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Analysis of Students' Mathematical Literacy Ability in Algebraic Concepts Based on Trends in International Mathematics and Science Study (TIMSS) Problems

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Abstract. This research uses descriptive qualitative. The aim is to examine students' mathematical literacy abilities and types of errors made by students of MTs Mathla'ul Anwar Kedondong in solving algebraic concept questions that were first accessed from TIMSS. The subjects of this study were all students of class VIII-A MTs Mathla'ul Anwar Kedondong, which had 30 students. The data was collected using tests and interviews. All student answers in the analysis of mathematical errors are based on empathy for students' mathematical literacy abilities, namely aspects of knowledge, application, and communication. Furthermore, for further analysis of the students' mathematical errors, 2 students with the lowest scores were selected, representing the mathematical errors of all students based on the four aspects of the students' mathematical literacy abilities for interviews. The data analysis technique is by reducing data, presenting data, and drawing conclusions. The results of the analysis of the data collected, the mathematical literacy ability of students included in the medium category with an average score of 62.38 scores on a scale of 100. Based on the analysis of the mathematical literacy scheme capability mentioned, students can request solutions according to their needs and sufficient good at solving problems on the criminal aspect. However, judging from the mathematical mistakes made by students, students who made mistakes did not review the answers in solving the problems. This causes the problem solving is not correct.

Keywords. Mathematical Literacy Ability, Algebra Concepts, TIMSS Questions

1. Introduction

Mathematics comes from the Greek word *mathein* or *manthenein*, which means to study. This word has a close relationship with the Sanskrit word, *medha* or *widya*, which means intelligence or discovery. According to Afrilianto and Tina (2014: 45), mathematics, as one of the disciplines in education, has a big role and benefits various scientific developments. In addition, according to Sutjipto (2005: 25), mathematics is one of the lessons that needs to be taught in schools because of its many uses in everyday life. Based on this definition, it can be concluded that mathematics is one of the branches of science or subjects that are very important to be applied in schools.

In Dutch, mathematics is called the word *wiskunde*, which means the science of learning. In contrast, the Arabs call mathematics the science of *alhisab*, which means the science of counting. Soedjadi (Alimuddin, 2009) states that one of the functions of mathematics is

structuring students' reasoning. In this case, the role of the teacher is crucial. Namely, the teacher must be able to manage the class in optimal and comfortable conditions for students so that students are more flexible in developing the potential of each student. Lack of understanding in mathematics can often make students lose interest in the subject and affect the results obtained from their mathematics learning. It is known that mathematics is included in subjects that require a continuous process of reasoning and understanding of concepts.

Indonesia has participated in an international scale test, namely Trends in International Mathematics and Science Study (TIMSS). One of the activities measured in TIMSS is students' mathematical ability in countries that take the international test. Each country will send its students to take the test. After the countries take the test, the results will be obtained. Namely, the ranking of each country taking the test, including Indonesia's ranking, can also be known. Based on the results of the TIMSS study, Indonesia ranks low. In fact, Indonesia's ranking is often a reference in looking at students' mathematical abilities. In addition, the results of the TIMSS are used as a reference in making learning curricula in Indonesia. There are many students' mathematical abilities, one of which is students' mathematical literacy skills.

Mathematical literacy is the ability of a person who can formulate, describe, and use mathematics in various contexts, including mathematical reasoning and using concepts, procedures, facts and mathematical tools in explaining and predicting an event. Thus, mathematical literacy helps a person recognize the role of mathematics in the world and make judgments and/or decisions requiring citizens to make decisions. However, the reality in the field shows a lack of students' mathematical literacy skills. The low literacy rate is measured using international instruments and is not specifically adapted to Indonesian conditions. For example, there are items in the TIMSS study that use a stimulus about the subway (underground train) that is unfamiliar to Indonesian children.

This study looks at four aspects of mathematical literacy skills: aspects of knowledge, aspects of the application, aspects of reasoning, and aspects of communication. According to Kusniati (2018), mathematical literacy is divided into several dimensions, including numerical literacy, spatial literacy and data literacy. This is also in line with the main goal of TIMSS is the material contained in the curriculum, for example, for mathematics subjects regarding numbers, measurements, geometry, data, and algebra.

The reality in the field today, in general, educators still do not pay more attention to students who make mathematical mistakes in solving the problems given. Based on the results of preliminary observations and interviews of researchers with mathematics teachers at MTs Mathla'ul Anwar Kedondong, it is known from the odd semester exams that 40% of students have not achieved the KKM and 60% of students who have achieved the KKM. This can be seen from the mathematical abilities of students of class VIII-A Mathla'ul Anwar Kedondong, namely the ability of the middle and upper class.

Meanwhile, the teacher has never analyzed mathematical errors from solving problems done by students. As a result, mathematical mistakes made by students can be repeated continuously in solving problems. Realizing this fact and considering the importance of literacy skills, the researchers conducted this qualitative research to determine the mathematical literacy abilities of students in class VIII-A Mathla'ul Anwar Kedondong and students in solving problems made what types of mathematical errors. In addition, it is also a reference in the subsequent mathematics learning process and prepares learning strategies so that students can improve students' mathematical literacy skills. The types of errors in solving math problems are a) errors in the use of data, b) errors in not reviewing the answers again, and c) technical errors.

In measuring the mathematical literacy ability of students of class VIII-A MTs Mathla'ul Anwar Kedondong, whose thinking abilities vary by each student, the researchers used

questions adapted from TIMSS as an instrument to measure students' mathematical literacy skills. The TIMSS questions used by the researcher accommodate all international benchmarks (international benchmarks), namely advanced, high, medium, and low levels. It is hoped that with this research, teachers can find out the students' mathematical literacy skills and the types of errors made by students in solving problems, as well as consideration in implementing further learning strategies, especially in improving students' mathematical literacy skills. Based on this description, the researcher conducted a study entitled "Analysis of Students' Mathematical Literacy Ability in Algebraic Concepts based on TIMSS questions at MTs Mathla'ul Anwar Kedondong".

2. Method

This type of research uses a descriptive qualitative approach. Qualitative research intends to understand the phenomenon of what is experienced by the research subject, such as behaviour, how to describe it in words and language, in a special natural context and by utilizing various methods.

Qualitative research uses methods, namely observation, interviews, or document review. This qualitative method is used for several reasons. First, this method presents the nature of the relationship between the researcher and the respondent directly. Second, this method is more sensitive and more adaptable to the many sharpening of shared influences on the patterns of values encountered. Third, to determine how students' mathematical literacy skills on algebraic concepts are based on TIMSS questions at MTs Mathla'ul Anwar Kedondong.

The subjects taken in this study were class VIII-A, totalling 30 students at MTs Mathla'ul Anwar Kedondong who had An accreditation in the even semester of the 2019/2020 school year. The researcher selected the research subjects to obtain more in-depth and detailed information about the types of students' mathematical errors that appeared in problem-solving. According to Lincoln and Guba (Cahyani, 2019), qualitative research subjects are chosen to obtain maximum information, not to be generalized.

Data collection techniques using tests and analysis. According to Sugiyono (2015: 330), triangulation is defined as a data collection technique that combines various data collection techniques and existing data sources. The triangulation used in this study uses triangulation techniques. This triangulation technique is a data checking technique carried out by checking data from existing sources with different techniques. The aim is to test the credibility of the research data so that there is a guarantee about the level of trustworthiness of the data so that there is no subjectivity.

The instruments used are test instruments and interview guidelines. The data analysis technique used in this study is to use the Miles and Huberman model in Sugiyono (2015: 337), namely through the process of data reduction, data display, and conclusion drawing.

3. Results and discussion

The research was conducted in class VIII-A of MTs Mathla'ul Anwar Kedondong in the even semester of the 2019/2020 school year. The research subjects were all students of class VIII-A, namely 30 students. All students' answers will be analyzed related to mathematical errors based on four aspects of students' mathematical literacy abilities: knowledge, application, reasoning, and communication. Then, for further analysis related to mathematical errors, two students with the lowest scores were selected, representing the mathematical errors of all students based on the four aspects of the students' mathematical literacy abilities. The total number of students is eight students. The code in this study is as follows, namely P for

researchers and S for students. Giving code to students by using the student attendance system. For example, the code S20 means that the student with the absent number is 20.

The researcher conducted a literacy test on November 17, 2020. Then the researcher analyzed the students' answers contained on the student answer sheets. After being analyzed, the average score of students' mathematical literacy skills was 62.38 on a scale of 100. Based on the value interval of the students' mathematical literacy ability category, the literacy ability of MTs Mathla'ul Anwar Kedondong students was moderate. The following is the average score for each aspect of students' mathematical literacy skills.

Table 1. Average Score of Each Aspect of Students' Mathematical Literacy Ability

No	Category	Average Score
1.	Aspect of Knowledge	81,67
2.	Aspects of Application	83,33
3.	Aspect of Reasoning	41,67
4.	Aspect of Communication	49,44
Average		64,03

The table shows that the average score of students in completing the test of students' mathematical literacy skills based on these four aspects is 64.03. The average score of students for each aspect of student literacy ability can be said that students are better able to solve problems with aspects of the application with an average score of 83.33, and students get the lowest average score on the reasoning aspect, 41.67. Then an analysis of the students' answers was carried out. The analysis will be divided into 2 parts: the analysis of all answers based on the four aspects of mathematical literacy skills and further analysis based on each aspect of students' mathematical literacy abilities.

Analysis of All Student Answers

After the test is done, the test data from each student will be analyzed related to the student's answers to the math questions. Based on the analysis of the answers of 30 students, many students still make mistakes in solving the algebra questions given. The types of mathematical errors made by each student were analyzed based on a theoretical study of mathematical errors. Therefore, Table 4.2 shows the types of errors that arise when MTs Mathla'ul Anwar Kedondong students complete the test questions on the algebraic concept.

Table 2. Results of Student Math Error Analysis

Aspect	JKM	Fault Characteristics	BS	Percentage (%)
Knowledge	Data usage	Writing information that is not in accordance with the problem	8	26,7
		Ignoring some of the data needed to solve the problem question	4	13,3
	Not reviewing answers again	Did not write down the completion procedure	4	13,3
		Writing the settlement procedure is unclear or incomplete	1	3,3
		Not re-check the final result	1	3,3
	Technical	Calculation	4	13,3



Application	Data usage	Writing information that is not in accordance with the problem	1	3,3
		Ignoring some of the data needed to solve the problem question	2	6,7
		Did not write down the completion procedure	1	3,3
	Not reviewing answers again	Writing the settlement procedure is unclear or incomplete	1	3,3
	Technical	Not re-check the final result	6	20
Penalaran	Penggunaan data	Writing information that is not in accordance with the problem	6	20
		Ignoring some of the data needed to solve the problem question	2	6,7
	Tidak meninjau kembali jawaban	Did not write down the completion procedure	13	43,3
		Writing the settlement procedure is unclear or incomplete	2	6,7
Komunikasi	Tidak meninjau kembali jawaban	Did not write down the completion procedure	8	26,7
		Writing the settlement procedure is unclear or incomplete	20	66,7
	Teknis	Calculation	1	3,3

Information:

JKM: Type of Math Error

BS: Many Students

From the table above, it can be seen that the types of mathematical errors that arise when students solve mathematical literacy ability test questions on algebraic concepts are based on four aspects, namely aspects of knowledge, application, reasoning, and communication.

Advanced Analysis

Based on the data in Table 1 and the types of errors that appear in Table 2, further analysis is carried out regarding mathematical errors made by students in solving test questions by interview. Eight students were selected, namely the two students with the lowest scores in each aspect of students' mathematical literacy skills. S20 and S29 for the knowledge aspect, S10 and S15 for the application aspect, S28 and S29 for the reasoning aspect, and S15 and S24 for the communication aspect.

Further analysis of the students' mathematical errors against the eight students was conducted by employing interviews. The conversations in the interviews with the eight students can be seen below based on each aspect of students' mathematical literacy abilities.

Knowledge Aspect

For example, from the test results, S20 solves questions on the knowledge aspect questions number 1 and 4 only get a score of 1 out of a maximum score of 2.

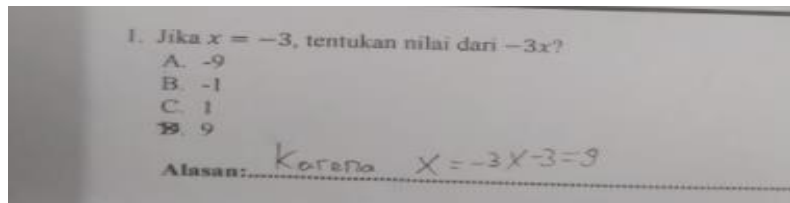


Figure 1. The answer of S20 to Question Number 1

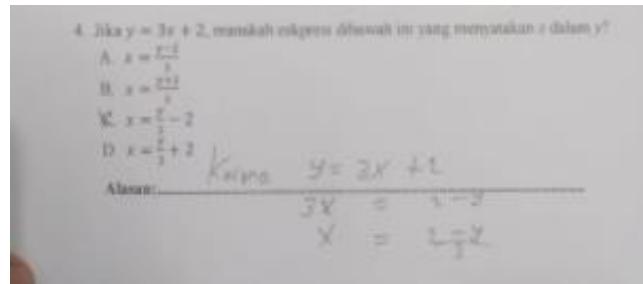


Figure 2. The Answers S20 to Question Number 4

The transcript of the interview results related to the S20 answers in numbers 1 and 4 are as follows:

P: Alright.. I want to ask about your answers, especially number 1 and 4. First, number 1, why did you write the answer like that? Please explain!

S20: Erm... that's it, sir, in the question, what is known is $x = -3$, and the question is $-3x$. So I did it, sir.

P: But you write like this (while pointing to the answer sheet S21 at number 1). No sentence shows what he knows and what he is asked about.

S20: Oh yes, sir, I should have written known and asked.

P: Your answer is correct, but the way you write your answer confuses me.

$$\begin{aligned} x &= -3 \\ &= -3 \times -3 \\ &= 9 \end{aligned}$$

What do you mean?

S20: That should be $-3x = -3 \times -3 = 9$.

Q: I see. Good. Now number 4. How do you solve it? Can you explain again?

S20: So ma'am, right, the problem is $y = 3x + 2$, then what is being asked is changing it to the expression x . So I'm like that bu doing it

Q: Are you sure your answer is correct?

S20: Yes, ma'am.

Q: What concept do you use when you work?

$$\begin{aligned} y &= 3x + 2 \\ 3x &= 2 - y \end{aligned}$$

How can it be like that?

S20: Yes, sir, the teacher taught that, so if you want to form x , then x must be equal to ($x =$) It means that what I moved the y into is $3x = 2 - y$, sir. Right, if the sign is positive (+), move to negative, sir.

Q: Are you sure? Try to rework and re-examine your answers

S20: Ok, sir. (S21 also worked on and re-examined the answer)

Q: How are you doing?

S20: Yes, sir, I was wrong. The answer should be $3x = y - 2$, sir. I was wrong in transferring the sign, sir, not careful enough.

Q: Alright. Thank you.

From the interview above, it is clear that S20 could solve questions number 1 and 4. It's just that for answer number 1, S20 did not write down the information on the question correctly and incorrectly in writing the answer that omitted the variables and coefficients asked. Then for question number 4, S20 uses the concept of fair treatment operation on both segments. However, when working on number 4, S20 was less thorough, and the answers were not re-checked, causing S20 only to write down information on the questions and complete incorrect answers.

Aspects of Application

For example, based on the test results, S10, in answering question number 2, gets a 0 out of a maximum score of 2.

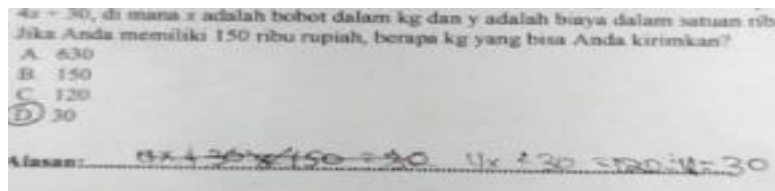


Figure 5. The Answer S10 Question Number 2

The results of the interview with S10 to find more detailed information from S10's answer are as follows:

P: Okay, I will ask the answer from your test, especially for question number 2. What do you mean by this answer, huh? (while showing the answer S10)

S10: Eee... that's how it is, sir. that's the problem (while pointing to the question). What is being asked is the x. Because the problem is PG, so I try it.

Q: But if you try, why is it $120 - 150 = 30$? Is that true?

S10: Uh yes, sir wrong...

P: If the question is PG and you try it, what if it is an essay? Try to do it without a trial and error system

S10: (then S10 starts working). Here's the answer, sir

Q: Are you sure about your answer?

S10: Yes, sir.

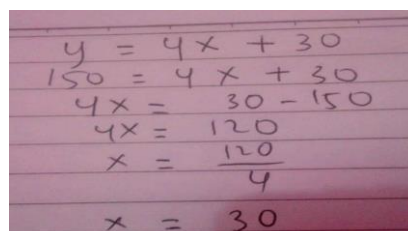


Figure 6. The answer of S10 to Question Number 2 (repeated)

From S10's answer, S10 can find out information on the question and solve it. However, in solving the problem, it turned out that S10 had a technical error, namely calculating the reduction of small numbers with large numbers. In addition, S10 made a mistake in carrying

out the concept of a fair treatment operation on both segments. S10 immediately moves numbers with a positive sign to negative, regardless of their location.

Aspect of Reasoning

For example, from the test results completed by S28, for the reasoning aspect, students answering question number 3 get a score of 0 out of a maximum score of 2.

P: Alright, for your answer, why don't you answer question number 3?

S28: Yes, sir, I did not answer it. Because I don't understand, sir.

Q: Why don't you understand? What is the question sentence that confuses you? So you can't answer it?

S28: No, sir, but I'm confused about the form of the equation

P: But before that, you have received material like questions, right?

S28: Yes, sir, I have, but I forgot and confused about finishing it

Q: If you don't use the completion procedure, can you find the price for 1 pen and 1 pencil?

S28: (read the questions and understand). Yes, sir, 1 pen costs 4,000, and 1 pencil costs 3,000

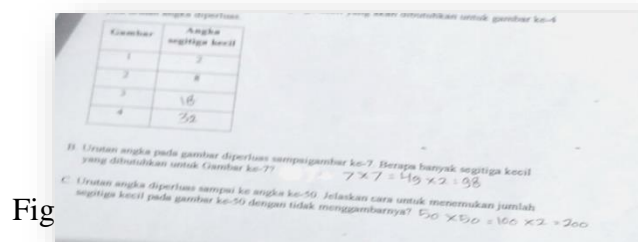
Q: Are you sure?

S28: Yes sir, I'm sure, so if 1 pen and 2 pencils, the answer is 10,000, sir

From the interview results with S28, S28 was able to reason without writing the answer in writing on paper. However, the math error that S28 made was not answering. This is because S28 is not able to make the equation in mathematical form. According to the interviews with subject teachers regarding S28, it turns out that S28 is indeed lacking in converting questions into mathematical form. S28 is good at reasoning, so if there are questions that use reasoning, S28 can reason well.

Communication Aspect

In solving question number 5, S15 gets a score of 1 out of a maximum score of 2. Question number 5 has 3 points that must be answered, and each point is related. However, S15 only earned points A, while points B and C scored 0.



Fig

The results of interviews with S15 are as follows:

P: Okay, I want to ask about your answer number 5. There are 3 points in the question, A, B, and C. Let's start with A. The reason why you answered like that, why?

S15: That's it, sir, right there are pictures 1, 2, and 3, then there are triangles, so determine the number of triangles in pictures 3 and 4, so I count pictures 3 and picture 4

Q: Why don't you write it down in tabular form according to the question?

S15: It's okay, sir. I want pictures 3 and 4

P: If your answer is written like this, I might think that picture 3 is 32 and vice versa. Because there is no explanation from you regarding the answer you wrote

S15: Oh yes, sir, sorry, forgot.

Q: Why is your answer $3 \times 3 \times 2$? Where did you get it from?

S15: Judging from the drawing pattern, sir, it turns out that in the 3rd picture, there are 9 squares arranged 3 3, sir (while showing that it is rows and columns). So, the question is the number of triangles, so multiply by 2 because each square is divided into 2 equal triangles.

P: Oh, I see, then for points B and C?

S15: ee.. point B I forgot to multiply by 2 packs. The 7th picture should be $7 \times 7 = 49$, then multiplied by 2, and the result is 98.

If the C I did not write down the number 0, sir...

Q: Alright...

From the interview results, it was clear that S15 was able to solve problem number 5. Still, the mathematical mistakes he made were not explaining in clear sentences, wrong calculations, and wrong in writing answers or drawing conclusions.

4. Discussion

This study's mathematical literacy ability was viewed from 4 aspects of ability, namely aspects of knowledge, aspects of the application, aspects of reasoning, and aspects of communication. According to Ma'sum (2014), it can be divided into 3 categories of abilities based on the results of the research subject test data, which can be seen in Table 4.3 below.

Table 3. List of Research Subject Ability Categories

Category	Number of Students	Percentage
High	12	40%
Medium	14	46,67%
Low	4	13,33%

Knowledge Aspect

After analyzing students' test data at MTs Mathla'ul Anwar Kedondong on the aspect of knowledgeability, most of the students already know the facts and concepts in an algebraic expression. Students also demonstrate the ability to interpret contextual problems into simple algebraic expressions. However, some students still make mistakes in solving problems in this aspect.

Some of the mistakes made by students were at the time of completion of not writing down information that was by the problem in the problem, some were making errors in the operation of calculating the multiplication of number signs (positive, negative), and some students were not careful as a result the answers they wrote were wrong. After further analysis was carried out by interviewing students who had the lowest scores based on each aspect, it turned out that these students understood variables and coefficients. Still, in solving them, the student was wrong in calculating multiplication involving number signs. Students tended to remember the nature of the addition of negative numbers with signs negative.

Students in this aspect of knowledge understand that $-3 \times -3 = -9$ is the same operation as an addition. This wrong understanding is suspected that students do not understand multiplication operations with number signs because students tend to memorize rather than understand the material. In this aspect of knowledge, many students can complete well, write down information that is following the problem in the problem and write down the procedure for solving it correctly. Therefore, students' mathematical literacy skills from the aspect of knowledge have a good level of literacy.

Aspects of Application

In this aspect of the application, some students can apply their knowledge and understanding of the material on the equation of two variables. However, there were also errors made by 6 students in calculating the distribution of variable coefficients and calculating the fair reduction between the right and left sides.

In addition, some students tend to be unable to apply their knowledge and understanding in solving problems. From the results of the further analysis with interviews, it turned out that these students also made mistakes in calculating fairly. The students did not answer the questions because they did not master the questions in stories. Based on the results of interviews, students tend to be not careful in reading and understanding the questions well, but when asked to solve the questions in a simpler form or not in the form of stories, the students can solve them well.

Errors in this aspect of the application made by students were errors in data use, solutions that were not rechecked, and errors in calculations. The mistakes that students mostly make are errors in the use of data and technical or calculation errors. If students are more thorough in solving them, then errors made by students in this aspect can be anticipated. Although there are still errors in completing students, as mentioned, many students can solve them and write down the completion procedures properly in this aspect of the application. Therefore, students' mathematical literacy skills from the application aspect have a fairly good level of literacy.

Aspect of Reasoning

The student has good reasoning. In the aspect of reasoning, some students can complete it correctly. However, some students cannot understand the information on the problem but have not been able to solve the problem by linking the concepts that should be used in solving it. In addition, some students are unable to show their reasoning because students do not answer the question.

Then further analysis was carried out on the students using interviews. Some students did not answer and answered without the completion procedure based on the analysis and interviews results. After the interview, it turned out that the student had good reasoning in solving questions in reasoning without writing down the complete procedure with the concept that should be on the student answer sheet.

Items in this aspect of reasoning can indeed be solved logically. However, there are still errors made by students in solving problems. The mathematical errors are students writing information that does not match the problem, errors in calculations, ignoring coefficients, and not writing detailed and complete completion procedures. The biggest mistakes made in this aspect is the error of not reviewing the answers. If students double-check their every work, then such mistakes will not occur. Even with these math errors, students who can reason well by solving them are just that students don't write down the completion procedures correctly. Therefore, students' mathematical literacy skills from reasoning are still low compared to other aspects.

Communication Aspect

In this aspect, 96.7% of students have not been able to express their thoughts clearly fully. This is because students are not used to and are not trained in expressing their arguments, especially in writing. This was shown during further analysis by interviewing the two students who had the lowest scores in this aspect.

In the results of the interview, students made mistakes in expressing ideas in solving them. This is because students are not accustomed to expressing their ideas and arguments through writing and have difficulty assembling sentences. Students also make errors in calculations, extract data from tables, and do not explain the complete procedure with sentences or arguments. Therefore, students' mathematical literacy skills from the communication aspect are still low.

Based on the description above, to solve a problem, students should understand the problem they are facing and use their reasoning to analyze any useful information in solving the problem. However, in this study, only a few students were able to do so. Students are not trained and are not used to solving TIMSS and PISA type questions which require a lot of knowledge, application, reasoning, and communication skills. Students are fixated on routine questions that only require simple solutions found in textbooks and memorized with completion patterns. As a result, when given the same question, but presented in a different form, for example, converted into a contextual story, students cannot solve the problem.

When examining the communication aspect in this study, 96.7% of students were not fluent in compiling their arguments. This is due to the lack of trained students in communicating their understanding, ideas or ideas. Students are too fixated on examples of short solutions without understanding the concept more deeply. As a result, students find it difficult to assemble arguments to show their understanding in written form. Likewise, in terms of presenting the results of problem-solving. Students ignore writing rules in mathematics, even though they have been given direction from the researcher regarding the complete procedure.

Students need further guidance and teaching from the teacher. The mistakes made by students must be followed up immediately so that they are not carried away to cause fatal errors in their application. In addition, according to the National Council of Teachers of Mathematics (NCTM) (2000: 22), assessment must support learning and provide useful information for teachers and students. If mastered and has not been mastered, students can know the parts that must be improved and improved again.

However, the weakness of this research is that the researcher's limitations are that the researcher does not analyze the types of mathematical errors using logic in concluding. This type of error should be included in the type of mathematical error in this study used to analyse aspects of students' reasoning. This is because the researcher did not analyze the researcher's mathematical errors and limitations in finding sources or studies related to this research.

Behind these weaknesses, as for the advantages of this research, it can be seen that class VIII-A students can actually do the TIMSS questions at MTs Mathla'ul Anwar Kedondong. In addition, it can be seen that not all Indonesian students have low mathematical abilities in taking the International study test, namely TIMSS.

5. Conclusion

Research conducted in class VIII-A of MTs Mathla'ul Anwar Kedondong can be concluded that students' mathematical literacy skills in algebraic concepts with all four aspects achieve an average score of 62.38 on a scale of 100. This study also obtained information related to students' errors in solving algebraic concepts adapted from TIMSS. Based on the results of the research and analysis of errors, it can be concluded that the dominant student made a mistake by not reviewing the answers when solving the questions. Every aspect of mathematical literacy skills, namely aspects of knowledge, application, reasoning, and communication, many students do not review the results of their work. This causes the procedure or solution of the problem to be incorrect or incorrect.

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