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Analysis of Students' Errors in Solving Mathematical Literacy Problems by Using Newman's Method: A Comparative Study of Gender

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Abstract
The importance of mathematical literacy skills in the 21st century is the main reason for conducting this study. However, students' mathematical literacy skills do not students' to match reality, as reflected in the low PISA scores in 2023-this proves that their mathematical literacy is still low and raises doubts about their ability to solve mathematical problems at the elementary school level. This low level of mathematical literacy is caused by the high number of errors students make when solving problems, necessitating further research into the difficulties students face in completing mathematical literacy problems. This study used a qualitative descriptive method, in which data was collected through a survey involving 262 students from three elementary schools in Muara Bungo, Jambi Province. Students were then classified according to their initial mathematical ability, which was divided into three categories: high, medium, and low. After that, six male and female students were selected for interviews. Data triangulation (Mathematical Literacy Test and Interview) ensured the validity of the data in this study. Data analysis was conducted following the steps Miles and Huberman outlined, namely data reduction, information presentation, and conclusions. This study shows that the most common errors made by male students are reading: inability to read mathematical symbols; comprehension: inablity to determine what is known and asked in a questions; and transformation, failure to transform mathematical questions and units. Meanwhile female students more often make mistakes in process skills, incorrect mathematical operations, and encoding, failure to write answer, conlclusions, and final units.

Keywords: Comparative study, Gender, Mathematical Literacy, Newman

1. Introduction

Mathematical literacy skills are among the essential competencies for society in the 21st century. Although mathematical literacy plays an important role, the quality of education in Indonesia does

not yet fully reflect this, as seen in the results of various international assessments such as PISA, which assesses these skills. The 2022 PISA results showed a decline, with a score of 366, a decrease of 13 points from the previous year. This data demonstrates that students' mathematical literacy levels remain low (OECD, 2023).

Therefore, minimizing low mathematical literacy skills is essential by analyzing students' mistakes in solving mathematical literacy problems from an early age. This is because elementary school students still have difficulty understanding and solving math problems contextual to everyday life (Vitantri and Syafrudin, 2022). This leads to students making many mistakes when solving problems. The errors frequently occur when students work on mathematical literacy problems are highly varied (Nuryati, et al., 2022). For example, students have difficulty understanding mathematical symbols and terms and determining the data provided and the questions that must be answered.

Additionally, students' mistakes in using methods or formulas prevent them from solving problems correctly, and they may also make mistakes in determining the appropriate units for the results obtained. According to Ariska and Rahman (2020), errors are deviations that occur when solving problems. Errors in solving mathematical problems are inevitable. Azizah's research only discusses errors in understanding problems, planning and implementing problem solving, and checking answers, so there is still much to consider (Rozianita et al., 2022). Thus, researchers sought to conduct a more in-depth study of the errors made by students when solving mathematical problems.

Indicators of mathematical literacy according to Atiyah & Priatna (2023) include: 1. Formulate: the ability to formulate situations systematically. 2. Employ: applying facts, concepts, and steps mathematically to obtain solutions. 3. Interpreting (Interprete): interpreting, applying, and evaluating mathematical results. Many theories can be used to analyze students' mathematical literacy errors. Among the Castellan, Polya, and Newman theories, Newman's theory is the most suitable for students to examine their errors in solving mathematical literacy problems. This theory can be used to explore descriptive issues in a story and has more detailed indicators. Error analysis based on Newman's theory has the highest credibility compared to other theories (Jamal, 2018). Newman explains five sequential steps (hierarchy) that a person must go through in completing a written math assignment, including reading, comprehension, transformation of process skills, and writing the final notation. (Lestari et al., 2018).

Research conducted by Mahardani (2024) and Suharti (2024) States that the research only focuses on differences in mathematical ability. It focused only on analyzing students' errors in solving problems related to flat shapes (Aryanti, 2016; Safitri et al., 2019). The analysis used Newman's approach, which includes five indicators: errors in reading, understanding, transforming, process skills, and writing the final answer. However, there are other aspects, such as gender differences, which are essential to study. Therefore, researchers want to study in more depth the errors made by students using Newman's method based on gender.

Gender is an inherent characteristic of men and women that is shaped by social and cultural factors, giving rise to certain assumptions about the social and cultural roles of men and women (Roisah et al., 2024). As a result, male and female students naturally have many differences in solving mathematical problems (story problems). Another opinion states that there are physiological and psychological differences between individuals in learning (Azzahroh & Putri, 2023). Male students often tend to be lazy in the learning process, unlike female students, who contribute more to solving problems (Patricia & Zamzam, 2019). Meanwhile, male students are better at reasoning, while female students are better at precision. Based on the above background, this study aims to conduct a "Comparative Study of Student Errors Based on Gender in Solving Mathematical Literacy Problems Using Newman's Analysis".

2. Methods

The method used in this study was qualitative descriptive, with surveys as the data collection tool. This study aimed to examine and explain the errors made by students in solving mathematical literacy problems, using Newman's analysis approach based on gender differences, which were analyzed from test results and interviews.

The selection of research subjects used purposive sampling techniques. The subjects in this study were sixth-grade students from three elementary schools in Muara Bungo who had taken the test. Next, six students were selected, consisting of male and female students, each representing the high, medium, and low mathematics ability categories. Data collection was conducted using a test consisting of 5 essay questions and interviews. Questions 1 and 4 measured the indicator of mathematical formulation ability, questions 2 and 3 measured the indicator of application, and question 5 measured mathematical interpretation. Before administering the test to the students, the instruments used were validated using expert validity. To ensure data validity, this study used triangulation techniques. Data analysis refers to the Miles and Huberman (1992) model, which includes reducing data, presenting information, and drawing conclusions.

3. Results and Discussion

3.1. Result

The research data were obtained by testing an instrument consisting of five essay questions given to 262 sixth-grade students from three elementary schools in Muara Bungo. The test results were then categorized based on gender and calculated using Newman's error percentage.

Table 1.
Description of Student Errors

Category	Indicator	Gender							
		Male				Female			
		High	Medium	Low	Average	High	Medium	Low	Average
	RE	1,67%	42,91%	82,50%	42,36%	10,00%	39,36%	67,50%	40,90%
	RC	83,75%	95,10%	97,50%	92,12%	80,00%	90,00%	100,00%	91,21%
	TE	34,58%	75,68%	94,38%	68,21%	35,00%	68,00%	98,75%	67,80%
	PS	15,00%	67,18%	97,50%	59,89%	16,67%	65,55%	98,33%	60,02%
	EE	49,58%	82,23%	97,50%	76,44%	51,67%	83,68%	100,00%	77,30%

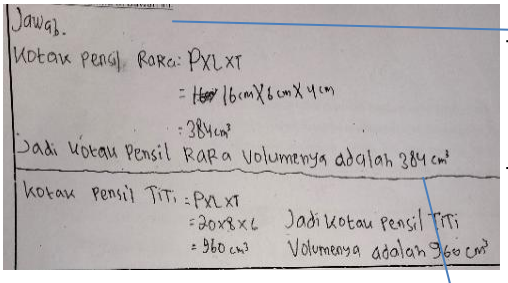
Ket: RE = Reading Errors; RC = Comprehension Errors; TE = Transformation Errors; PS = Process Skills Errors; EE = Encoding Errors

The table above shows the number of students who made mistakes in each indicator experienced by male students, with an average percentage of 42,36% Reading errors, 92,12% comprehension errors, 68,21% Transformation Errors, 59,89% Process Skill Errors, and 76,44% Encoding Errors. Female students made errors with an average percentage of 40,90% for Reading Errors, 91,21% for Comprehension Errors, 67,80% for Transformation Errors, 60,02% for Process Skill Errors, and 77,30% For Encoding Errors. Using Newman's indicator, there appears to be a difference in error patterns between male and female students. Male students show higher error rates than female students in reading, comprehension, and transformation errors. Conversely, female students tend to make more errors in process skills and coding (writing final answers).

3.1.1. Analysis of Errors Made by High-Ability Students Based on Gender (Male and Female) in Solving Problems

Table 2.
Responses from male students with high ability

Rara and Titi bought a pencil case at the stationery store. Rara's pencil case is rectangular, measuring 16 cm in length, 6 cm in width, and 4 cm in height. Titi's pencil case, on the other hand, measures 20 cm in length, 8 cm in width, and 6 cm in height. What is the difference in volume between Rara's and Titi's pencil cases?



TE

RC

PS

EE

Translated into English
Answer:
Rara's Pencil case: P×L×T
= 16cm×16cm×16cm
= 384 cm^3
So, the volume of Rara's pencil case is 384 cm^3.
Titi's Pencil case: P×L×T
=20cm×8cm×6cm
= 960 cm^3
So, the volume of Titi's pencil case is 960 cm^3.

In the answer sheets of male students with high abilities, it was found that they made mistakes in the comprehension section. This was evident from the omission of known information and all five questions. Although the students understood the content of the questions, they did not write down that part in their answers. The students also made transformation errors by not writing down the units and misinterpreting the questions.

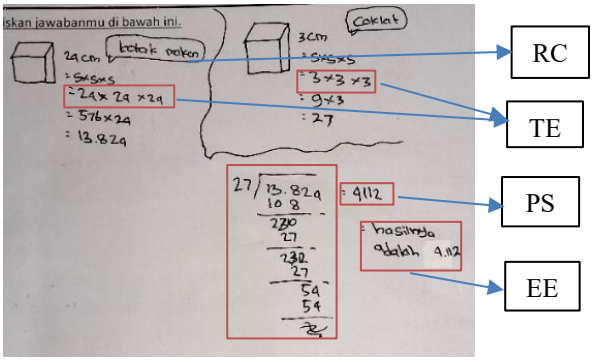
The student made a process skill error by not continuing the answer because they did not understand the symbol used, specifically the symbol for “difference,” as the student was unfamiliar with how the difference symbol is used. As a result, the student made a process skill error by being unable to continue the answer to solve the question. This led to the student's inability to write the final answer and caused an encoding error. This is evident in the following interview results:

P :“Please read the question aloud!”
SLT :(read out the questions).
P :“What information is given in the question?"
SLT :“Rara's pencil case is rectangular, 16 cm long, 6 cm wide, and 4 cm high, while Titi's pencil case is 20 cm long, 8 cm wide, and 6 cm high.”
P :” What is being asked in the question?”
SLT :” The question asks how much the difference is between the lunch boxes.”
P :” Why not use known and asked?”
SLT :” Because of the way I answer like this, sis.”
P :” Usually, when working on story problems, do you write down what you know and what is being asked?”
SLT :” Usually, I respond to the steps, sis.”
P :” Do you think this answer is complete?”
SLT :” I don't think so, sis.”
P :” Why isn't it complete?”
SLT :” Because I'm confused about the volume difference.”
P :But do you know what the difference in volume means?”
SLT :I think volume difference is added.”

P= Reseracher; SLT = Acronim of student name

Based on the interview results, male students understood the questions' meaning. However, when answering, they did not write down the parts they knew and were asked because they were not used to doing so. In addition, students could not continue answering the questions because they could not transform the question, namely “difference,” because they did not understand what difference meant.

Table 3.
Responses from female students with high ability



Translated Into English:

Lunch box
24 cm
=S×S×S
= 24×24×24
=576×24
=13.824

Chocolate
3 cm
=S×S×S
= 3×3×3
=9×3
=27

$\sqrt[27]{13.824} = 4112$

= The result is 4.112

The answers given by female students with high abilities differed significantly from those provided by male students. Female students did not make mistakes in reading and comprehension. However, in the Transformation Indicator, there were errors such as failing to include units in their solutions, and students also made process skill errors by incorrectly applying their answers, leading to errors in the final answer writing indicator, where they were unable to write the answers and their units accurately. This was due to the students being less careful in solving the problems. Below are the results of the student interviews:

P : "Read the following question!"
SPT : "(read the question)".
P : "What is being asked in the question?"
SPT : "The length of the lunch box is 24 cm, and the length of the chocolate bar is 3 cm."
P : "What is being asked in the question?"
SPT : "How much chocolate does Alya need to fill the lunch box?"
P : "Why didn't you write down what was being asked in the question?"
SPT : "Because I have never been taught to write down what is known and what is being asked."
P= Reseracher
SPT = Acronim of student name

P : "Why didn't you write down the units when answering the question?
SPT : "Oh yeah, I forgot to write it down.".
P : "Why did you forget?"
SPT : "Because I was in a hurry and nervous, afraid of making a mistake".
P : "Do you think this answer is correct?"
SPT : "It's wrong, sister".
P : "Why is it wrong?"
SPT : "Because I was in a hurry, sis".
P : " What about the units? Why weren't they written down?
SPT : " Because *I forgot, sis"*.

Based on the interview results, students made comprehension errors, namely, not writing down what was asked, because they did not have a preliminary understanding of how to answer the question. They also did not write down the units when answering questions because they had never

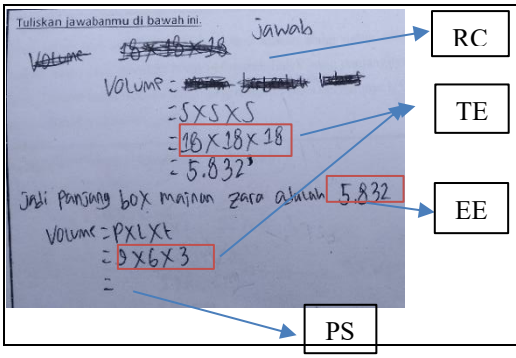
been taught to do so, causing them to make transformation errors. Operational errors were also made due to rushing, causing process skill errors and encoding errors.

3.1.2. Analysis of Errors Made by Students with Average Ability Based on Gender (Male and Female) in Problem Solving

Regarding ability, male and female students in the intermediate category made errors in comprehension (RC), transformation (TE), process skills (PS), and encoding (EE) (figure 3). Based on the answer sheet, male students made comprehension errors, namely, not writing down what they knew and what was asked in the question. However, based on the interview results, students could correctly explain what they learned and what was asked in the question. The student also made a transformation error by not writing the units when answering the question, as well as a process skill error by being unable to continue their answer, resulting in the student not writing the conclusion, final units in the answer, and being unable to complete the procedure correctly.

Table 4.

Responses from male students with moderate abilities

	Translated into English: Answer. Volume = S×S×S = 18×18×18 = 5832^3 So, the length of Zahra's toy box is 5832 Volume = p×l×t = 9×6×3 =…

This aligns with the interview results as follows:

P :"Read question no. 5!"
SLS :"(read the question)"
P :" What can you gather from the question?
SLS : The toy box is 18 cm long, 9 cm wide, 6 cm high, and 3 cm deep."
P :"Next, what is being asked in the question?"
SLS :" Is the box's volume equal to the total volume of the 36 erasers?"
P :" Why did you not write down the known and asked parts of the question?"
SLS: "Because I think it's unimportant, and I'm also afraid there won't be enough time."
P :" Why didn't you use centimeters when answering the question?"
SLS :" Because time is also limited, I wrote 18 without using centimeters."
P :" Why didn't you use the final unit?"

SLS :" I forgot because I was hurrying to do other questions."
P :" Why did you not complete the question and not write down the final answer?"

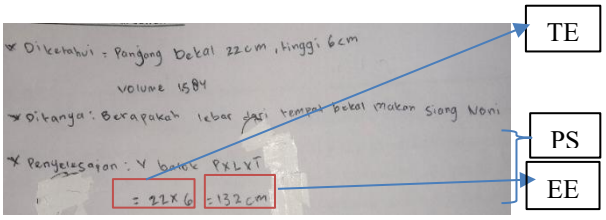
SLS :" Yeah, I forgot. Because yesterday I skipped doing other *questions*

P= Reseracher; SLS = Acronim of student name

Based on the interview results, the student made comprehension errors because they felt it was unimportant to write it down and were in a hurry. The student also made transformation errors because they were in a hurry due to insufficient time. The student also made process skill errors because they were in a hurry and could not write down the final answer.

In the analysis of the answers, female students in the low category made reading, transformation, and process skill errors, and could not write the final answer. The following are the answers of female students in the medium category based on Newman's error analysis.

Table 5.
Responses from female students with moderate abilities

	*Translated into English*: Given: length of lunch box 22 cm, height 6 cm, volume 1584 cm³ Question: What is the width of Noni's lunchbox? Solution: v block p×l×t = 22×6 = 132cm

Based on these answers, female students made reading errors, namely not being able to read the unit cm^3, where the text should have been read as cubic, but female students did not know this. This was because female students did not know this. Female students made transformation errors, namely, not writing the units when solving the problems. Female students also made process skill errors by not writing their answers according to the procedure in solving the problem, which should have been 22 × 6 = 132 cm, then dividing that result by the volume of the cube, 1584 cm^3. Still, they only wrote 132 cm and did not continue, even though the female students knew the answer. This was because the female students were unsure of what they were doing. In the final answer, the student should have written 132 cm^2, but only wrote 132 cm without the correct unit. The interview results prove this:

P :" Read question no. 3!"
SPS :(Reading the question)"

P :" What can you gather from the question?"
SPS :"22 cm"

P :" What is being asked in the question?"
SPS :" What is the width of Noni's lunch box?"
P :" What formula was used?"
SPS :" Pxt"
P :" Please explain further!
SPS :" The result of 22x6 is 132 cm."
P :" Why is the answer not written as 22 cm, 6 cm?"
SPS :" Because that's how we're used to doing it."
P :" What's next??"
SPS :" Next, divide it, but it's not finished yet."
P :" Are the steps correct?
SPS :" Not yet."
P :" Why not?"
SPS :" Because I'm not sure."
P :"Which part are you not sure about?"
SPS :" The formula, sis."
P :" What does the formula pxlxt mean?"
SPS :" I don't know, sis, it seems like a block formula."

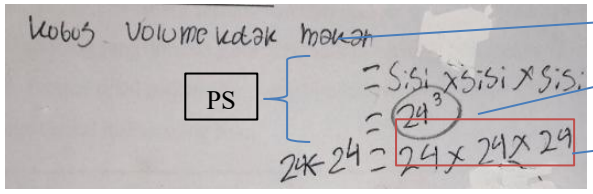
P= Reseracher; SPS = Acronim of student name

Based on the interview results, it was proven that female students made mistakes in solving problems, namely transformation errors by not writing down the units when working on the issues, and process skill errors, namely not being able to continue with the answers because the students were not used to writing them down, thus causing encoding errors.

3.1.3. Analysis of Errors Made by Students with Low Ability Based on Gender (Male and Female) in Problem Solving

In the answers given by male subjects in the low category, errors were found in reading (RE), comprehension (RC), transformation (TE), process skills (PS), and encoding (EE).

Table 6.
Male Students' Responses with Low Ability

	*Translated into English*: Cube volume of a box = sisi×sisi×sisi = 24^3 24×24 = 24×24×24

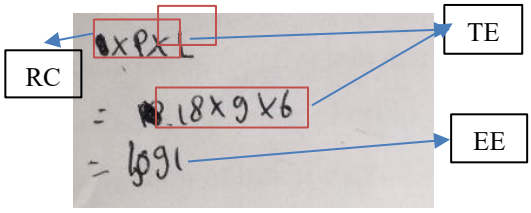
Based on the analysis of male students' answers, male students were unable to complete the questions given because they did not understand and were unfamiliar with the material covered in the questions, which prevented them from reading the questions correctly and understanding them, resulting in transformation errors and an inability to complete the questions according to the procedures, thus preventing them from writing the correct final answers. Based on the above explanation, the following was proven from the student interviews:

P :"Read question no. 1!"
SLR:"(Reading the question)"
P :"Based on the question, is there anything you don't understand?"
SLR:"No, sir."
P :"What is the formula?"
SLR:"Side × side × side."
P :"What formula does side × side × side belong to?"
SLR:"I'm not sure, but I generally don't enjoy mathematics."
P :"Based on the question given, what is known from the question?"
SLR:"side × side × side"
P :"Next, what is being asked in the question?"
SLR:"(reading all the questions)"
P :"Do you think this answer is complete?"
SLR:"Not yet, sir."
P :"In that answer, why didn't you write 24 cm?"
SLR:"Because I forgot, sir."
P :"What's the next step?"
SLR:"Multiply, sir."
P :"Why didn't you multiply?"
SLR:"Because I'm not good at multiplication, sir."
P :"Why didn't you continue?"
SLR:"Because I don't know, sis."

P= Reseracher; SPS = Acronim of student name

Based on the interview results, it was evident that students made comprehension errors by not writing down what they knew and were asked because they did not understand when asked what was "asked." Students read the entire question. Students also made transformation errors by not writing down the units because they forgot. Furthermore, students made process skill errors because they could not continue the operation, so they could not write down the final answer.
In response to the low-ability female students, the low-category subjects also made reading, comprehension, and transformation errors. They were unable to perform process skills and made encoding errors.

Table 7.
Responses from women in the low category

	Translated into English: =.. ×P×L =18×9×6 =1091

The figure shows that female students have low comprehension skills, as indicated by errors such as not writing down information that is known and asked in the questions. Based on the interview results, it is known that female students do not fully understand the meaning of the questions given. In addition, they also make mistakes in the transformation stage, such as not including units in

calculations and being unable to perform arithmetic operations correctly, so they cannot write the final answer correctly. The interview findings also reinforce that female students have difficulty understanding questions, which affects their accuracy in completing them. Below are excerpts from the dialogue obtained from the interview.

P : "Read the question!"
SPR : (reads the question)
P : "What do you know about the question?"
SPR : "I don't know, sir."
P : "What is the formula?"
SPR : "Pxlxt"
P : "What is the transformation value?"
SPR : "18x9x6"
P : "So this is the step?"
SPR : "Yes."
P : "Why didn't you write down the unit?"
SPR : "Usually it's just like this, sir."
P : "So you didn't use cm?"
SPR : "Yes, sir, I didn't use it."
P : "In your opinion, what is the unit of volume?"
SPR : "Usually just 18, sir."
P : "Do you write a conclusion when answering the question?"
SPR : "No."
P : "Do you think the steps you took are correct?"
SPR : "I'm not sure about this, sir."

Based on this, students made mistakes because they did not yet have sufficient skills, resulting in comprehension errors (RE), transformation errors (TE), process skill errors (PS), and encoding errors (EE). This was because students did not understand the questions they were asked to answer, which led to other mistakes.

3.2. Discussion

Based on the study's findings, the most common errors among male and female students were reading errors, comprehension errors, transformation errors, and errors in writing/coding. These results align with previous studies showing that comprehension has the highest student error rate (Adiningsih et al., 2021; Fatmawati & Nasution, 2024; Mulyani & Muhtadi, 2019).

This study also revealed that reading errors were the least common type of Newman error, experienced by male and female students at all ability levels (high, medium, and low). This study aligns with the research by Ramdan (2022) and Mubarokah & Amir (2024) However, this contradicts other studies that claim students across all categories do not make reading errors when solving problems (Fatmawati & Nasution, 2024; Halim & Rasidah, 2019).

In terms of comprehension errors, male students made more comprehension errors than female students. Students do not write down what they know or what is asked, but from the interview results, they know that they understand these things. This was because they were not used to it, forgot, and felt it was unimportant to write down. This finding is consistent with the study by Sulaiman (2023), which reports that students are generally not in the habit of writing down what they know and what is being asked on their answer sheets.

Transformation errors in answering questions: Male students made more mistakes than female students. The mistakes made by students at the transformation error stage were that they did not write down the units of cubes and blocks according to the concept because they did not have a basic understanding of how to write down units, and did not/incorrectly wrote down the formulas used in solving the questions. These mistakes were caused by the students rushing. The results indicate that female students perform better than male students in transformation. This aligns with research Handayani & Anggraini (2024) Stating that male students' transformation errors are classified as very high.

Regarding process skill errors, female students with high and low abilities made the most mistakes compared to male students. However, male students with moderate abilities made more procedural skill errors. Female students made process skill errors because they were not careful enough, rushed, lacked confidence, were not yet proficient in the operations, and did not follow the procedures in solving the problems. Female students made more procedural skill errors based on the overall average of mistakes. This contradicts other research stating that male students made more process skill errors than female students (Handayani & Anggraini, 2024). This is influenced by the different gender ratios, with more female than male students.

The next mistake made by students was encoding errors, made by both male and female students. The percentage results show that in each category, female students made more mistakes in encoding errors, namely, not writing conclusions, and not or incorrectly writing the final units in calculating the answers. Students did not write findings because they were not accustomed to writing conclusions because they assumed that the final calculation result was the final answer (Dina et al., 2024; Rawi & Nuriadin, 2023). Another encoding error was not writing the final unit when answering because students forgot and were in a hurry to answer the questions (Agustiani, 2021; Mubarokah & Amir, 2024). Forgetting one or more terms of a concept is a sign that students are still experiencing mathematical difficulties, indicating that they do not understand the mathematical material because they do not understand the idea (Hatary et al., 2025).

4. Conclusion

Newman's analysis shows that sixth-grade students experience four types of errors: reading, comprehension, transformation, process skills, and encoding. The results show that male students make more errors in reading, comprehension, and transformation, while female students are more dominant in making errors in process skills and coding. Errors occur because students often rush, fail to note important information, ignore units, or misinterpret symbols. For female students, low self-confidence and poor understanding of the questions are also major causes, especially among students with lower abilities. Errors made in the early stages lead to errors in the final stages, including in the writing of answers. Based on the results of this study, the author provides several suggestions, which are summarized as follows. (1) For researchers, it is necessary to conduct further research in schools with characteristics similar to those of the research site, with a gender

perspective. This is to see whether the findings are the same or different from this study's. This can further develop the research. It can also help build more varied research. Further research can be conducted on the types of student errors based on Newman's indicators. (2) For teachers, when teaching male students, it is important to emphasize their understanding of the comprehension and transformation steps to prevent them from making mistakes in determining formulas and units when answering questions. For female students, it is also important to emphasize their understanding of the process skill steps to prevent them from making mistakes in operating answers and encoding. Additionally, increasing practice with mathematical literacy questions is necessary to enable students to solve problems correctly and systematically.

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