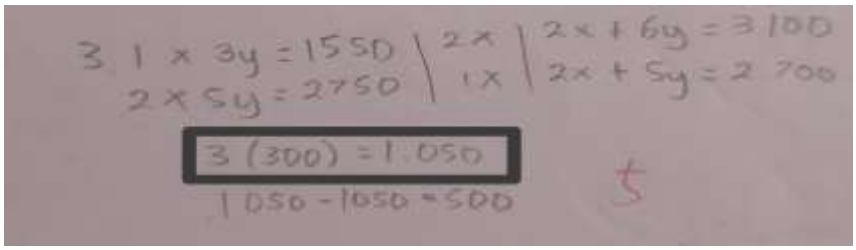

Figure 4. Student Answer Sheet Who Made Processing Errors

The answer in the picture is the student's answer to question number 3: determining the solution to the contextual problem. Based on the analysis of student answers, as in the picture, students made mistakes at the processing stage because they could not correctly carry out the calculation process on the questions the researcher gave. White stated that the process skills stage is where students know the systematics or stages of arithmetic operations used in solving problems and can carry out the correct calculation process with the correct steps [9].

From the interviews, the factors causing students to make mistakes were not understanding the concept of algebraic calculations and being careless and careless. The *Scaffolding* provided is stage three *Scaffolding*, namely linking previously owned knowledge. An appropriate

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form of *Scaffolding* for questions is to ask students to re-check the work process being carried out and provide directions to link the calculation process with algebraic calculations that have been studied previously.

5. Student Errors at the Encoding Stage

Errors at the encoding stage include errors in writing the final answer or answers that match what was asked in the question. Overall, errors at the encoding stage were mostly made by class VIII students at SMPN 15 Bandung, namely 67%. The following is an example of a student's answer who made a mistake at the encoding stage:

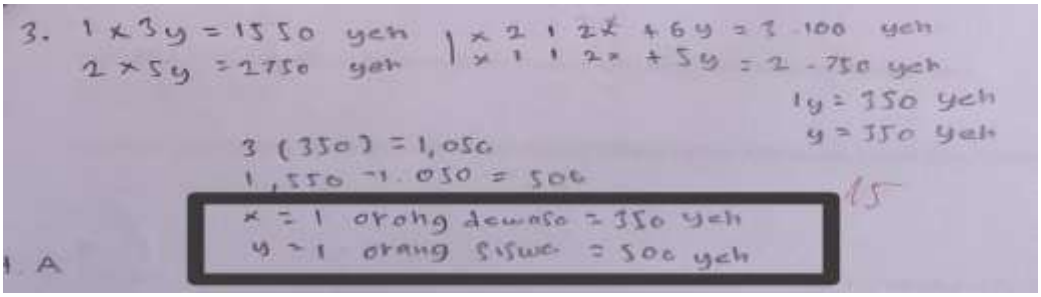

Figure 5. Student Answer Sheet Who Made Encoding Errors

The student's answer in the picture is the answer to question number 3, which is about determining the solution to a contextual problem using the solution method that has been studied. Based on the analysis of student's answers, as in the picture, students made mistakes at the encoding stage, namely in writing final answers or answers to questions that did not match what was asked in the question. In the answer, as in the picture, the adult ticket should be 500 yen and the student ticket 350 yen, while the student wrote the opposite. This means that students cannot write the final answer wholly and correctly. Apart from that, encoding errors also occur in the form of students providing information unrelated to what is asked in the question.

Based on interviews, students made mistakes because they did not understand the concept of the examples used in the solution process; apart from that, students were also not careful and careless. Some students did not write answers because they were in a hurry and did not read the questions correctly. The *Scaffolding* that can be provided is type two: explaining, reviewing and restructuring, providing explanations, and reviewing and strengthening students' understanding. The form of *Scaffolding* given by the question is assistance in the form of an explanation, namely by explaining the meaning of the question given to students, reviewing, namely by providing examples or non-examples so that students can better understand and understand the problem being asked. Exist and restructure understanding by rebuilding students' knowledge to solve problems.

Based on the explanation above, it can be seen that students make many mistakes when solving mathematics problems, such as errors in reading, understanding, transformation, processing skills, and writing answers. The mistakes made by each student vary based on ability level, gender, level of motivation, and so on. Based on previous research, it was explained that providing *Scaffolding* can help students solve problems slowly and can also increase students' learning motivation. Thus, providing *Scaffolding* is one solution to minimize students' mistakes in

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making mistakes. Thus, the study results regarding student error analysis and appropriate *Scaffolding* analysis to minimize student errors based on Newman's error analysis can be an illustration and reference for teachers in choosing better learning approaches, methods and strategies according to student characteristics.

Based on Newman's error analysis, students often make errors at the transformation, calculation and encoding stages. At the transformation stage, students make mistakes when changing questions into mathematical model form. The number of errors made was 76%, which is considered the highest number of errors. At the processing stage, students make mistakes when doing calculations. The number of errors made was 55%, which is quite a lot of mistakes. At the encoding stage, students make mistakes when they write the final answer incorrectly or incompletely. The number of errors made was 67%, classified as making the most mistakes. Factors that cause errors are a lack of understanding of concepts and the ability to link old knowledge with new knowledge, being careless, and being careless and unable to construct old knowledge. The *Scaffolding* that can be given is type one *Scaffolding*., type two and type three.

The stage where students make the fewest mistakes is the reading and understanding stage. At the reading stage, students make mistakes when writing numbers and notations in the questions. This reading stage error was 24%, considered a small error. At the understanding stage, students make mistakes when understanding what they know and what is asked in the question. Errors at the understanding stage of 40% are classified as making a few mistakes. Error factors include being careless and careless and lacking understanding of the concept. The *Scaffolding* that can be provided is type one and type two *Scaffolding*.

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