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Mathematical Communication Ability Based on *Anyaman Purun* Ethnomathematics

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ABSTRACT

Mathematical communication skills are essential for students to effectively express and understand mathematical ideas. This study investigates these skills within the context of one-variable linear equations and inequalities, incorporating ethnomathematics through the lens of *anyaman purun* (traditional grass weaving) as a culturally relevant framework. A qualitative descriptive research design was employed. The participants included six grade 7 students selected purposively from a pool of 28 students. Data collection methods comprised tests, interviews, and documentation. Data analysis was conducted following Miles and Huberman's model, which includes data reduction, data presentation, and conclusion drawing. Triangulation through test results and interviews was used to ensure data validity. Findings revealed that 46.4% of the students displayed high-level mathematical communication skills, 28.6% demonstrated moderate skills, and 25% exhibited low skills. Students with high proficiency effectively conveyed mathematical concepts using written, visual, and mathematical expressions, while those with moderate skills performed adequately in these areas. Students with lower skills faced challenges across all aspects of mathematical communication. The integration of *anyaman purun* within mathematics instruction highlighted cultural relevance as a tool for enhancing mathematical communication. High and moderate skill levels corresponded with more effective communication and understanding of mathematical concepts, whereas students with lower skill levels struggled with these aspects. The study suggests that incorporating culturally relevant contexts like *anyaman purun* can improve mathematical communication skills, potentially enhancing learning quality and fostering students' ability to articulate mathematical ideas.

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1. INTRODUCTION

Proficiency in communication is crucial when it comes to mastering mathematics. Proficiency in mathematical communication stands as one of the skills developed in the process of learning mathematics (NCTM, 2020). Low communication skills can hinder the process of conveying effective information. Thus, it might lead to misunderstandings. In problem-solving, mathematical communication is essential because it helps express the problem and the process of finding its solution (Sari, Syahputra, & Surya, 2020). So, there needs to be important considerations in designing ways to improve students' communication skills, and one of them is through ethnomathematics.

However, the actual fact is that in the context of mathematics learning, mathematical ability still has not reached the optimal level. The low level of mathematical ability in Indonesian students can be identified through the results of the PISA survey in 2022. Indonesia is ranked 70 out of 81 countries in terms of mathematical ability, with a score of 366 (OECD., 2023). This result shows a decrease compared to 2018, when Indonesia was ranked 72 out of 78 countries with a score of 379 in the category of math skills, according to the PISA report that year (OECD, 2019). The same thing can also be seen from several previous studies which say the mathematical communication skills of junior high school students are observed to be at a relatively low level (Aurelyasari & Nur, 2023; Rochmad et al., 2020; Hutapea et al., 2019; Yanti et al., 2019). Based on these results, teachers need to provide guidance so that students can achieve optimal learning outcomes.

Mathematical communication skills refer to an individual's capacity to articulate mathematical concepts, comprehend, interpret, evaluate, or react to mathematical ideas, and utilize terminology, notations, and symbols to convey these mathematical concepts (Rohid et al., 2019). Another opinion says Mathematical communication serves as a means for students to articulate mathematical concepts verbally or in written form, whether through visual aids such as pictures, tables, graphs, or demonstrations involving mathematical symbols (Qohar & Fazira, 2022). There are three indicators of mathematical communication, according to Kusumah (2020), namely (1) written, students, are able to express ideas using their own words, design mathematical models using correct mathematical language, and provide arguments in writing well; (2) drawing, students are able to explain a problem presented in the form of diagrams or tables so that they can interpret the mathematical or vice versa; (3) mathematical expressions, students are able to convey mathematical concepts fluently using mathematical language.

Students still lack mathematical communication abilities; therefore, interesting learning is needed. One promising approach to addressing these challenges is through the integration of ethnomathematics, which connects mathematics with culture. By connecting mathematical concepts to cultural practices, such as *anyaman purun* from South Kalimantan, students can engage with mathematics in ways that are both meaningful and relevant to their cultural experiences. Ethnomathematics, as the intersection of mathematics and culture, provides a framework for exploring how cultural practices, such as *anyaman purun*, can be used to enhance mathematics learning. By using traditional weaving crafts, which involve geometric patterns and problem-solving, students can develop their mathematical communication skills in a familiar and engaging context.

Ethnomathematics not only discusses historical locations but is also not just a tool for learning in multicultural classrooms. The ethnomathematics approach, which views mathematics as a subject closely linked to context and culture, helps provide a significant framework for enhancing creativity in classroom mathematics learning (Herawaty et al., 2020). Ethnomathematics can also be defined as the intersection of culture, mathematics, and mathematical modeling used to help understand and connect some mathematical ideas (Orey & Rosa, 2021). In addition, Rosa & De Oliveira (2020) also define Ethnomathematics as encompassing mathematical concepts and techniques derived from cultural customs that evolve within both conventional and non-conventional societies. The cultural object used in this research is *anyaman purun* from South Kalimantan. *Purun* is one of the wild plant varieties that widely grows and develops in the swampy areas of South Kalimantan. Ernawati (2021) also categorizes *anyaman purun* into two types, namely flat or two-dimensional and three-dimensional. Flat refers to a technique made with a flat, thin, and wide shape. It is usually used for making mats, tablecloths, traditional house booth walls, and various other decorative items. Meanwhile, three-dimensional plaiting is a type of *anyaman purun* craft that has been modified to create products such as bags, tissue holders, and pencil cases.

Several studies have examined ethnomathematics in weaving practices across various cultures, revealing mathematical elements and skills embedded within traditional crafts. Dosinaeng et al. (2020) identified mathematical concepts such as representation, spatial awareness, connections, and problem-solving within the Boti Tribe's weaving traditions. Yudianto et al. (2020) explored bamboo weaving in Gintangan village, Banyuwangi, identifying cultural elements conducive to ethnomathematics. Similarly, Nurbaeti et al. (2019) focused on geometry concepts found in woven fabric (*tembe nggoli*) from the Mbojo tribe as valuable educational resources. Sowanto & Mulyadin (2019) further developed geometry-based teaching materials derived from Mbojo-NTB traditional woven patterns. Wurdani & Budiarto (2021) examined mathematical literacy within the rattan weaving craft of the Gresik community, underscoring its role in developing essential mathematical skills. Additionally, Amalia et al. (2019) investigated the correlation between students' logical-mathematical thinking and their engagement with diverse rattan weaving motifs in Galmantro Rattan Tourism Village, Cirebon, highlighting the cognitive benefits of traditional crafts. Kamid et al. (2020) categorized mathematical communication abilities by gender, while this study classifies them into high, medium, and low categories. Elfareta & Murtiyasa (2022) analyzed these abilities in the context of two-variable linear equations using Bruner's theoretical framework. In contrast, the present study focuses on mathematical communication skills within the context of *anyaman purun* (South Kalimantan weaving) and one-variable linear equations and inequalities.

However, research on students' mathematical communication abilities based on *anyaman purun* has not existed yet. There are still many researchers who only explore cultural objects but do not apply them in a class. Therefor, this study aims to explore students' mathematical communication skills when solving one-variable linear equations and inequalities, using the ethnomathematics of *anyaman purun* which will be categorized into high, moderate, and low categories.

2. METHODS

This research uses qualitative descriptive research, to describe student learning outcomes in solving mathematical communication problems on the material one-variable linear equations and inequalities, using the ethnomathematics of *anyaman purun*. The research was conducted at Abu Bakar Integrated Islamic Junior High School Yogyakarta in the odd semester of the 2023/2024 academic year. The subjects in this study were six students selected from 28 students from grade 7 I. They were selected by using a purpose sampling technique. This technique is used because the sample is representative enough and has representative value so that the research objectives can be met. Researchers will take 6 students of class 7 I of Abu Bakar Integrated Islamic Junior High School Yogyakarta, comprises two students with high ability, two with moderate ability, and two with low ability. The classification of student scores is shown in the table as follows:

Table 1. Classification of student score

Score	Classification
$80 \le x < 100$	High
$65 \le x < 80$	Moderate
$0 \le x < 65$	Low

After the learning process, students were given a mathematical communication test. The test was in the form of an essay question consisting of 6 questions. Then students were categorized into high, moderate, and low categories. The selected subjects will be analyzed the results of the work and interviews. There is ethnomathematics in *anyaman purun* including woven motifs that form squares, rectangles, cubes, and blocks that have length, width, and height. The mathematical communication test are presented in Figure 1.

1. Make 1 closed sentence and 1 open sentence.
2. Make 1 open sentence into a closed sentence with the correct value.
3. Find the solution of the following linear equation of one variable:
   a. $\frac{5}{7}x + 9 = 15$
   b. $5\left(2y + \frac{3}{5}\right) = 6\left(y - \frac{1}{6}\right)$
   c. $\frac{4a}{4} = \frac{4a+2}{6}$
4. Find the solution of the following one-variable linear inequality where x, y, and r are real number. Then draw the solution on a number line.
   a. $\frac{1}{2}x + 5 > 15$
   b. $2y - 6 \geq 8y + 5$
   c. $3 - (5 + r) < 15$
5. An advice box made of *anyaman purun* is a block with a length of 20 cm more than its width. If the circumference of the base of the advice box is equal to 60 cm.

Source: Misliani 2019

   a. Write down the information with the mathematical model that you obtained based on the problem above.
   b. Determine the length to make the suggestion box.
6. Dalit mats made from *anyaman purun* are rectangular in shape with a length of 3 m and width of $(3x - 2)$ m. The area of the dalit mat is not less than 3 m^2. If the cost of making the mat 1 m^2 is Rp 40.000, then.

Sumber: Misliani 2019

   a. Write down the information with the mathematical model that you obtained based on the problem above.
   b. Determine the minimum wodth and cost that must be provided to make Dalit Mats.

This ethnomathematics aspect can be integrated into the mathematical communication ability test questions. The relationship between *anyaman purun* ethnomathematics and mathematical communication skills is that students can communicate or convert mathematical ideas such as length, width, height into mathematical models. The methods employed for gathering data included tests, interviews, and documentation. Tests were conducted to obtain student answers on the subject of linear equations and inequalities of one variable. The essay test questions were adjusted to the mathematical communication indicators. The indicators of mathematical communication ability used in this study are as follows:

Table 2. Indicator of mathematical communication ability

Indicator	Question number	Problem form
Written. Writing down given information and the inquiry being posed, expressing everyday events into mathematical language or symbols	1,2,5a,6a	Essay
Drawing. Describe the problem situation in the form of a picture or explain the idea of a mathematical situation with a picture	4a,4b,4c	Essay
Mathematical expression. Develop mathematical ideas using mathematical expressions and solve problems	3a,3b,3c,5b,6b	Essay

As for the data collection technique, the researcher gave a mathematical communication ability test to 28 students at the end of the lesson to determine the percentage of students who were in the high, medium, and low categories. After obtaining student mathematical ability test data, researchers selected two students in the high category, two students in the medium category, and two students in the low category for further analysis and interviews. The interview questions aimed to obtain more in-depth data about the students' mathematical students' mathematical abilities and verify students' answers. The documents used were test results and student rosters.

The analysis followed the Miles and Huberman model, involving data reduction, presentation, and drawing conclusions. The data reduction stage involves verifying the responses of six research subjects using mathematical communication indicators. The presentation stage, namely, displays the results of scanned students' answers that have been given indicators of mathematical communication, followed by obtaining interview results to determine whether they support student responses. The drawing conclusions stage is namely the conclusion from the results of verification. Data verification involves cross-referencing the test results with the interview results. Data validation was ensured through triangulation, which relied on information obtained from both test result analyses and interviews.

3. FINDINGS AND DISCUSSION

Table 3 shows the test results of mathematical communication skills of grade 7 students on the material of linear equations and inequalities of one variable. Based on the test results, 13 students are in the high category, 8 students are moderate, and 7 students are low. Thus, students' mathematical communication skills can be said to be good. Then, six students were selected with 2 high categories, 2 medium categories, and 2 low categories.

Table 3. Classification of students’ mathematical communication ability

Category	Many students	Percentage %
High	13	46,4
Moderate	8	28,6
Low	7	25

Table 4. Result of students’ mathematical communication

No	Indicator	Question number	High		Moderate		Low	
			KZ	QSK	DASD	KS	AGN	KAP
1	Written	1	√	√	√	√	√	√
		2	√	√	√	√	√	-
		5a	√	√	√	√	√	√
		6a	√	√	√	√	-	√
2	Drawing	4a	√	√	√	-	-	√
		4b	√	√	√	√	-	√
		4c	√	√	-	√	-	√
3	Mathematical expression	3a	√	√	√	√	√	√
		3b	√	√	√	√	√	√
		3c	√	√	√	√	√	√
		5b	√	√	-	√	√	√
		6b	√	√	√	√	-	-

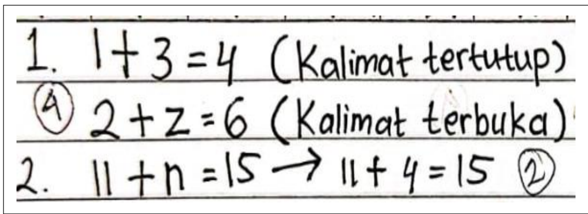
Table 4 demonstrates that students in the high category, such as KZ and QSK, were able to meet the majority of indicators (marked by ‘√’), while those in the low category, such as AGN and KAP, showed gaps in their ability to solve linear inequalities and create accurate mathematical models (as indicated by the absence of check marks).

Students' mathematical communication skills were assessed by interpreting students' work on the six problems for each category. Samples of student answers are divided into high, moderate, and low, namely students in the high category, such as KZ. Students in the moderate category, such as DASD. Students in the low category, such as AGN.

3.1. Students' Mathematical Communication Ability in High Category

3.1.1 KZ Student

Problem number 1, KZ demonstrated mathematical communication ability by open sentences and closed sentences, fulfilling the written indicator. Problem number 2, KZ demonstrate mathematical communication ability by transform an open sentence into a closed sentence, fulfilling the written indicator. KZ could express open and closed sentences into mathematical language or symbols. Apart from that, KZ could transform an open sentence into a closed sentence into mathematical language or symbols.



1. $1 + 3 = 4$ (Closed sentences)
   $2 + Z = 6$ (Open sentences)
2. $11 + n = 15 \longrightarrow 11 + 4 = 15$

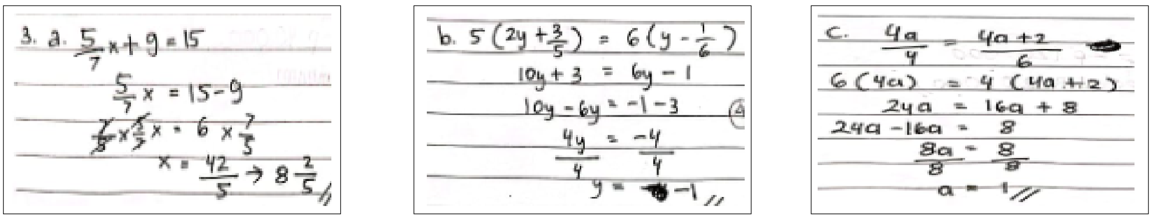
Figure 2. KZ Answer in Solving Problem number 1 and 2

Here is excerpt of the interview between KZ and Researcher (S).

S : *How did you know that* $1 + 3 = 4$ *is closed sentences and* $2 + Z = 6$ *is open sentences?*
KZ : *Open sentences are sentences that have variables while closed sentences do not have variables.*
S : *How about number 2, please tell me why you wrote* $11 + n = 15$ *into* $11 + 4 = 15$ *?*
KZ : *I changed the variable n with 4 so that it becomes a closed sentence.*

The interview results show that student has understood the concept of open sentences and closed sentences. Students are also able to convert open sentences into closed sentences.

Problem numbers 3a, 3b, and 3c, KZ showed mathematical communication ability by solving problems with precise calculations, fulfilling the mathematical expression indicators. KZ could develop mathematical ideas using mathematical expressions and solve problems.



(a) (b) (c)

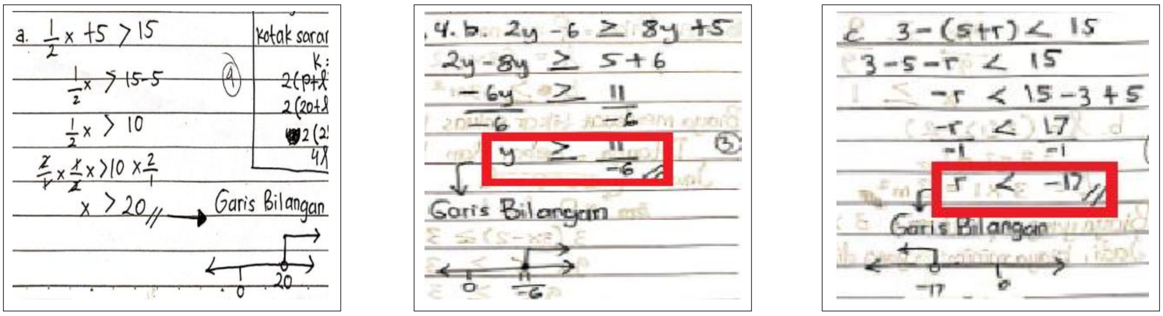
Figure 2. KZ Answer in Solving Problem (a) Problem 3a; (b) Problem 3b; (c) Problem 3c

Here is excerpt of the interview between KZ and Researcher (S).

S : *How did you solve number 3a, 3b, and 3c?*
KZ : *Problem 3a, I put variables with variables, then constants with constants, so as to obtain the value of x. Problem 3b, I worked on the one inside the brackets first. While problem 3c, I did cross multiplication.*

The interview results show that the student has understood the concept of one-variable linear equations. The calculation procedure is appropriate.

Problem number 4a, KZ students showed mathematical communication skills by drawing the right number line, fulfilling the drawing indicator. Problem number 4b and 4c, KZ was able to draw the solution of one-variable linear inequality on a number line, although it was less precise in solving the linear inequality related to “if multiplied by a negative real number then the sign of the inequality will change”. Problem number 4b, KZ wrote $y \geq -\frac{11}{6}$, while the correct calculation should be $y \leq -\frac{11}{6}$. Problem number 4c, KZ wrote $r < -17$, while the correct calculation should be $r > -17$.



(a) (b) (c)

Figure 3. KZ Answer in Solving Problem (a) Problem 4a; (b) Problem 4b; (c) Problem 4c

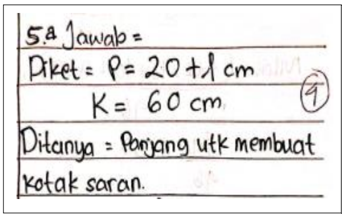
Here is excerpt of the interview between KZ and Researcher (S).

S : *How did you draw number line problem 4a, 4b, and 4c?*

KZ : *Problem 4a, because it is more than 20, the arrow is to the right, then there is a white circle near the arrow which indicates the inequality is more than not more than equal to. Problem 4b, because it is more than equal to* $-\frac{11}{6}$*, the arrow is to the right, then there is a black circle near the arrow indicating the inequality is more than equal to. Problem 4c, because less than then* -17 *the arrow is to the left, then there is a white circle near the arrow indicating less than not less than equal to.*

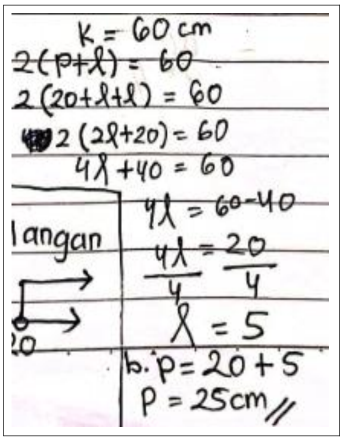
The interview results show that students have understood the concept of how to draw a number line, but KZ needs to improve his accuracy in counting.

Problem 5a, KZ could convey information from the suggestion box made of *anyaman purun* by writing what is known and asked, fulfilling the written indicator. Problem 5b, KZ calculates the width of the suggestion box through the perimeter and the known suggestion box length equation, then puts the width value of the suggestion box into the suggestion box length equation, thus obtaining the length to make the suggestion box, fulfilling the mathematical expression indicator.



Known = $p = 20 + l\ cm$
$K = 60\ cm$
Asked = length to create a suggestion box

Figure 4. KZ Answer in Solving Problem 5a



$K = 60\ cm$
$2(p + l) = 60$
$2(20 + l + l) = 60$
$2(2l + 20) = 60$
$4l + 40 = 60$
$4l = 60 - 40$
$\frac{4l}{4} = \frac{20}{4}$
$l = 5$

b. $p = 20 + 5$
$p = 25\ cm$

Figure 5. KZ Answer in Solving Problem 5b

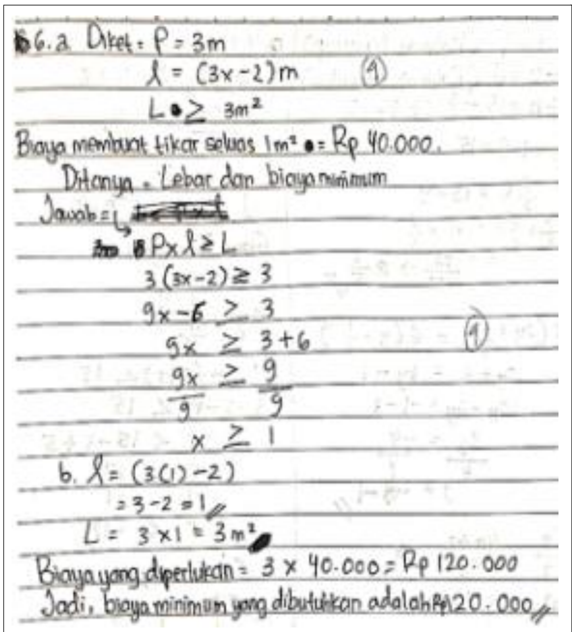
Here is excerpt of the interview between KZ and Researcher (S).

S : *How did you solve number 5a and 5b?*

KZ : *I first wrote down what is known and asked. Then find the width by inputting it into the circumference formula. so that the width is 5 cm and the length is 25 cm.*

The interview results show that students have understood the ethnomathematics problem given, has used the right formula, and the argument given makes sense.

Problem 6a, KZ can convey information from dalit mats made of *anyaman purun* by writing what is known and asked, thus fulfilling the written indicator. Problem 6b, KZ calculated the width of the dalit mats through the known area and length of the dalit mat, then calculated the minimum cost to make the dalit mat, fulfilling the mathematical expression indicator.



Known = $p = 3\ m$
$l = (3x - 2)m$
$L \geq 3m^2$
The cost of making $1m^2$ mat = $Rp\ 40.000$
Asked = Width and minimum cost
$p \times l \geq L$
$3(3x - 2) \geq 3$
$9x - 6 \geq 3$
$9x \geq 3 + 6$
$\frac{9x}{9} \geq \frac{9}{9}$
$x \geq 1$
b. $l = (3(1) - 2)$
$= 3 - 2 = 1$
$L = 3 \times 1 = 3m^2$
Costs required $3 \times 40.000 = Rp\ 120.000$
So, the minimum cost required is Rp120.000.

Figure 6. KZ Answer in Solving Problem 6

Here is excerpt of the interview between KZ and Researcher (S).

S : *How did you solve number 6?*

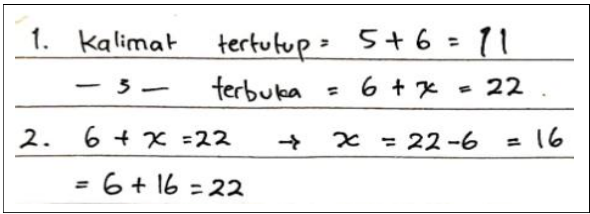
KZ : *I first wrote down what was known and what was asked. Then find the value of the x variable contained in the dalit mat width equation through the known area and length formulas. After that, the width is 1 m. Calculating the cost of making dalit mats, just multiply it by 3 so that it is Rp120.000.*

The interview results show that students have understood the ethnomathematics problem given, has used the right formula, the argument given makes sense, and the calculation procedure is appropriate.

3.2. *Students' Mathematical Communication Ability in Moderat Category*

3.2.1. DASD Student

Problem number 1, DASD showed proficiency in writing open and closed sentences, fulfilling the written indicators. Problem number 2, DASD showed proficiency in converting open sentences into closed sentences, fulfilling the written indicator. DASD always uses the variable x as an example, even though there are many variables that can be used. In addition, DASD always uses the addition operation as an example, even though there are many operations in mathematics that can be used.



1. Closed sentences $= 5 + 6 = 11$
   Open sentences $= 6 + x = 22$
2. $6 + x = 22 \longrightarrow x = 22 - 6 = 16$
   $= 6 + 16 = 22$

Figure 7. DASD Answer in Solving Problem number 1 and 2

Here is excerpt of the interview between DASD and Researcher (S).

S : *How did you know that* $5 + 6 = 11$ *is closed sentences and* $6 + x = 22$ *is open sentences?*

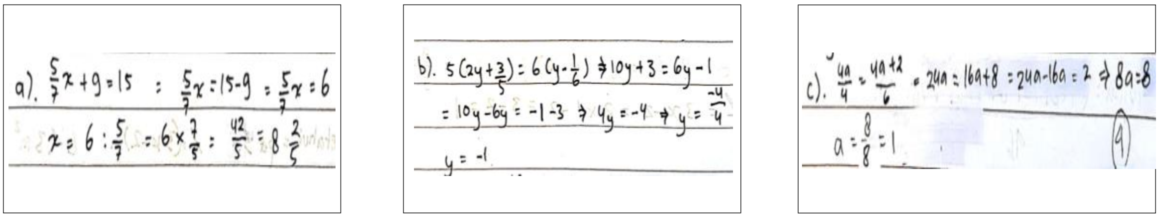
DASD : $5 + 6 = 11$ *has definite truth so it is called a closed sentence, while* $6 + x = 22$ *has no truth because there are still variables whose values are unknown, so it is called an open sentence.*

S : *How about number 2, please tell me why you wrote* $6 + x = 22$ *into* $6 + 16 = 22$ *?*

DASD : *I calculated the value of x first, then substituted it into the equation, so it became a closed sentence.*

The interview results show that DASD can give correct definitions of open sentences and closed sentences.

Problem numbers 3a, 3b, and 3c, DASD showed proficiency in solving problems with precise calculations, fulfilling the mathematical expression indicators. However, DASD needs to write the solution better so that it is easy to understand.



(a) (b) (c)

Figure 8. DASD Answer in Solving Problem (a) Problem 3a; (b) Problem 3b; (c) Problem 3c

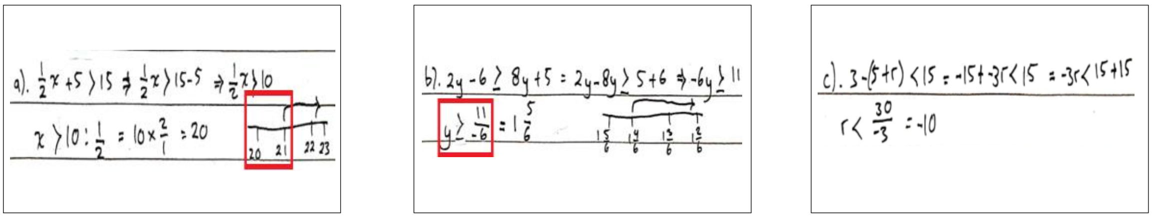
Here is an excerpt of the interview between DASD and Researcher (S).

S : *How did you solve number 3a, 3b, and 3c?*

DASD : *First, I group variables with variables, then constants with constants. If I find parentheses, I do it first. Then for problem 3c, I cross multiply.*

The interview results show that DASD understands how to solve an equation. what rules are prioritized in the calculation.

Problem number 4a, DASD showed proficiency in drawing the number line. However, there are still errors in placing the arrows, drawn on the number 21, it should be number 20. Problem number 4b, DASD was able to draw the solution of one-variable linear inequality on a number line, although it was less precise in solving the linear inequality related to "if multiplied by a negative real number then the sign of the inequality will change". Problem number 4b, DASD wrote $y \geq -\frac{11}{6}$, while the correct calculation should be $y \leq -\frac{11}{6}$. Problem number 4c, DASD made calculation errors and did not draw a number line.



(a) (b) (c)

Figure 9. DASD Answer in Solving Problem (a) Problem 4a; (b) Problem 4b; (c) Problem 4c

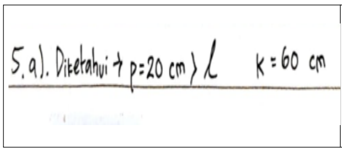
Here is excerpt of the interview between DASD and Researcher (S).

S : *How did you draw number line problem 4a, 4b, and 4c?*

DASD : *Problem 4a, because it is more than 20, the arrow is to the right. Problem 4b, because it is more than equal to* $-\frac{11}{6}$*, the arrow is to the right. Problem 4c, I did not draw the number line.*

The interview results show that students have understood the concept of how to draw a number line, but there are still some mistakes. DASD needs to improve his accuracy in counting and drawing.

Problem 5a, DASD can convey information from the suggestion box made of woven purun by writing what is known, but not writing what is asked. Problem 5b, DASD did not use the perimeter formula correctly which led to calculation errors.



Known = $p = 20\ cm > l$
$K = 60\ cm$

Figure 10. DASD Answer in Solving Problem 5a

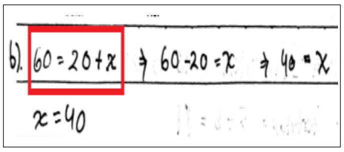


Figure 11. DASD Answer in Solving Problem 5b

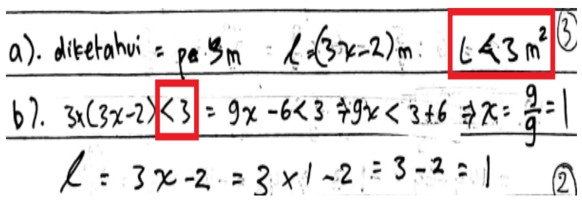
Here is excerpt of the interview between DASD and Researcher (S).

S : *How did you solve number 5a and 5b?*

DASD : *I first wrote down what is known. Then find the width by inputting it into the circumference formula.*

The interview results show that students have understood the ethnomathematics problem given, but did not explain in detail the calculations made.

Problem 6a, DASD can convey information from the problem of dalit mats made of *anyaman purun* by writing what is known, but is wrong in interpreting the sentence "not less than". DASD wrote $L < 3m^2$, while the answer should be $L \geq 3m^2$. Problem 6b, DASD calculated the width of the dalit mats through the known area and length of the dalit mat, then calculated the minimum cost to make the dalit mat, thus fulfilling the mathematical expression indicator.



Known = $p = 3\ m$
$l = (3x - 2)m$
$L < 3m^2$

Figure 12. DASD Answer in Solving Problem number 6a and 6b

Here is excerpt of the interview between DASD and Researcher (S).

S : *How did you solve number 6?*

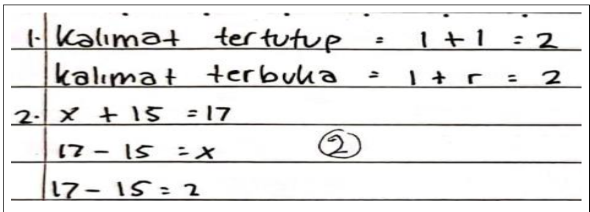
DASD : *I first wrote down what was known. Then find the value of the x variable contained in the dalit mat width equation through the known area and length formulas. After that, the width is 1 m.*

The interview results show that students have understood the ethnomathematics problem given, but did not solve the problem until the end. DASD needs to increase accuracy in working on a problem.

3.3. Students' Mathematical Communication Ability in Low Category

3.3.1 AGN Student

Problem number 1, AGN can give examples of open and closed sentences, fulfilling the written indicator. Problem number 2, AGN can give an example of converting an open sentence into a closed sentence, fulfilling the written indicator. AGN has used a variety of variables and arithmetic operations in giving the example.



1. Closed sentences $= 1 + 1 = 2$
   Open sentences $= 1 + r = 2$
2. $x + 15 = 17$
   $17 - 15 = x$
   $17 - 15 = 2$

Figure 13. AGN Answer in Solving Problem number 1 and 2

Here is excerpt of the interview between AGN and Researcher (S).

S : *How did you know that* $1 + 1 = 2$ *is closed sentences and* $1 + r = 2$ *is open sentences?*

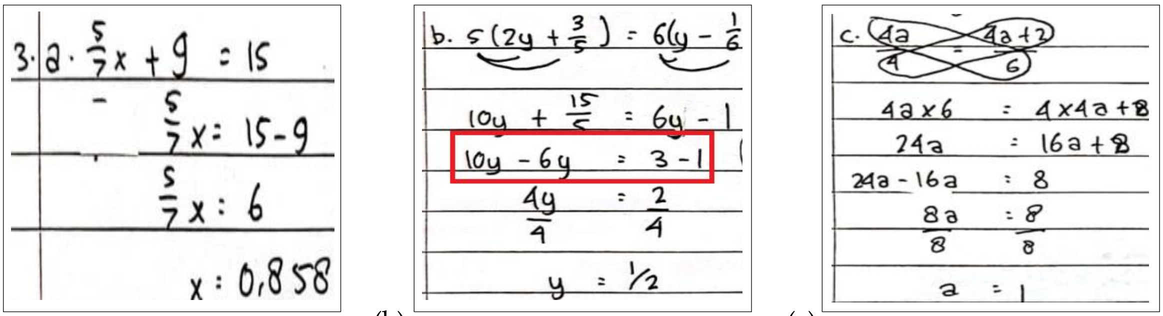
AGN : *One plus one is definitely equal to two. Whereas one plus r equals 2 is still unknown because the value of r is unknown. So, a closed sentence is a sentence that has a truth value, while an open sentence does not.*

S : *How about number 2, please tell me why you wrote* $17 - 15 = x$ *into* $17 - 15 = 2$ *?*

AGN : *Converting an open sentence into a closed sentence, I just finding the unknown variables.*

The interview results show that AGN can give examples of open sentences and closed sentences then can give a reasonable argument.

Problem number 3a, AGN has done the calculation correctly. Problem number 3b, AGN made a calculation error. AGN wrote $10y - 6y = 3 - 1$, while the correct calculation should be $10y - 6y = -3 - 1$. Problem number 3c, AGN has done the calculation correctly.



(a) (b) (c)

Figure 14. AGN Answer in Solving Problem (a) Problem 3a; (b) Problem 3b; (c) Problem 3c

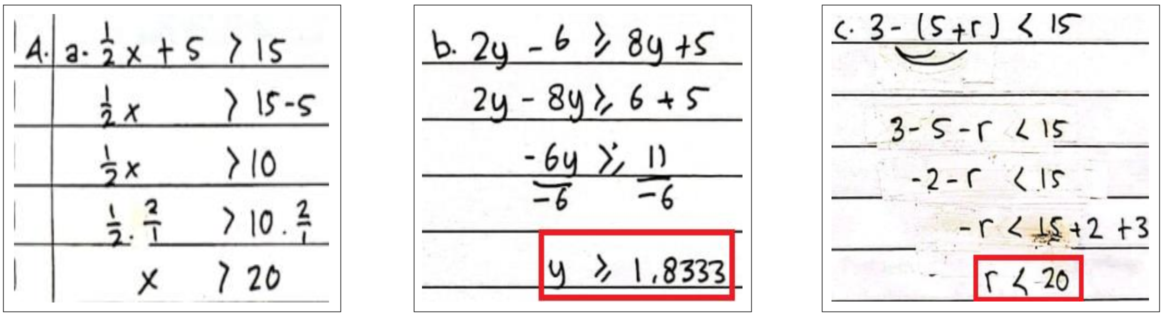
Here is an excerpt of the interview between AGN and Researcher (S).

S : *How did you solve number 3a, 3b, and 3c?*

AGN : *Problem 3a, I group variables with variables, then constants with constants. problem 3b, I used the concept of rainbow multiplication. Problem 3c, I used cross multiplication.*

The interview results show that AGN understands how to solve an equation. What rules are prioritized in the calculation. AGN needs to improve his counting accuracy.

Problem number 4a: AGN did the calculation correctly but did not draw the number line. Problem number 4b and 4c, AGN less precise in solving the linear inequality related to "if multiplied by a negative real number then the sign of the inequality will change". Problem number 4b, AGN wrote $y \geq 1{,}8333$, while the correct calculation should be $y \leq -1{,}8333$. Problem number 4c, AGN wrote $r < 20$, while the correct calculation should be $r > -17$. AGN did not draw the number line problem 4b and 4c.



(a) (b) (c)

Figure 15. AGN Answer in Solving Problem (a) Problem 4a; (b) Problem 4b; (c) Problem 4c

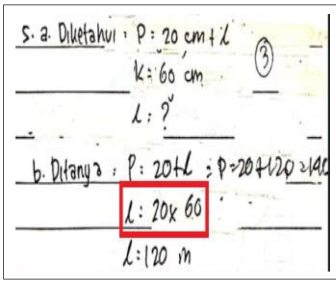
Here is excerpt of the interview between AGN and Researcher (S).

S : *How did you draw number line problem 4a, 4b, and 4c?*

AGN : *I* did not draw the number line problem 4a, 4b, and, 4c.

The interview results show that AGN does not yet understand how to draw a number line. AGN needs to learn more about how to draw a number line for linear inequality of one variable.

Problem 5a, AGN could convey information from the suggestion box made of *anyaman purun* by writing what is known and asked, fulfilling the written indicator. Problem 5b, AGN used the wrong formula to find the width value of the suggestion box.



Known = $p = 20 + l$
$k = 60\ cm$
Asked = l?

$p = 20 + l = 20 + 120 = 140$
$l = 20 \times 60$
$l = 120\ m$

Figure 16. AGN Answer in Solving Problem 5

Here is excerpt of the interview between AGN and Researcher (S).

S : *How did you solve number 5?*

AGN : *I first wrote down what is known and asked. I calculated the width first, obtained the width is 120 cm. Then the length becomes 140 cm.*

The interview results indicate that AGN applied an incorrect formula when attempting to determine the width of the suggestion box, resulting in a miscalculated answer. Moreover, the reasoning provided by AGN lacked coherence, suggesting a limited understanding of the correct approach for solving the problem. In problems 6a and 6b, AGN left the questions unanswered, which may indicate difficulty in comprehending the problem requirements or a lack of confidence in applying mathematical procedures. This suggests potential gaps in AGN's foundational understanding or familiarity with the mathematical concepts needed for these tasks. Additional support, such as targeted feedback or instructional reinforcement, may be beneficial to improve AGN's ability to apply formulas accurately and strengthen their mathematical reasoning skills.

Discussion

From the analysis of mathematical communication ability, it is evident that students in the high category exhibit proficient mathematical communication skills. This is evident as KZ and QSK successfully meet the criteria for writing, drawing, and mathematical expression. Students can solve the problem coherently and correctly at each stage. Then, students can be said to have high ability (Elfareta & Murtiyasa, 2022). Students in the moderate category demonstrate reasonably good mathematical communication skills, as DASD and KS can adequately fulfill the indicators for writing, drawing, and mathematical expression. Students can solve problems coherently but not perfectly at some stages then students can be said to have moderate ability (Elfareta & Murtiyasa, 2022). On the other hand, students in the low category display inadequate mathematical communication skills, as AGN and KAP struggle to meet the criteria for writing, drawing, and mathematical expression. Students have not been able to solve problems well, so it is said that their mathematical communication skills are still low (Elfareta & Murtiyasa, 2022).

Students who have high mathematical communication skills can write mathematical representations in the form of formulas used to solve mathematical problems. They are also able to use mathematical language effectively, including writing mathematical symbols in problem solving, although they do not always use mathematical symbols when explaining known and requested information. High mathematical communication skills are also reflected in the students' ability to describe the shape that matches the image description and provide a clear flow of thought by writing down the steps. In addition, they are able to use various forms of representation, including calculations and writing conclusions accurately (Sinaga, Sinaga, & Napitupulu, 2020).

Students who have moderate mathematical communication abilities can compose mathematical representations in the form of formulas used to solve mathematical problems. They are also able to use mathematical language effectively by writing mathematical symbols to explain problem solving, although they may not always use mathematical symbols when describing known and required information. Moderate mathematical communication abilities also include students' ability to draw appropriate shapes even without picture captions. In addition, students with moderate mathematical communication ability are able to provide a clear picture of their train of thought by writing down the steps, as well as using various forms of representation, including calculations and writing conclusions appropriately (Sinaga et al., 2020).

Students who have low mathematical communication skills show limitations in the use of language and forms of mathematical representation. They tend not to present complete information about what is known and what is asked and do not describe the form that matches the question. In addition, students with low mathematical communication abilities often have difficulty in providing a clear flow of thought, mainly due to their lack of ability to write down the steps appropriately. There are also problems in the use of mathematical representation form, where students may be able to perform calculations but still often produce inaccurate conclusions (Sinaga et al., 2020).

Students classified in the high category exhibit proficient mathematical communication ability (Ikhtiar et al., 2021). Students with high proficiency possess effective written mathematical communication ability, those with moderate proficiency demonstrate reasonably good written mathematical communication ability, and students with low proficiency exhibit weak written mathematical communication skills (Faizah & Sugandi, 2022). The mathematical communication ability of students in the high category can be deemed excellent as they satisfy the criteria for writing, drawing, and mathematical expression. Students in the moderate category only excel in two indicators, namely writing and mathematical expression. Meanwhile, students in the low category can be considered deficient in each of the writing, drawing, and mathematical expression indicators (Ikhsan et al., 2020). The ability to communicate mathematically encompasses more than just students' capability to convey ideas through writing. It also involves skills in verbally expressing, elucidating, narrating, actively listening, inquiring, clarifying, collaborating (sharing), writing, and, in the end, articulating the comprehension acquired through learning. (Dominikus et al., 2020).

Through communication, students can develop and integrate mathematical thinking and knowledge when solving problems. Students often have difficulty in explaining the reasoning behind their understanding of a text. There are still many students who are unable to present solutions effectively in the context of intrapersonal (internal processing of messages) and interpersonal (exchange of information with others) communication, which is an important aspect of understanding the terms needed to solve mathematical problems. This obstacle is related to the different ways students process symbolic message, store information, and use that knowledge in response to mathematical task (Nurjanah, Herman, & Prabawanto, 2019).

4. CONCLUSION

The findings of this study indicate that students categorized as high achievers demonstrate strong mathematical communication skills, while those in the moderate group show adequate proficiency, and students in the low category exhibit significant difficulties in effectively communicating mathematical concepts. These results suggest that teachers should place greater emphasis on fundamental concepts, particularly in teaching students how to accurately represent mathematical information on a number line. Additionally, encouraging students to clearly identify known values and question requirements may improve their problem-solving clarity. A limitation of this research is the sample's homogeneity, as it included only female students, which restricts the generalizability of the findings across gender groups. Future studies are encouraged to include male or mixed-gender samples to assess potential differences in mathematical communication skills across genders. Furthermore, the study's scope was limited to questions rooted in one-variable linear equations and inequalities with limited use of ethnomathematics. Future research should explore a broader range of mathematical topics and incorporate diverse ethnomathematical contexts to further investigate the impact of cultural relevance on mathematical communication skills.

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