



## An Analysis of Students' Mathematical Representations in Solving Algebraic Problem of Seventh Grade Based on Gender

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### ABSTRACT

This study aims to describe the mathematical representations used by male and female students when solving algebra problems. This study employs a qualitative descriptive approach. The research subjects consisted of two seventh-grade students from SMP Negeri 9 Palu who were selected through written tests and interviews. The results show that both male and female students use verbal representations during the problem-understanding and planning stages. During the execution stage, female students use verbal and symbolic representations, while male students use verbal, symbolic, and visual representations. During the review stage, female students continue to use verbal and symbolic representations by rechecking their answers, whereas male students do not use any representations because they do not recheck their work.

Keywords: mathematical representation; algebraic problem solving; gender

### INTRODUCTION

Sormin & Ratuanik (2023) state that representation is a form of interpretation of students' thinking regarding a problem, used as a tool to find solutions to that problem. Representation is crucial for improving mathematics teaching and learning. This aligns with Mainali's (2020) view that representation is a key element in mathematics teaching and learning. According to Rahmadian (2019), several skills can help improve and develop students' ability to think logically, rationally, systematically, critically, and creatively; one of these is mathematical representation. Lette & Manoy (2019) state that representational skills help students communicate and connect mathematical concepts when solving given problems. Therefore, mathematical representational skills are essential for students to communicate and express their mathematical ideas.

There are two types of representation: external and internal. According to Simbolon et al. (2018), internal representations refer to the mental processes that occur in students' minds as they understand and process mathematical information, whereas external representations are the tangible forms of these processes, expressed through writing, drawings, symbols, or mathematical models. Sahendra et al. (2018) define mathematical representations as internal and external configurations that may include words, images, symbols, graphs, tables, mathematical equations, or physical objects that can help students understand and express mathematical ideas. Villegas et al. (2009) there are several types of representation: pictorial representation, symbolic representation, and verbal representation. In his research, Villegas identifies three forms of mathematical representation, namely: (1) verbal representation, which is the expression of mathematical problems or ideas orally or in writing; (2) pictorial representation, which is the presentation of problems in visual forms

such as tables, diagrams, graphs, or pictures; and (3) symbolic representation, which is the expression of problems using mathematical symbols, including mathematical models or equations formed from those symbols.

Mathematical representations can be used as tools for solving mathematical problems (NCTM, 2014). According to Davita & Pujiastuti (2020), problem-solving is a crucial component of the learning process, as it enables students to gain experience in applying their knowledge and skills to solve both everyday and non-routine problems. Rahayu & Hakim (2021) note that solving complex mathematical problems requires simplification through the use of students' mathematical representations. Polya (2004) outlines the steps in problem-solving: understanding the problem, making a plan, carrying out the plan, and looking back. To understand a problem, one must clearly identify what is needed to solve it, then determine how those elements are interrelated and how the unknowns relate to the knowns in order to formulate a plan. According to Polya (2004), once the plan is formulated, it must be implemented, followed by reflection on the problem that has been solved for evaluation and discussion. Thus, students' success in problem-solving depends heavily on the extent to which they can manipulate various representations to explore their mathematical ideas.

Mulyaningsih et al. (2020) indicate that students' mathematical representation skills in Indonesia remain low. One of the most challenging math topics for junior high school students is algebra. Similarly, in the study by Klara et al. (2021), it was found that students still struggle with mathematical representations when solving math problems, particularly in algebra. This was confirmed by interviews conducted at SMPN 9 Palu, which revealed that many students struggle to solve algebra problems, especially when the problems differ from the examples provided. Students also often rely on the methods their teachers use to solve problems. This is because students do not emphasize finding new ways to solve problems. This is consistent with the view of Nur Sabrina et al. (2023) that the use of a single representation leads to a narrow understanding of mathematics among students because they do not have the opportunity to view mathematical problem-solving from other perspectives. This can result in students having underdeveloped mathematical representations, making it difficult for them to build on their existing ideas.

Fuad (2016) states that differences in students' abilities-among both male and female students-influence their representational skills. According to Adnan et al. (2019), an individual's mathematical ability is believed to be influenced by gender differences. Fuad (2016) noted that the varying abilities of both male and female students affect their representational skills. When the same mathematical problem is given to many students, the results they obtain will differ. According to Hajeniati & Kaharuddin (2021), female students' mathematical representations are better than those of male students. According to Saputra et al. (2025), male students tend to be more spatially oriented, while female students are more verbally oriented; thus, it cannot be denied that there are differences in how they present their ideas. Therefore, gender plays an important role in students' mathematical representation abilities.

Several studies indicate that mathematical representations can help students understand problems, communicate ideas, and systematically find solutions to mathematical problems. Research by Puspitasari & Susanah (2022) reveals that mathematical representations play a crucial role in solving social arithmetic problems, while Saputra et al.

(2025) highlight gender-based differences in mathematical representation skills when solving divergent problems. Additionally, Umaroh & Pujiastuti (2020) demonstrate that students' mathematical representation abilities in solving PISA questions are also influenced by gender differences. Meanwhile, Fattah et al. (2018) examined mathematical representations from Bruner's perspective in geometry content, considering mathematical ability and gender. Nevertheless, most of these studies focus on different subject contexts such as social arithmetic, geometry, and PISA questions, and have not specifically examined mathematical representations in algebraic expressions at the junior high school level in depth, even with a limited sample size.

Based on the above discussion, it is evident that students' mathematical representation skills in solving algebraic problems still require attention. Students employ different methods to represent their mathematical ideas, whether through visual, verbal, or symbolic representations. Additionally, gender differences may also influence how students understand and solve mathematical problems. However, it is not yet clearly understood how male and female students' mathematical representations differ when solving algebraic problems, particularly at each stage of problem-solving according to Polya. Therefore, this study was conducted to describe the mathematical representations of male and female seventh-grade students at SMPN 9 Palu in solving algebraic problems. Based on this background, the research questions in this study are: what are the mathematical representations of male seventh-grade students at SMPN 9 Palu in solving algebraic problems, and what are the mathematical representations of female seventh-grade students at SMPN 9 Palu in solving algebraic problems?

## RESEARCH METHODS

The research approach used in this study is qualitative research. This study was conducted at SMP Negeri 9 Palu, Central Sulawesi. The subjects in this study were two students with high mathematical ability, namely one male and one female seventh-grade student. Subjects were selected by reviewing their daily test scores in mathematics. The subjects were determined based on the average score of their daily mathematics tests, followed by the calculation of the standard deviation. The grouping of students based on their mathematical ability is based on table 1.

Table 1. Student Group Criteria

Category	Intervals
High	$n > \bar{x} + SD$
Middle	$\bar{x} - SD \leq n \leq \bar{x} + SD$
Low	$n < \bar{x} - SD$

Notes:

$\bar{x}$  : Mean

$n$  : student scores

$SD$  : standard deviation

This study uses the mathematical representation indicators presented in Table 2.

Table 2. Mathematical Representation Indicators Based on Polya's Stages

Polya's Step	Verbal	Visual	Simbolik
Understanding The Problem	Write down or explain known and requested information in writing or orally	Present information using images, diagrams, or graphs	Restate information using mathematical symbols or models
Making a Plan	Write down or explain strategies in writing or orally	Develop strategies using images, diagrams, or graphs	Develop a strategy for writing formulas using mathematical symbols or models
Carrying Out The Plan	Write down or explain the steps to solve a problem in writing or orally	Carry out the steps of a solution strategy using images, diagrams, or graphs	Follow the steps of a problem-solving strategy using mathematical symbols or models
Looking Back	Write down or explain the review process in writing or orally	Checking the results using images, diagrams, or graphs	Check calculations using mathematical symbols or models

The instruments used in this study consist of a written test and an interview guide. The test instruments in this study are:

Kezia memiliki dua kolam ikan. Kolam pertama yang alasnya berbentuk persegi dan digunakan untuk pembibitan ikan. Kolam kedua yang alasnya berbentuk persegi panjang dan digunakan untuk pembesaran ikan. Panjang alas kolam pembesaran 6 meter lebih panjang daripada sisi kolam pembibitan, sedangkan lebar alas kolam pembesaran 4 meter lebih pendek daripada sisi kolam pembibitan. Jika luas alas kedua kolam tersebut sama, tentukan luas alas kolam pembibitannya.

Figure 1. Problem-Solving Test

To enhance the credibility of the data in this study, member checking was employed to ensure the accuracy and consistency of the data obtained from the informants. In this study, data analysis was conducted using qualitative data analysis techniques, as the data obtained consisted of narrative accounts. The data analysis used in this study refers to qualitative data analysis according to Miles et al. (2014), which consists of three stages: data condensation, data display, and conclusion drawing/verification.

## RESULTS AND DISCUSSION

Based on the calculations, the average score on the daily quizzes for a total of 30 students was 72.3, with a standard deviation of 8. The cutoff points for grouping students by mathematical ability are shown in Table 3.

Table 3. Mathematics Ability Grouping Categories

Category	Intervals	Number of Student
High	$n > 80.2$	3
Middle	$64.4 \leq n \leq 80.2$	25
Low	$n < 64.4$	2

Based on the grouping criteria presented in Table 3, data on the grouping of seventh-grade Class B students' mathematical abilities were obtained. In this study, the researcher selected two subjects with high mathematical ability: one female and one male. The researchers selected subjects with high mathematical ability because these subjects were able to demonstrate a more comprehensive thought process and use of mathematical representations in problem-solving. Students with high mathematical ability generally have a better conceptual understanding, enabling them to express mathematical ideas through various forms of representation, such as verbal, symbolic, and visual. Thus, the selection of high-ability subjects is expected to provide more in-depth data regarding students' mathematical representations at each stage of problem-solving.

### **Analysis of Subject SL Data in Solving Algebra Problems**

#### ***Understanding the Problem***

During the problem-understanding phase, the SL only provided verbal feedback. Those statements are presented below.

WA01 : What information do you understand from this problem?

SL02 : There are a few things known in this problem. First, Pool 1 is square and Pool 2 is rectangular. Also, Pool 2 is 6 meters longer than the side of Pool 1, and Pool 2 is 4 meters shorter than the side of Pool 1. We also know that Pool 1 and Pool 2 are the same.

WA03 : Okay, good. So, what is the question asking for?

SL04 : The question is asking for the area of Pool 1, or the breeding pool.

Based on the results of the interviews conducted during the problem-understanding phase, the SL subjects used verbal representations. This indicates that the SL subjects were able to express the information they knew and the information asked in the questions verbally or using their own language.

#### ***Making a Plan***

When making the plan, SL did not include a strategy for implementation; therefore, an interview with SL was necessary. The statements are presented below.

WA05 : Now that you know the information in the problem, what are you going to do?

SL06 : I'll write down the given information and the question, then let the side of Pool 1 be  $x$ , find the length and width of Pool 2, and draw diagrams of Pool 1 and Pool 2. Then, I'll use a formula to find the areas of Pool 1 and Pool 2.

Based on the results of the interviews conducted during the planning stage, the SL subject used verbal representations. This was evident when the SL subject verbally outlined a plan for solving the problem by explaining the steps to be taken to resolve it.

#### ***Carrying Out The Plan***

The results of the written test for SL subjects at carrying out the plan are presented in Figure 2.

di: • kolam 1 persegi  
 • Panjang kolam 1 = 6m lebih panjang dari kolam 2 Persegi. Artinya  
 • Lebar Panjang kolam 2 = 6m lebih panjang dari kolam 1  
 • Lebar kolam 2 = 4m lebih pendek dari kolam 1  
 • luas kolam 1 dan luas kolam 2 sama

dit: Luas kolam 1

Misal: sisi kolam 1 =  $x$   
 Luas kolam 1 =  $x \times x = x^2$

P. kolam 2 =  $2x$   
 L. kolam 2 =  $x$

Gambar:

$L. \text{kolam 1} = L. \text{kolam 2}$   
 $x^2 = p \times l$   
 $x^2 = (x+6) \cdot (x-4)$   
 $x^2 = x^2 - 4x + 6x$   
 $x^2 = x^2 + 2x - 24 \rightarrow \text{ke'luas kanan}$   
 $x^2 - x^2 = 2x - 24 = 0$   
 $0 - 2x + 24 = 0$   
 $-2x + 24 = 0$   
 $-2x = -24$   
 $x = \frac{-24}{-2}$   
 $x = 12$

$L. \text{kolam 1} = x^2 = 12^2 = 144$   
 $L. \text{kolam 2} = 12 \times 18 = 216$

Figure 2. Test Result SL In Carrying Out The Plan

Based on the answers SL wrote during the planning phase, using verbal, symbolic, and visual representations. The verbal representation shown involves briefly writing down what is known and what is being asked. Another representation used is symbolic representation, which involves making substitutions using the symbol  $x$ , writing formulas, setting up equations, and performing algebraic operations to determine the area of the breeding pond. In addition, visual representations were evident when SL also drew two two-dimensional shapes—a square for pond 1 and a rectangle for pond 2—with labels on each side using symbols to understand the relationship between the sizes of the two ponds.

During the interview stage, the SL participant also made statements describing verbal, symbolic, and visual representations during the implementation of the plan. These statements are presented below.

- WA07 : Try to explain how you solved it.
- SL08 : First, I wrote down the given information and the question, then I let the side length of Pool 1 be  $x$ . Since Pool 1 is a square, its area is  $x \times x = x^2$ .
- WA09 : Okay, what are the shapes of Pool 1 and Pool 2?
- SL10 : Pool 1 is a square and Pool 2 is a rectangle.
- WA11 : Okay, good. So what are the equations for Pool 1 and Pool 2?
- SL12 : I wrote  $L. \text{Pool 1} = L. \text{Pool 2}$ . For Pool 1, the area is  $x^2$ , and for Pool 2, the area is  $p \times l = (x + 6)(x - 4)$ . Then I multiplied them, resulting in the equation  $x^2 = x^2 + 2x - 24$ .
- WA13 : After getting that equation, what did you do next?
- SL14 : I moved the right side to the left side to find the value of  $x$ , so it became  $x^2 - x^2 - 2x + 24 = 0$ , which was then simplified to  $-2x + 24 = 0$ .
- WA15 : Then, how did you find the value of  $x$ ?
- SL16 : From  $-2x + 24 = 0$ , I moved 24 to the right side, so it became  $-2x = -24$ . After that, both sides were divided by  $-2$ , resulting in  $x = 12$ .
- WA17 : After finding  $x = 12$ , what did you do next?

SL18 : I calculated the area of Pool 1 by substituting the value of  $x$  into  $x^2$ . So, the area of Pool 1 is 144 square meters

Based on the interview results, it can be seen that SL is able to explain the process of implementing a problem-solving plan in a logical sequence according to the plan that was created. Thus, the written responses and the interview indicate that the representations used by SL during the implementation phase include symbolic, pictorial, and verbal representations-both written and oral-that support the symbolic and pictorial representations used.

### ***Looking Back***

During the review stage, subject SL did not use any representations. It appears that subject SL did not check the results of their work but simply concluded that the area of Pond 1 or the nursery pond was 144 square meters. The results of the interview with SL are presented below.

WA19 : Did you double-check the answer you found?

SL20 : No, but I'm sure my answer is correct.

WA21 : Okay, so what conclusion did you reach?

SL22 : The area of Pool 1, or the breeding pool, is 144 square meters.

Based on the interview results, subject SL did not double-check their answer but simply concluded that the area of Pond 1, or the nursery pond, was 144 meters. The result obtained was correct, but subject SL did not include the full unit of length. As a result, there was no representation of the unit during the double-checking stage.

## **Analysis of Subject SP Data in Solving Algebra Problems**

### ***Understanding the Problem***

During the problem-understanding phase, the SP only provided verbal feedback. Those statements are presented below.

WA01 : What information do you understand from this problem?

SP02 : There are a few things known in this problem. First, Pool 1 is square and Pool 2 is rectangular. Also, Pool 2 is 6 meters longer than the side of Pool 1, and Pool 2 is 4 meters shorter than the side of Pool 1. We also know that Pool 1 and Pool 2 are the same.

WA03 : Okay, good. So, what is the question asking for?

SP04 : The question is asking for the area of Pool 1, or the breeding pool.

Based on the results of the interviews conducted during the problem-understanding phase, the test subjects used verbal representations by expressing the information they knew and the information asked in the questions orally or in their own words.

### ***Making a Plan***

During the problem-planning stage, the SP only presented problem-solving strategies. These statements are presented below.

WA05 : Okay, so what will you do after you've gathered the information from the problem?

SP06 : After gathering the information, I'll write down what's known and what's being asked. Then I'll let the side of the breeding pond be  $x$ , find the area of each pond using the formula, and then equate the areas of the two ponds.

Based on the results of the interviews conducted during the planning phase, the test subject demonstrated verbal representation. This was evident in the fact that the test subject verbally explained the steps to be taken accurately, consistent with what was done in their written test answers.

### Carrying Out The Plan

The results of the written test for SP subjects at carrying out the plan are presented in Figure 3.

Dik = \* Kelam Pembesaran punya sisi berbentuk persegi panjang  
 \* Kelam Pembesaran punya sisi berbentuk persegi  
 \* Panjang kelam pembesaran  $\Rightarrow P = 6m$  lebih panjang dari sisi kelam pembesaran  
 \* Lebar kelam pembesaran  $\Rightarrow L = 4m$  lebih pendek dari sisi kelam pembesaran  
 \* Luas kedua kelam sama

Dit = Luas kelam pembesaran dan kelam

\* Misalkan  $\Rightarrow$  Sisi kelam pembesaran  $= x$   
 Luas kelam pembesaran  $= x \times x = x^2$

\* Rumus luas persegi panjang :  $L = P \times l$   
 $L = (x + 6) \cdot (x - 4)$   
 $L = x^2 - 4x + 6x - 24$   
 $L = x^2 + 2x - 24$

\* Luas k. Pembesaran = Luas k. Pembesaran  $\rightarrow$  Dari syarat  
 di atas  
 $x^2 = x^2 + 2x - 24$   
 $x^2 - x^2 - 2x + 24 = 0 \rightarrow$  Pindah ke ruas kiri  
 $-2x + 24 = 0$   
 $-2x = -24$   
 $x = \frac{-24}{-2}$   
 $x = 12$

\* Luas k. Pembesaran  $= x^2 = 12^2 = 144$

Figure 3. Test Result SP In Carrying Out The Plan

Based on the answers written by SP during the plan-execution stage, both verbal and symbolic representations were used. The verbal representation involved clearly writing down what was known and what was being asked. Another representation used was symbolic representation. This was evident in SP's use of the symbol  $x$  to make assumptions, writing down formulas, setting up equations, and performing algebraic operations to determine the area of the breeding pond.

During the interview stage, SP also made statements describing the verbal and symbolic representations during the plan implementation stage. These statements are presented below.

WA09 : Try to explain how you did it.

SP10 : Yes, I wrote down the given information and the question, then let the side length of the breeding pond be  $x$ .

WA11 : So, how do you find the area of both ponds?

SP12 : Earlier, the side of the breeding pond was  $x$  because it's a square, so the area of the square is  $x \times x = x^2$ . Then, for the area of the grow-out pond, I used the formula for the area of a rectangle:  $L = p \times l = (x + 6)(x - 4)$ . Then, I multiplied it to get  $L = x^2 - 4x + 6x - 24$ , and simplified it to  $L = x^2 + 2x - 24$ .

WA13 : So, what is the form of the equation for the area of the two ponds that you derived?

- SP14 : So, the equation is  $x^2 = x^2 + 2x - 24$ .  
 WA15 : Then, how did you find the value of  $x$ ?  
 SP16 : Since the  $x^2$  term cancels out, we're left with  $-2x + 24 = 0$ . So,  $-2x = -24$ ; then I divide by  $-2$  to get  $x = 12$ .  
 WA17 : After finding  $x = 12$ , what did you do next?  
 SP18 : I calculated the area of the nursery pond, since the side of the nursery pond is  $x$ . The area of the nursery pond is  $x^2$ , so  $12^2 = 144$ .

Based on the interview results, it was found that SP was able to explain the process of implementing the problem-solving plan in a logical sequence, in accordance with the plan that had been developed. Thus, both the written responses and the interview indicate that the representations used by SP during the implementation phase were symbolic and verbal-both written and oral-which supported the symbolic representations employed.

### Looking Back

The results of the written test for SP subjects at looking back are presented in figure 4 below.

The image shows handwritten mathematical work on lined paper. At the top, there is a problem statement in Indonesian: "Mencari luas k. Persegi panjang ipasuh sama dengan luas k. Persegi panjang." Below this, the student has written three equations:  $P = x + 6 = 12 + 6 = 18$ ,  $L = x - 4 = 12 - 4 = 8$ , and  $L = P \times l = 18 \times 8 = 144$ . A blue box labeled "SP24" is drawn around the second and third equations. At the bottom, the student concludes: "Jadi, luas kolam persegi panjang ipasuh adalah 144." There are some corrections and underlines in the work.

Figure 4. Test result SP in Looking Back Plan

Based on the answers SP wrote during the implementation stage using symbolic representations, it is evident that SP substituted the value  $x = 12$  into the length and width measurements of the fish farm pond.

During the interview stage, SP also made statements that described the symbolic representations used in the review stage. These statements are presented below.

- WA21 : Did you double-check the answer you found?  
 SP22 : Yes, I did, because I wanted to see if the area of the nursery pond is the same as the area of the grow-out pond.  
 WA23 : How did you do that, little brother?  
 SP24 : Well, the length of the grow-out pond is  $x + 6$ , so I substituted  $x = 12$ , which gives  $12 + 6 = 18$ . The width is  $x - 4$ , so  $12 - 4 = 8$ . Then I multiplied  $18 \times 8 = 144$ , so the area of the grow-out pond is also 144 square meters, big brother. So, it turns out the areas of the nursery pond and the grow-out pond are the same.

Based on the results of the interviews during the re-checking stage, the test subject was able to explain the re-checking process by substituting the value  $x = 12$  into the dimensions of the grow-out pond. Thus, the written responses and interviews indicate that the representations used by the SP during the review stage were symbolic and verbal oral representations that supported the symbolic representation employed. Based on the results of the analysis of algebraic problem-solving, the SP and SL groups demonstrated different

levels of mathematical representation at each stage of Polya's problem-solving model: understanding the problem, making a plan, carrying out the plan, and looking back.

Based on the results of the analysis of representations in algebraic problem-solving, the SP and SL groups exhibited differences in mathematical representations at each stage of Polya's problem-solving model: understanding the problem, planning the solution, executing the plan, and checking the solution.

In the problem-understanding stage, both male and female students only produced verbal representations, that is, by expressing the known and asked information in algebraic problem-solving questions orally or in words. This is consistent with the findings of Pangasta et al. (2024), who stated that male and female students can accurately restate the known and asked information related to numeracy problems orally.

During the problem-solving planning stage, both male and female students used verbal representations, meaning they only explained their problem-solving plans or strategies orally. This aligns with the findings of Lestari & Palupi (2023), who noted that neither male nor female students wrote down their problem-solving strategies; instead, both groups explained their strategies orally.

During the implementation stage, female students used verbal and symbolic representations. Meanwhile, male students used verbal, symbolic, and visual representations. When implementing the plan, male students may draw pictures to solve problems, whereas female students do not draw pictures. This aligns with the findings of Umaroh & Pujiastuti (2020), who noted that male students are able to use visual representations by drawing pictures correctly, whereas female students are not yet able to represent problems in the form of pictures.

During the review stage, female students used symbolic and verbal representations. Male students, on the other hand, did not produce any representations. This was because male students did not review their answers, so they did not produce any representations. This is consistent with the findings of Kowiyah & Mulyawati (2018), who noted that some students often skip the review stage, resulting in the absence of representations.

## **CONCLUSION**

Based on the research findings, it can be concluded that the mathematical representations used by seventh-grade students at SMPN 9 Palu in solving algebraic problems, as viewed from a gender perspective, show differences at each stage of problem-solving.

At the stage of understanding the problem and formulating a plan, both male and female students used verbal representations by explaining the given information, the question, and their solution strategies orally. However, at the implementation stage, there is a difference: female students use verbal and symbolic representations, while male students use verbal, symbolic, and visual representations by drawing pictures to aid in problem-solving. Additionally, at the review stage, female students continue to use verbal and symbolic representations by rechecking their answers, whereas male students do not employ any representations because they do not recheck their answers.

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