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THE PROCESS OF TRANSLATING A LINEAR PROGRAM PROBLEM INTO A MATHEMATICAL REPRESENTATION

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ABSTRACT

This research aims to describe the representation translation process in solving linear programming problems. The representation translation process will be explained at each stage of problem-solving according to Polya. The types of representation that will be explained are algebraic, numerical, graphic, and verbal. This research uses a descriptive qualitative approach. The research subjects consisted of two mathematics education students taking linear programming courses. Both subjects are students with high mathematical abilities who have good communication skills so that researchers can explore more in-depth information about the representation translation process. The instrument in this research is a linear program test which consists of two problems. The research results showed that subject 1 (S1) and subject 2 (S2) fulfilled three stages of problem-solving, namely understanding the problem, making a plan, and implementing the plan. Both subjects used all four representations in solving problems. The translation process that occurs starts with exploring sources, compiling initial knowledge, building targets, and determining suitability.

Keywords: Translation Process, Mathematical Representation, Problem Solving

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INTRODUCTION

Linear programming is one of the mandatory courses taught to mathematics education students. Linear programming is useful for solving problems in real life with limited resources to achieve the best results or achieve optimum (maximum or minimum) results (Siang, 2011). Based on the results of observations made, students still have difficulty solving linear programming problems. One of the causes of students experiencing difficulties is their lack of ability to communicate the information obtained into mathematical sentences or mathematical models. This is by research by Maryani and Setiawan (2021), which states that students experience difficulty in communicating the information obtained into mathematical models. Students need quite a long time to transform the problem given into a mathematical model. Apart from that, students are also less skilled in procedural solutions and determining solution areas on graphs.

One of the keys to success in understanding mathematical concepts and solving problems is mathematical representation (Anwar et al., 2016; Bal, 2014; Tripathi, 2008). Representation is a mathematical process in which students try to model a problem in a useful way that will enable them to solve the problem (Brahier, 2010). Representation is a symbol or sign scheme expressed in a combination of characters, diagrams, images, or graphics (Putri & Zukhrufurrohmah, 2022). In the mathematics domain, various types of representation can be used to describe an aspect such as verbal, pictorial, numerical, symbolic, algebraic, table, and graphic representations (Putri & Zukhrufurrohmah, 2022; Rahmawati et al., 2017; Tripathi, 2008). Brahier (2010) explains that four types of representation can be used to solve problems related to functions, namely: algebraic, numerical (in the form of data presented in tables), graphical and verbal representations.

Representation ability is one of the five standards of the mathematics learning process besides problem solving, reasoning, connection and communication (NCTM 2000). Based on this, it is important for students to have representation skills. As one of the process standards, representation is useful in communicating mathematical ideas, understanding concepts, and solving problems (Brahier, 2010). The National Council of Teacher of Mathematics (2000) explains that representation skills must be possessed, namely being able to select, implement and carry out translations between mathematical representations to solve problems. The ability to translate one form of representation into another form of representation is a basic ability that must be possessed so that one can develop conceptual and mathematical thinking (Rahmawati et al., 2017). In this case, translation is defined as a thinking process in interpreting source representations into mathematical representations (Bossé & Chandler, 2014). The representation translation process includes unpacking the source (exploring the source), preliminary coordination (compiling initial knowledge), constructing the target (building a representation of the target), and determining equivalence (determining equivalence) (Bossé & Chandler, 2014; Putri & Zukhrufurrohmah, 2022).

Several previous studies have examined student representations in linear programming problems (Irawati & Hasanah, 2016; Monariska & Komala, 2021), the translation process between mathematical representations between (Bossé & Chandler, 2014) translation of verbal representations to graphics, (Anwar et al., 2016) translation of graphic representations to symbolic and vice versa, (Rahmawati et al., 2017) translation of verbal representations to graphic and vice versa, (Putri & Zukhrufurrohmah, 2022) focuses on the process of translating mathematical representations from realistic problems . Meanwhile, this research focuses on the translation process of linear program problem solving representations. This research will describe the translation process of verbal, bold, graphic and equation representations in solving linear programming problems.

This research refers to the stages of problem-solving according to Polya (1973) which include: 1) Understanding the problem: understanding all the information contained in the problem. 2) Make a plan: make a problem-solving strategy in the form of guessing, drawing, looking for patterns, and making models. 3) Implement the plan: implement the chosen strategy so that the problem can be resolved. 4) Recheck: reconsider the entire problem-solving process.

METHOD

This research is a qualitative descriptive study. The subjects in this research were third-semester students at Muhammadiyah University of Kupang who took the Linear Program course. The subjects consisted of two students who had high mathematical abilities and good communication skills so that researchers could dig up more in-depth information about the representation translation process. The data in this research was obtained from written test questions and interviews. The written test questions given contain two linear programming problems. The first problem relates to investment products offered by two different banks and the second problem relates to information on the nutritional content of two food products. The form of representation in test questions is verbal representation.

Table 1. Written Test Instrument

Linear Programming Problems	
1.	Margareta berencana untuk berinvestasi hingga $\$22.000$ pada deposito di bank kota dan bank rakyat. Dia ingin berinvestasi setidaknya $\$2.000$ tetapi tidak lebih dari $\$14.000$ pada bank kota. Bank rakyat tidak mengasuransikan lebih dari $\$15.000$ investasi sehingga dia tidak akan berinvestasi lebih dari itu. bunga yang diperoleh selama setahun dari bank kota sebesar 6% dan bungaa yang diperoleh pada bank rakyat adalah $6\frac{1}{2}\%$. Berapa banyak yang harus ia investasikan pada setiap bank untuk memperoleh penghasilan maksimum? Berapa penghasilan maksimum yang diperoleh?
2	Sebuah rumah sakit memberikan program diet pada pasien dengan menyusun dua makanan N dan M. Setiap ons makanan M berisi 30 unit kalsium (Ca), 10 unit zat besi (Fe), 10 unit vitamin A dan 8 unit kolesterol. Sedangkan setiap ons makanan N berisi 10 unit kalsium (Ca), 10 unit zat besi (Fe), 30 unit vitamin A dan 4 unit kolesterol. Jika setiap hari minimum diperlukan 360 unit kalsium (Ca), 160 unit zat besi (Fe), 240 unit vitamin A. Berapa ons setiap makanan harus dimakan untuk memenuhi keperluan minimum dan pada waktu yang sama meminimalkan kolesterol yang masuk? Berapa kolesterol yang masuk?

In this research, the representation translation process will be described at each stage of problem-solving according to Polya. The following are indicators of the translation process developed by (Putri & Zukhrufurrohmah, 2022)

Table 2. Translation Process Indicators

	Translation Process	Indicators
1.	Exploring source	a. Articulating the source representation, that is, reading the source representation b. Carrying out selective coding, namely selecting relevant and irrelevant information from source information for further processing
2.	Organizing Prior Knowledge	Making coding, that is coding additional ideas (not necessarily encoded in the source representation).
3.	Building target representation	Distinguish and relate concepts in source and target representations.
4.	Determine the suitability of representation results and sources	Describes the relationship of newly encoded information (target) to previously stored schemas of old information (source).

RESULT

Below we will describe the results of the answers of 2 students, namely subject 1 (S1) and subject 2 (S2) with high mathematical abilities.

Description of S1 Answers and Representation Translation Process Used in Problem Solving

In the first and second problems, S1 fulfills three stages of problem-solving, namely understanding the problem, making a plan, and implementing the plan. S1 fulfills the stage of understanding the problem because it can understand and explain all the information contained in the problem. Where S1 explains his understanding of the problem using his own words. This was discovered through interviews. At this stage, the representation used by S1 is a verbal representation. At this stage, the researcher does not describe the translation process because no change in representation occurs.

S1 fulfills the planning stage because it can create a strategy to solve problems by converting known information into a mathematical model where S1 can determine the target function and constraints. Based on Figure 1. it can be seen that at the stage of preparing the S1 plan using Algebraic representation. The representation translation process at this stage begins with exploring the source, where S1 reads the representation source, namely a linear programming problem presented in the form of a verbal representation first. S1 reads the questions several times to identify all the information. After that, the translation process continues by compiling initial knowledge where S1 carries out coding by making examples from previously owned information. The codes used by S1 in making the examples are X_1 and X_2.

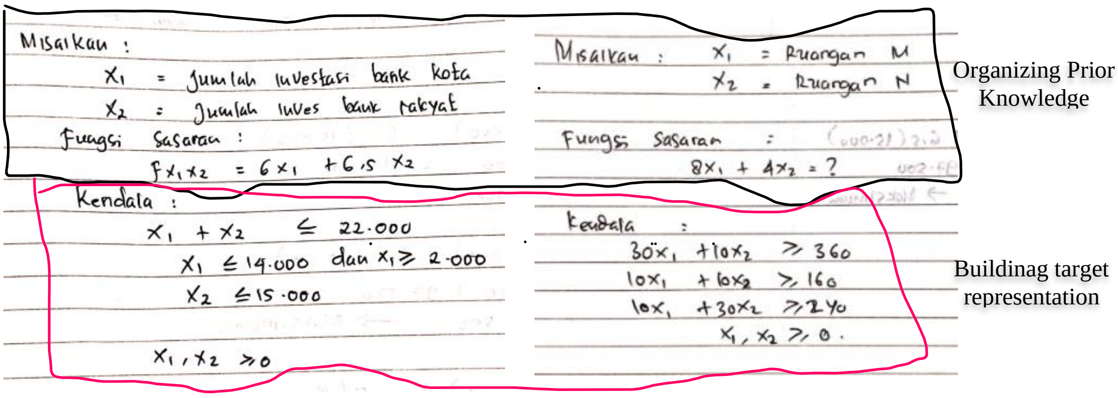

Figure 1. Answers of subject 1 (S1) at the planning stage

Then the translation process continues by building a target representation where S1 translates the source representation (verbal representation) into a target representation (Algebraic representation). The algebraic representation formed is a linear function on the target function and SPtLDV on the constraints. Thew final translation process is determining the suitability of the target representation to the source representation. In this process S1 reviews the results of his representation. Overall, the representation of the source and target was appropriate, but several things were still found that were not quite right, namely in the process of compiling initial knowledge S1 it was not quite right in making an example of the second problem. Codes X_1 and X_2 should be for example type food M and type food N, but S1 makes the example room M and room N. Apart from that, S1 is also inaccurate in building the target representation for the first problem, this can be seen in writing the second constraint, namely X_1 is between 2,000 and 14,000 dollars, it should be written $2.000 \leq X_1 \leq 14.000$

S1 fulfills the plan implementation stage because it can implement the chosen strategy to solve the problem. The representations used at this stage are numerical representation and graphic representation. In the first problem, S1 uses graphical representation to determine the solution area and numerical representation to determine the desired optimum value.

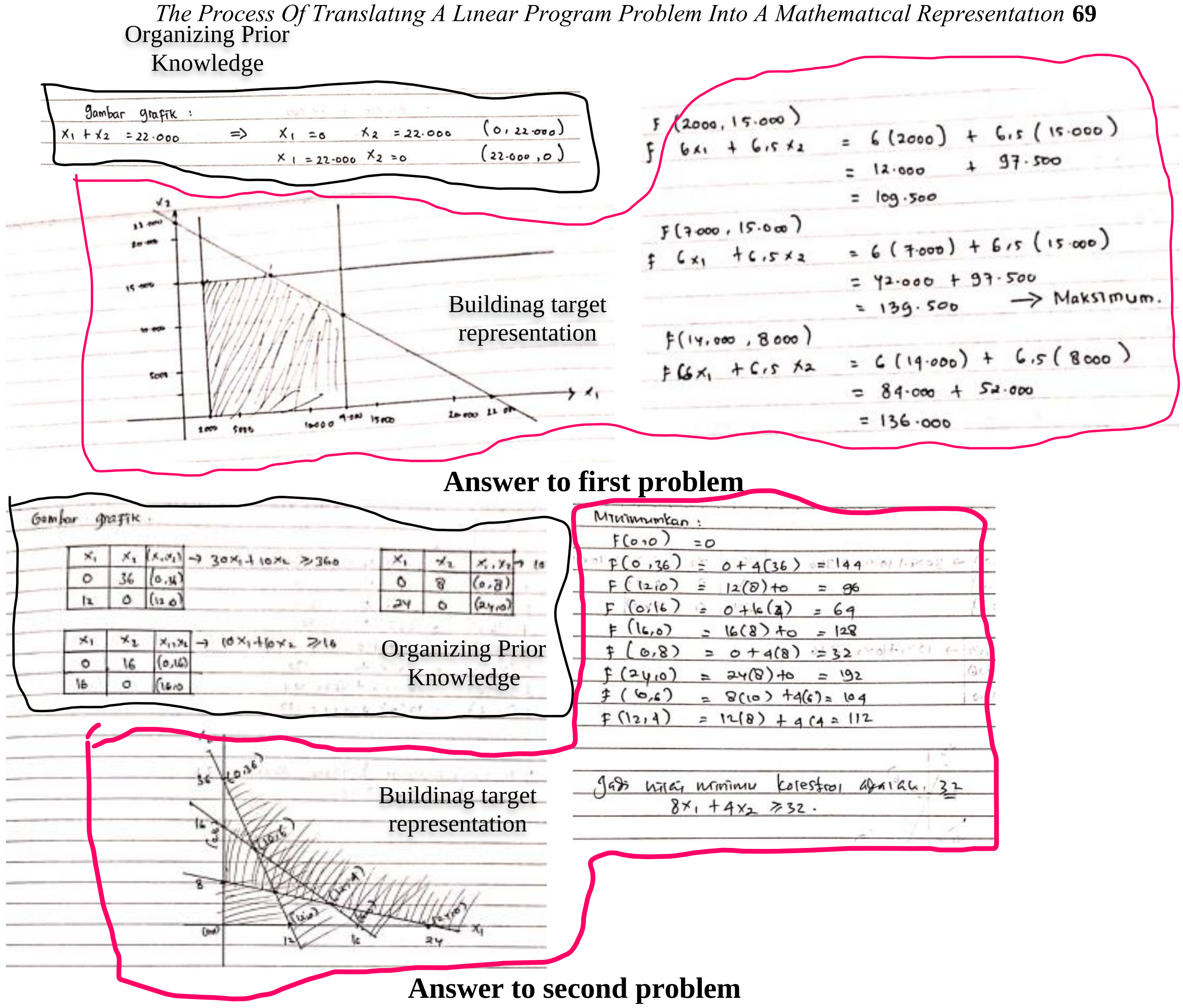

Figure 2. S1's answers at the Implementing Plan Stage

The translation process begins with exploring sources. S1 selects relevant information for solving problems. S1 selects which constraints can be drawn directly on the graph and which constraints must have intersection points determined first before being drawn on the graph. In the first problem, there is one constraint whose intersection point must be determined, while in the second problem, all constraints must have an intersection point determined. The next translation process is compiling initial knowledge. In this process, S1 determines the intersection point of the X_1 axis and the X_2 axis first. To determine the intersection point on the X_2 axis, S1 assumes the value $X_1 = 0$ and vice versa. In the answer to problem number 2, S1 uses a numerical representation in the form of a table to make it easier to determine the interception point.

The translation process continues by building the target representation. In this process, S1 translates the algebraic representation into a graphical representation of the first problem. S1 translates all previously known constraints into graphical form to obtain the SPtLDV solution graph. From this graph, S1 obtains 3 corner points of the solution area. With the numerical representation, S1 uses these 3 corner points to determine the desired optimum value.

In the second problem, S1 translates Algebraic representation into numerical representation and graphical representation. S1 translates the algebraic representation into a numerical representation to determine the point of intersection of the axes. After obtaining the point of intersection, S1 translates it into graphic form. Based on the image above, it can be seen that S1 is not precise in determining the solution area so S1 obtains inaccurate corner points. The final translation process is determining the suitability of the source and target representations. In the first problem, S1 has reviewed the suitability of each translation process, but in the second problem, S1 is less precise in determining the suitability of the source representation and the target representation. This can be seen from the graph drawn. S1 is not precise in determining the settlement area, which results in determining the corner points of the settlement area. S1 did not fulfill the last problem-solving stage because he had not yet checked the entire problem-solving process again.

Description of S2 Answers and Representation Translation Process Used in Problem Solving

In the first and second problems, S2 fulfills three stages of problem-solving, namely understanding the problem, preparing a plan, and implementing the plan. Masters fulfill the problem-solving stage, namely making a plan because they can understand and explain all the information contained in the problem in their own words. This is known from the results of interviews between researchers and S2. The representation used at this stage is verbal representation.

S2 fulfills the second problem solving stage because S2 can develop strategies to solve problems. This can be seen in S2's answer which can determine the decision variables, constraints and target function. At this stage S2 uses an algebraic representation in the first problem, while in the second problem S2 uses a numerical representation in the form of a table. At this stage the representation translation process begins with exploring the source. In this process S2 reads the source representation more than twice to understand all the information contained in the problem. Then the translation process continues by compiling initial knowledge. In this process, S2 encodes the information by creating variable examples, namely X_1 and X_2.

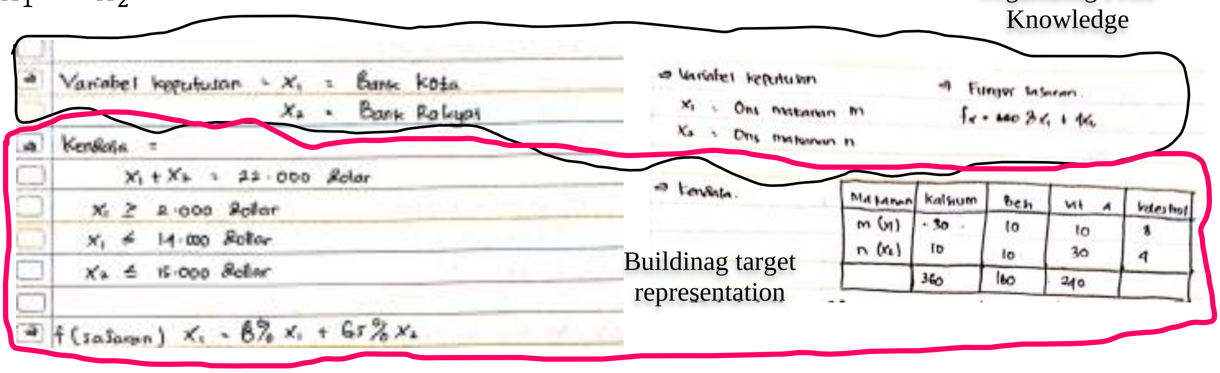

Figure 3. Answers of Subject 2 (S2) at the planning stage

The translation process continues with building the target representation. In the first problem, the target representation used is an algebraic representation. From the existing coding, S2 translates the constraints into SPtLDV form and the target function into linear function form. Meanwhile, in the second problem, the existing information is represented in tabular form (numerical representation) and then translated into algebraic representation. The final translation process is determining the suitability between the target representation and the source representation. In this process, S2 re-checks the results of the representation. Overall the target representation and source representation are appropriate.

S2 fulfills the plan implementation stage because it can implement the chosen strategy to solve the problem. In the first and second problems S2 uses graphical representation and numerical representation to carry out the plan. The translation process begins with exploring sources. In this process, S1 selects which constraints can be drawn directly and which constraints must find intersection points first. In the first problem, the constraint $X_1 + X_2 = 22$ determines the intersection point first. Meanwhile, in the second problem, all constraints have their intersection points determined. The translation process continues by building initial knowledge. In this process S2 determines the intersection point on the X_1 axis and the intersection point on the X_2 axis first. To determine the intersection point on the X_2 S2 axis, assume the value $X_1 = 0$ and vice versa. In the second problem, S2 uses a table to make it easier to determine the intersection points of the X_1 and X_2 axes for all constraints.

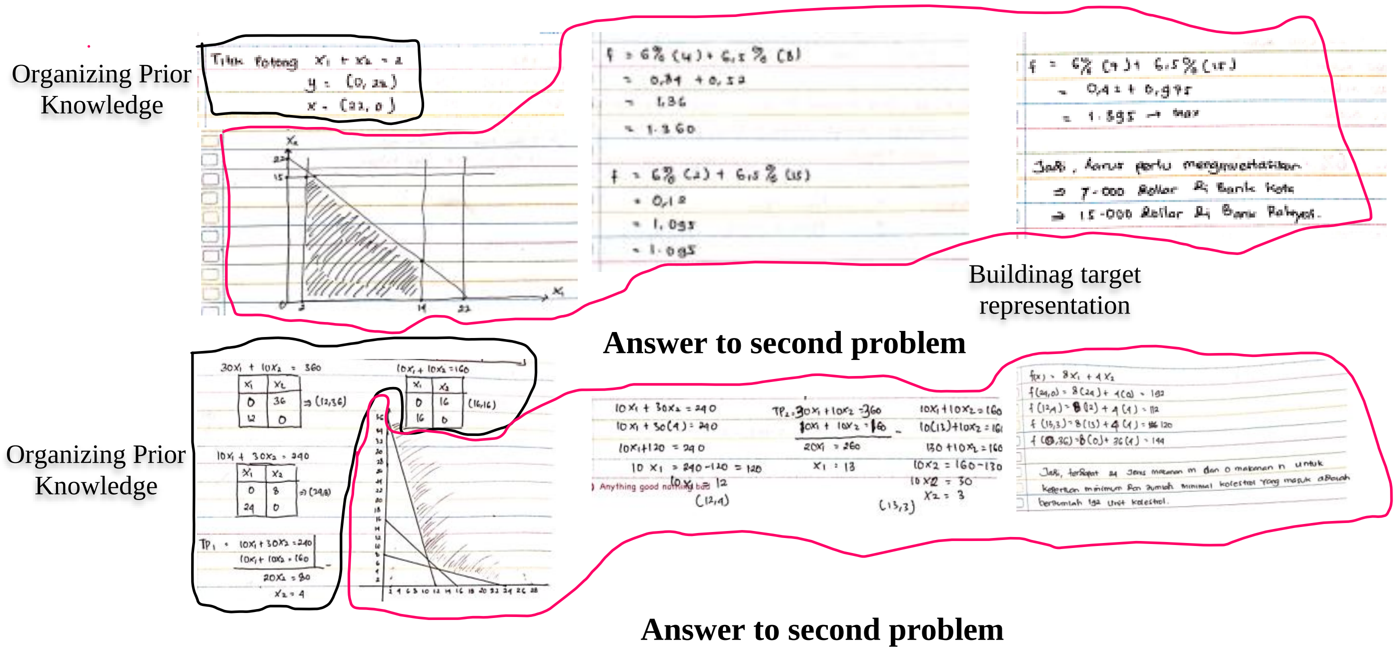

Figure 4. Answers of Master's students (Subject 2) at the Implementing Plan stage

The next translation process is building the target representation. In this process, the problem is first transacted from algebraic representation to graphical representation. S2 translates the constraints into graphical form. From the translation results, 3 corner points of the solution area are obtained. The three corner points are then substituted into the target function to obtain optimum results. In the second problem, S2 translates algebraic representations into numerical and graphical representations. S2 translates the algebraic representation into a numerical representation to determine the axis intersection point, after obtaining the intersection point S2 translates it into graphic form.

The final translation process is determining the suitability of the source and target representations. In the first and second problems, S1 has reviewed the suitability of the source and target representations. Checking starts from the source exploration stage to the stage of building target representation. This is known from the interview process. S2 does not fulfill the rechecking stage.

DISCUSSION

Based on the results of the research, both subjects fulfilled the stage of understanding the problem because they were able to understand the problem given and explain it again in their own words. At this stage, the representation used is verbal representation. These results are by research by Puspitasari (2022) and Juniati and Sulaiman (2019) who said that symbolic representation and verbal representation are more widely used at the stage of understanding the problem. At this stage, the translation process is not explained because there is no change in the form of representation.

S1 and S2 fulfill the planning stage because they can develop strategies to solve problems. The representations used at this stage are algebraic representations and numerical representations. At this stage, the translation process begins by exploring the source by reading the problem repeatedly to understand all the available information. This is by Rahmawati (2019) who said that it is necessary to read the problem repeatedly to uncover information from the problem. The following translation process is to organize initial knowledge by coding. The translation process continues by building the target representation. At this stage, two subjects use numerical representations to build target representations, namely algebraic representations. In this case, the numerical representation is referred to as an intermediate representation. This representation is an intermediary for creating a target representation (Putri & Zukhrufurrohmah, 2022). According to `Adu-Gyamfi et al. (2012) and Rahmawati et al., (2017), the process of defining between representations requires more than one definition process involving intermediate representations such as symbols, schemes, equations, and numbers. The final translation process is determining the suitability of the source and target representations.

S1 and S2 fulfill the plan implementation stage because they can apply strategies to solve problems. The representations used at this stage are numerical and graphic representations. The translation process that occurs begins with exploring sources by selecting information that is relevant to solving the problem. The next translation process is to compile initial knowledge by first determining the intersection point of the X_1 and X_2 axes. The translation process continues by building the target representation. The representation used in this process is graphic and numerical. The final translation process is determining the suitability of the source and target representations.

Both subjects did not meet the final problem-solving indicator because they did not recheck the results of their solution. This is in line with research by Bal (2014) and Kowiyah & Mulyawati (2018) who say that some students skip this stage.

CONCLUSION AND SUGGESTIONS

Based on the discussion above, it can be concluded that the two subjects only fulfill three stages of problem-solving, namely understanding the problem, making a plan, and implementing the plan. Both subjects did not fulfill the final problem-solving stage, namely checking again. Both subjects use algebraic, verbal, numerical, and graphic representations in solving problems. In this research, the translation process is only explained at the stage of making plans and implementing plans.

Future researchers who will conduct similar research are advised to consider the characteristics of the research subject in depth, such as learning style, cognitive style, or gender. Apart from that, you can also carry out similar research on different materials.

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