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

Widya Astuti [1,*], Fajriani [2], Muh. Rizal [3], Sukayasa[4]
[1,2,3,4]Universitas Tadulako, Indonesia
*Corresponding Authors: Astwide60@gmail.com

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ABSTRACT

This study aims to analyze students' mathematical representations in solving algebraic expression problems in terms of gender. The approach used in this study is descriptive qualitative research, with two seventh-grade students of SMP Negeri 9 Palu as the subjects, consisting of one male student and one female student who have high mathematical ability. The results show that, at the stage of understanding the problem, both subjects used verbal representation to identify the information presented in the problem. At the stage of planning the solution, both subjects used verbal and symbolic representations to model the problem into algebraic form. At the stage of carrying out the plan, the male student demonstrated a more complete use of representations, namely verbal, symbolic, and visual representations, whereas the female student used verbal and symbolic representations. At the stage of looking back, both subjects again used verbal and symbolic representations to evaluate the results of the solution through explanation and substitution of values.

Keywords: algebraic problem solving; gender; mathematical representation

INTRODUCTION

Representation is the manifestation of students' thought processes in understanding a problem, used as a tool to devise and find its solution. This is supported by Sormin & Ratuanik (2023), who stated that representation is a form of interpreting students' thinking about a problem, which is used as a tool to find a solution to that problem. The importance of representation in mathematics learning is also reinforced by Mainali (2020) who stated that representation is a key element in the teaching and learning of mathematics.

In mathematics learning, mathematical representations function not only as tools for problem-solving, but also as means to develop students' logical, rational, systematic, critical, and creative thinking skills. This statement is supported by Rahmadian (2019), who explains that mathematical representation ability is one of the abilities that can help improve and develop students' thinking skills. In addition, Lette & Manoy (2019) state that representation ability helps students communicate and connect mathematical concepts in solving given problems. Therefore, mathematical representation ability is important for learners in order to communicate and express their mathematical ideas.

Mathematical representations can take the form of mental processes in students' minds as well as tangible forms such as writing, drawings, symbols, or mathematical models that reflect how students understand and process mathematical information. This is in line with Simbolon et al. (2018) who state that internal representation refers to the mental processes that occur in students' minds when they understand and process mathematical information, whereas external representation is the tangible form of those processes, expressed through writing, images, symbols, or mathematical models. Sahendra et al. (2018) also define mathematical representation 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.

Mathematical representation can be seen through three forms, namely verbal representation, visual representation, and symbolic representation. These forms are supported by Villegas et al. (2009), who identified three types of mathematical representations, namely pictorial representation, symbolic representation, and verbal representation. These three forms of representation can be used to observe how students understand, formulate, and solve mathematical problems.

Mathematical representation is closely related to problem solving because it helps students understand information, devise strategies, perform calculations, and review their answers, making complex problems simpler and easier to solve. This is supported by NCTM (2014), which states that mathematical representations can be used as a tool for solving mathematical problems. Davita & Pujiastuti (2020) also state that problem solving is an important part of learning because it enables students to use their knowledge and skills to solve problems in everyday life as well as non-routine problems. In addition, Rahayu & Hakim (2021) revealed that solving complex mathematical problems requires simplification through the use of students' mathematical representations.

According to Polya (2004), to understand a problem, a person must clearly identify what is needed to solve it, then determine how those elements are related to one another and how the unknowns are connected to the knowns in order to formulate a plan. After the plan has been formulated, it must be carried out, followed by reflection on the problem that has been solved for the purposes of evaluation and discussion. Thus, students' success in solving problems depends greatly on the extent to which they are able to use various representations to explore their mathematical ideas.

One of the mathematics topics that requires mathematical representation skills is algebraic expressions, because students must understand relationships between quantities, make assumptions, construct models, and manipulate symbols. However, students still often experience difficulties in solving algebra problems, especially when the form of the problem differs from the examples they usually study. This condition is in line with Mulyaningsih et al. (2020), who showed that students' mathematical representation skills in Indonesia are still low. Klara et al. (2021) also revealed that students still experience difficulties in using mathematical representations when solving mathematical problems, particularly in algebra.

A similar problem was also found at SMPN 9 Palu. Based on the interview results, many students experience difficulties in determining strategies for solving algebra problems, especially when the problems differ from the teacher's examples, so they tend to use the same method and have not yet been able to develop new strategies, which indicates that their mathematical representation skills are not yet optimal. This is in line with the opinion of Nur Sabrina et al. (2023), who stated that the use of a single form of representation can cause students' mathematical development to become limited because students do not have the opportunity to view problem-solving from other perspectives. This can result in students' mathematical representation skills being insufficiently trained, making it difficult to develop the ideas they possess.

Students' mathematical representation can be influenced by mathematical ability and gender, where male and female students may show differences in understanding, expressing, and solving mathematical problems. This is supported by Fattah et al. (2018), who revealed that mathematical representation is closely related to mathematical ability and gender. According to Adnan et al. (2019), a person's mathematical ability is also thought to be influenced by gender differences. In addition, Fuad (2016) revealed that students' varying abilities, both among male and female students, affect their representational abilities.

When given the same mathematics problem, many students will obtain different results. According to Hajeniati & Kaharuddin (2021), female students' mathematical representations are better than those of male students. Meanwhile, Saputra et al. (2025) found that male students tend to excel in spatial abilities, whereas female students tend to excel in verbal abilities, so it is undeniable that there are differences in how they present ideas. These differing tendencies make it possible for male and female students to represent mathematical ideas in different ways.

A number of studies show that mathematical representation skills play an important role in helping students understand problems, build models, and formulate solution steps. Fuad (2016) found differences in high school students' mathematical representations based on gender when solving quadratic equation problems. Pangasta et al. (2024) also reported that male students tend to use a greater variety of representations than female students in the context of algebraic numeracy. Meanwhile, Mulyadi & Manoy (2022) showed that high-ability students are able to use various forms of representation, although they did not specifically discuss differences based on gender at the junior high school level.

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.

This study uses the mathematical representation indicators presented in table 1.

Table 1. Mathematical Representation Indicators

Representation	Indicators
Pictorial Representation	Expressing problems in the form of pictures or graphs.
Symbolic Representation	Expressing problems in the form of symbols
Verbal Representation	Expressing problems verbally or in words

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

RESULTS AND DISCUSSION

Analysis of Subject SL Data in Solving Algebra Problems

Understanding the Problem

At the stage of understanding the problem, subject SL used verbal representations to represent the information contained in the problem. These verbal representations were evident through SL's oral responses when stating that Kezia had two fish ponds, namely the first pond in the shape of a square and the second pond in the shape of a rectangle (SL02). Verbal representation was also evident when SL explained the size relationship between the grow-out pond and the nursery pond (SL04). Furthermore, verbal representation appeared again when SL stated that the area of the nursery pond and the area of the grow-out pond were the same (SL06). In addition, SL also used verbal representation when stating that what was being asked in the problem was the area of the nursery pond (SL08). The following are the results of the interview with SL at the stage of understanding the problem:

WA01	:	What information do you understand from the problem?
SL02	:	What I understand, sis, is that Kezia has two fish ponds. The first pond is square, while the second pond is rectangular.
WA03	:	How are the dimensions of the grow-out pond related to those of the nursery pond?
SL04	:	So, sis, the length of the grow-out pond is 6 meters longer than the side of the nursery pond, while its width is 4 meters shorter than the side of the nursery pond.
WA05	:	How are the areas of the two ponds related?
SL06	:	The area of the nursery pond and the area of the grow-out pond are the same, sis.
WA07	:	Is that all the information you know?
SL08	:	Oh, there's more, sis. What the problem asks for is the area of the nursery pond.

Making A Plan

Based on the interview results at the planning stage, subject SL used verbal and symbolic representations. The verbal representation appeared when SL explained the solution plan in words, namely by assuming the side of the nursery pond as (x) because its size was not yet known (SL10). The symbolic representation appeared when SL used the symbol (x) to represent the side length of the nursery pond's base. Furthermore, because the base of the nursery pond was square-shaped, SL expressed its area as $(x \times x = x^2)$ (SL10). The symbolic representation was also evident when SL determined the dimensions of the grow-out pond's base, namely the length expressed as $(x + 6)$ and the width as $(x - 4)$ (SL12). The verbal representation appeared again when SL made the next plan that SL would draw the first pond as a square and the second pond as a rectangle during the implementation of the plan (SL14). The following are the results of the SL interview at the problem-solving planning stage:

WA09	:	After finding out the information from the problem, what plan will you carry out?
SL10	:	First, I assume the side of the first pond is x, because the side length is not yet known. Then, because the pond is square-shaped, its area is $x \times x = x^2$.
WA11	:	Then how do you determine the dimensions of the grow-out pond?
SL12	:	Because the length of the grow-out pond is 6 meters longer than the nursery pond, I write it as $(x + 6)$. If the width is 4 meters shorter, I write it as $(x - 4)$.
WA13	:	After that, what is your next plan?
SL14	:	I draw the ponds first. I draw the first pond as a square, then I draw the second pond as a rectangle. After that, I make the area of the first pond and the second pond equal, because the problem says their areas are the same.

Carrying Out The Plan

At the stage of carrying out the problem-solving plan, SL used verbal, visual, and symbolic representations. Verbal representation appeared in the initial step when SL wrote down the known and asked information (SL16). Symbolic representation appeared when SL denoted the side of the first pond by (x); then, because the first pond was square-shaped, its area was written as $(x \times x = x^2)$ (SL18). Symbolic representation was also evident when SL determined the dimensions of the second pond. SL explained that the length of the second pond was written as $(x + 6)$, while its width was written as $(x - 4)$ (SL18). In addition to verbal and symbolic representations, SL also showed visual representation. Visual representation appeared when SL drew the first pond as a square and the second pond as a rectangle complete with size labels (x), $(x + 6)$, and $(x - 4)$ (SL20).

Thus, the drawing made by SL shows a visual representation accompanied by a symbolic representation. In the next step, SL used symbolic representation to express the relationship between the areas of the two ponds. SL explained that because the area of the first pond and the second pond were equal, he wrote the equation $(x^2 = (x + 6)(x - 4))$ (SL22). Furthermore, symbolic representation appeared in the algebraic solution process. SL explained that the expression $((x + 6)(x - 4))$ was multiplied first to become $(x^2 - 4x + 6x - 24)$, then simplified to $(x^2 + 2x - 24)$. After that, SL moved the terms to one side, obtaining the form $(-2x + 24 = 0)$, then solved it to get the value $(x = 12)$ (SL24). This process shows the use of symbolic representation through algebraic operations and equation manipulation. After obtaining the value $(x = 12)$, SL again used a symbolic representation by substituting that value into the formula for the area of the first pond, namely (x^2). SL stated that $(12^2 = 12 \times 12 = 144)$ (SL26). In the final step, SL used a verbal representation to write the conclusion that the area of the first pond, or the nursery pond area, was (144) meters (SL26). The results of the written test for SL subjects at carryig out the plan are presented in figure below.

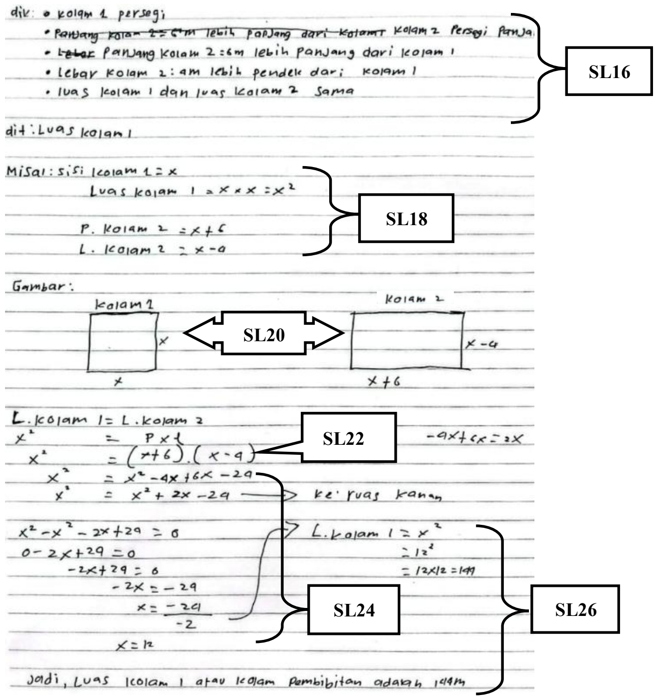

Figure 2. Test Result SL in Carrying Out The Plan

Looking Back

At the checking stage, subject SL showed the use of verbal representation and symbolic representation. Verbal representation appeared when SL stated that they checked the answer again to see whether the area of the first pond was the same as the area of the second pond (SL28). Symbolic representation was evident when SL used the value nilai ($x = 12$) to check the dimensions of the second pond. SL stated that the length of the second pond was ($x + 6$), resulting in ($12 + 6 = 18$), while the width of the second pond was ($x - 4$), resulting in ($12 - 4 = 8$) (SL30). Next, SL multiplied ($18 \times 8 = 144$) to obtain the area of the enlarged pond base. Verbal representation appeared again when SL concluded that the area of the first pond was 144 square meters and that the result was the same as the area of the second pond (SL32). The results of the interview with SL at the checking stage are presented below.

WA27	:	Did you check the answer you found again?
SL28	:	Yes, sis. I checked it again because I wanted to see whether the area of the first pond was the same as the area of the second pond.
WA29	:	How did you check it?
SL30	:	I used value ($x = 12$), sis. The length of the second pond is ($x + 6$), so ($12 + 6 = 18$). Then the width is ($x - 4$), so ($12 - 4 = 8$). After that I multiplied them ($18 \times 8 = 144$). So the area of the second pond is also (144).
WA31	:	So what is your conclusion from that check?
SL32	:	So the answer is correct, sis. The area of the first pond is 144 meters, and it is the same as the area of the second pond.

Analysis of Subject SP Data in Solving Algebra Problems

Understanding the Problem

At the stage of understanding the problem, subject SP used verbal representations to represent the information contained in the problem, especially related to the shape of the pond base and the relationship between the base areas of the two ponds. This verbal representation was evident through SP's oral responses during the interview, when SP stated that the nursery pond was square-shaped, while the grow-out pond was rectangular (SP02).

In addition, verbal representation also appeared when SP stated that the side length of the nursery pond was unknown and because its shape was a square, all its sides were equal (SP04). SP also used verbal representation to explain the relationship between the dimensions of the grow-out pond base and the side length of the nursery pond base. SP stated that the length of the grow-out pond was 6 meters longer than the side length of the nursery pond, while its width was 4 meters shorter than the side length of the nursery pond (SP06). Finally, verbal representation was also evident when SP stated that the areas of the two ponds were equal, namely that the area of the square-shaped nursery pond was equal to the area of the rectangular grow-out pond (SP08). The following are the results of SP's interview at the stage of understanding the problem:

WA01 : What information do you understand from the problem?

SP02 : What I understand is that Kezia has two different fish ponds. The nursery pond is square-shaped, while the grow-out pond is rectangular.

WA03 : Okay, good. Is that all?

SP04 : There is more, sis. What is not yet known is the side length of the nursery pond. Because the nursery pond is square-shaped, all its sides are equal.

WA05 : What is the relationship between the length of the grow-out pond and the length of the nursery pond?

SP06 : The length of the grow-out pond is 6 meters longer than the side of the nursery pond. Its width is 4 meters shorter than the side of the nursery pond.

WA07 : What is the relationship between the areas of the two ponds in the problem?

SP08 : The areas of both ponds are the same. So the area of the nursery pond, which is square-shaped, is equal to the area of the grow-out pond, which is rectangular.

Making A Plan

At the stage of creating a problem-solving plan, subject SP used verbal and symbolic representations to formulate a problem-solving strategy. The verbal representation appeared when SP explained the plan to be carried out through words, namely by first assuming the side length of the nursery pond base as (x) because its size was not yet known (SP10).

Symbolic representation is evident through the use of the symbol (x) to denote the base side of the nursery pond (SP10), indicating that SP converts verbal information into mathematical symbols. Furthermore, SP represented the area of the nursery pond base, which is square-shaped, as $(x \times x)$ or (x^2) (SP12), indicating the use of symbolic representation to express the area formula of a square. Furthermore, SP also used symbolic representation when converting the information about the length and width of the grow-out pond base into algebraic form, namely length $(x + 6\ )$ and width $(x - 4)$ (SP14). Symbolic representation is also evident when SP writes the area of the grow-out pond as $(x + 6)(x - 4)$ (SP16), which comes from the formula for the area of a rectangle. SP also states that because the areas of the two ponds are the same, the area of the nursery pond and the grow-out pond are set equal to determine the value of (x) (SP16). The following are the results of the interview with SP at the planning stage:

WA09	:	What plan will you carry out after understanding the information?
SP10	:	My plan is to first represent the side length of the nursery pond as (x), because the side length of the nursery pond is not yet known.
WA11	:	Why did you choose to represent the side length of the nursery pond as (x)?
SP12	:	Because the nursery pond is square-shaped, so if its side length is represented as x, its area can be written as $(x \times x)$ or (x^2).
WA13	:	Then how do you determine the dimensions of the grow-out pond?
SP14	:	Because the length of the grow-out pond is 6 meters longer than the side length of the nursery pond, I write its length as $(x + 6)$. Its width is 4 meters shorter than the side length of the nursery pond, so I write it as $(x - 4)$.
WA15	:	After determining the dimensions of both ponds, what is the next plan?
SP16	:	I will use the area formula. The area of the nursery pond is (x^2), while the area of the grow-out pond is $(x + 6)(x - 4)$. ecause the areas of both ponds are the same, I will set them equal later to find the value of (x).

Carrying Out The Plan

The results of the written test for SP subjects at carryig out the plan are presented in figure below.

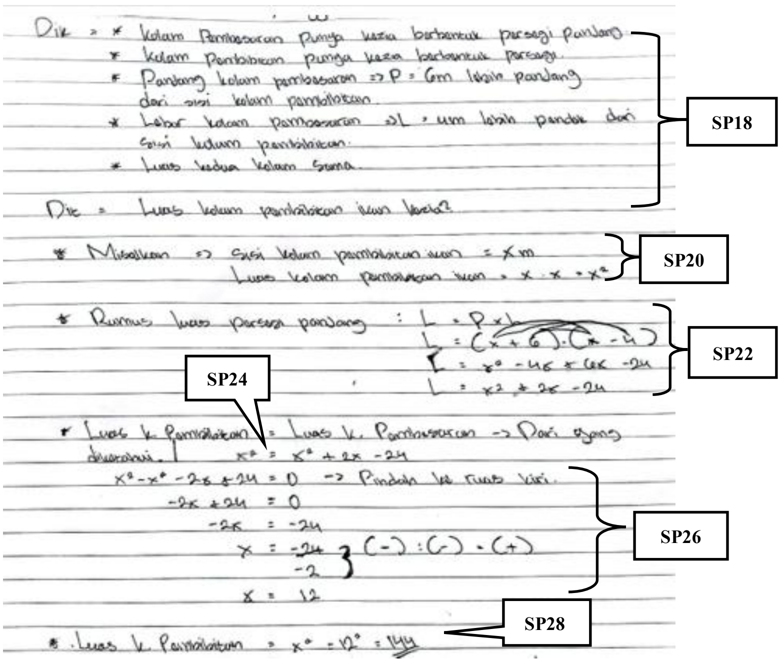

Figure 3. Test Result SP In Carrying Out The Plan

At the stage of carrying out the problem-solving plan, SP worked on the problem according to the planned steps. Based on the written test results, SP used verbal representation and symbolic representation at the implementation stage. Verbal representation is evident when SP wrote down the known and asked parts to make it easier to understand the information contained in the problem (SP18).

Symbolic representation began to appear when SP used the symbol (x) to represent the unknown side length of the nursery pond base (SP20). Next, SP represented the area of the nursery pond base, which is square-shaped, as (x^2). Furthermore, SP also used symbolic representation to determine the area of the grow-out pond using the rectangle area formula, namely $\left(A = l \times w = (x+6)(x-4)\right)$, then multiplied it to obtain $(x^2 - 4x + 6x - 24)$ and simplified it to $(x^2 + 2x - 24)$ (SP22). This shows that SP was able to represent the relationship of the grow-out pond base dimensions in the form of mathematical symbols.

Next, SP expressed the equality of the base areas of the two ponds in the form of the equation $(x^2 = x^2 + 2x - 24)$ (SP24). This equation shows that SP used symbolic representation to express the relationship between the area of the nursery pond base and the area of the grow-out pond base. Then SP performed algebraic manipulation by moving the terms to the left side, resulting in $(x^2 - x^2 - 2x + 24 = 0)$, then simplifying it to $(-2x + 24 = 0)$ until obtaining $(x = 12)$ (SP26). After obtaining the value $(x = 12)$, SP again used symbolic representation by substituting that value into the formula for the area of the nursery pond base, namely (x^2), resulting in $(12^2 = 144)$ (SP28). The following are the results of the SP interview at the stage of carrying out the plan.

Looking Back

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

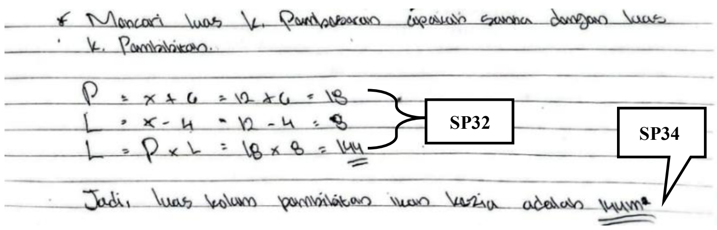

Figure 4. Test result SP in Looking Back Plan

Based on the answers written by SP at the reviewing stage using verbal representation and symbolic representation. Verbal representation is evident when SP explains that they rechecked the obtained answer to ensure whether the area of the nursery pond is the same as the area of the grow-out pond (SP30). During the interview stage, SP also made statements that described the symbolic representations used in the review stage.

Symbolic representation is evident when SP substitutes the value $(x = 12)$ into the dimensions of the base of the grow-out pond. SP states that the length of the grow-out pond is $(x + 6)$, thus obtaining $(12 + 6 = 18)$, while its width is $(x - 4)$, thus obtaining $(12 - 4 = 8)$ (SP32). Next, SP multiplies $(18 \times 8 = 144)$ to obtain the area of the base of the grow-out pond. This calculation shows that SP uses symbolic representations in the form of algebraic expressions, value substitution, and multiplication operations.

In addition, verbal representation appears again when SP writes the conclusion that the area of Kezia's fish nursery pond is (144) square meters and that its area is the same as the grow-out pond (SP34). This statement shows that SP represents the final result and the equality relationship between the areas of the two pond bases through written words. The following are the results of the SP interview at the reviewing stage to clarify the results of SP's written test.

Based on the results of the representation analysis in solving algebraic problems, subjects SP and SL showed differences in mathematical representations at each stage of Polya's problem-solving process, namely understanding the problem, devising a plan, carrying out the plan, and looking back.

At the stage of understanding the problem, both the female and male subjects only displayed verbal representations, where the female subject expressed the information contained in the algebraic problem-solving task orally or in words, while the male subject also demonstrated verbal representation through the ability to identify known information, understand what was being asked, and recognize the relationships among elements in the problem as an initial basis before converting it into mathematical form. This finding is in line with the study by Pangasta et al. (2024), which states that students, both male and female, tend to use verbal representations at the problem-understanding stage because they function to accurately restate information orally before moving on to other forms of representation.

At the stage of devising a problem-solving plan, both male and female subjects displayed verbal and symbolic representations, where verbal representation was evident from explanations of strategies such as determining unknown quantities and relating quantities in the problem, while symbolic representation appeared when students made assumptions and transformed information into algebraic form as the basis for a problem-solving model. This finding is consistent with Fuad (2016) findings, which showed that at the planning stage, male and female students tend to use a combination of verbal and symbolic representations in constructing problem-solving strategies.

At the stage of carrying out the problem-solving plan, the male subject used verbal, visual, and symbolic representations, where verbal representation appeared through explanations of solution steps, symbolic representation was evident from the use of assumptions, algebraic expressions, equations, and arithmetic operations, and visual representation appeared through sketches or drawings to model the problem context. Meanwhile, the female subject used verbal and symbolic representations, evident from writing known and asked information as well as descriptions of solution steps, using assumptions, constructing algebraic models, and performing algebraic operations until the final result was obtained. Thus, both demonstrated the ability to translate information into formal mathematical forms with different levels of representational completeness. This finding is consistent with the findings of Fuad (2016) and Pangasta et al. (2024), which emphasize that at the implementation stage, male students tend to display more varied representations, including visual ones, while female students are more dominant in verbal and symbolic representations when solving mathematical problems.

At the looking-back stage, both male and female subjects used verbal and symbolic representations to re-evaluate the correctness of their solutions, where verbal representation appeared through restating the reasons for the obtained answer, while symbolic representation was used when students substituted the results into the initial conditions of the problem and recalculated as a form of verification. Thus, this stage shows that the checking process is not only conceptual in nature but also involves the manipulation of mathematical symbols. This is in line with Mulyadi & Manoy (2022), who stated that students with high mathematical ability are able to use a combination of verbal and symbolic representations in problem solving, as well as Lestari & Palupi (2023), who emphasized that mathematical representation plays a role in the process of transforming and checking solutions in numeracy problems.

CONCLUSION

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

At the stage of understanding the problem and making a plan, both male and female students used verbal representations by representing the information contained in the problem. At the stage of devising a problem-solving plan, both used verbal and symbolic representations to formulate strategies through determining unknown quantities, relating the quantities in the problem, and modeling them into algebraic forms. At the stage of carrying out the problem-solving plan, the male subject showed more complete representations in the form of verbal, symbolic, and visual representations, whereas the female subject used verbal and symbolic representations in constructing and solving algebraic models until obtaining the final result. At the stage of reviewing, both subjects again used verbal and symbolic representations to evaluate their answers through re-explanation and substitution of the results into the initial conditions of the problem.

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