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Students' mathematical representation skills in solving numeracy problems with profession context

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ABSTRACT

This research aims to describe students' mathematical representation skills in solving numeracy problem with profession context. This is qualitative descriptive research with 12 students for its research subjects. There are four steps in analyzing the data, those are data collection, data condensation, data display, and conclusions. To check the validity, researchers used techniques triangulation. This research shows that, among those 12 subjects, there are four types of model in solving numeracy problem with profession context. Those are first, students use visual and external representation; second, they perform visual, verbal, math model, and internal representation; third, they use verbal, visual, and external representation; and fourth of all, they use verbal and external representation. To make this result fruitfull, other researchers can try to design mathematics learning activities to train students' mathematical representation skill such that when students solve numeracy problems, they will not face any difficulties.

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INTRODUCTION

Harmonious marriage life has A lot of problem in human life related of Mathematics. Mathematics has an abstract concept, so most students give predicate to mathematics as a study that is difficult to understand. In fact, the purpose of mathematics being taught at various levels of education is that students have the basic capital to improve their thinking skills logically, rationally, critically, carefully, effectively and efficiently (Sinaga, Hartoyo, and Hamdani 2016; Zhe 2012). So that students can innovate in science and technology. To achieve this, students must have mathematical skills so that students are able to integrate their mathematical understanding into other disciplines. One of the mathematical skills that students need to have and are considered fundamental is mathematical representation skills (Alifa et al., 2022; Zhe 2012; Hutagaol 2013).

Representation is a person's communication ability in conveying an idea (Hutagaol, 2013b). Mathematical representations are expressions of mathematical ideas that arise during the process of solving mathematical problems

((NCTM), 2000). Mathematical representation is also explained as a model that expresses problem situations (can be described in words, tables, concrete objects, or mathematical symbols) based on the interpretation of students' thoughts to find solutions to mathematical problems (Farkhan and Firmansyah 2019; Zhe 2012). In some countries including Indonesia, representation is used as one of the goals of learning mathematics in schools (Kemendikbud 2016; Zhe, 2012b). By having representational skills, students can organize their thoughts and visualize them into a model and the process of solving a mathematical problem correctly (Sari et al., 2019). In other words, good representation ability can be a thinking tool that makes it easier for students to understand and communicate abstract mathematical ideas into concrete, so that the goals and expectations of the results of pursuing mathematics can be achieved by students.

Mathematical representation occurs in two stages, namely internal and external (Mulligan 2002; Suningsih and Istiani 2021). Internal representations cannot be observed visually and cannot be assessed directly because it is a mental activity of students in their minds, so that external representations are obtained (Hudiono, 2010). External representation can encourage students to be more active in learning (Marsigit et al., 2020). External representations can be grouped into three: verbal representations, visual representations, and symbolic representations (Villegas et al., 2009). Verbal representation can be shown in words or written text in describing, analyzing or explaining a problem or writing down the process of problem solving (Dahlan and Juandi 2011; Zhe 2012). Visual representation can be shown by the ability of students to present data and information into graphs, tables, diagrams, and pictures so that students can understand problems and find solutions (Dahlan and Juandi 2011; Mulyani 2014). Whereas, symbolic representation can be shown by the ability to present problems and the problem-solving process in equations, mathematical models, and mathematical expressions (Dahlan & Juandi, 2011b). External representations can be converted into internal representations by memorizing (Zhang, 1997). It means that students who have good external representation will have good internal representation as well. External representations include verbal representations, visual representations, and symbolic representations .

Representation is a study that needs special attention. The representation of each student will be different, because the characteristics and ways of thinking of each student are different (Dreher, Kuntze, and Lerman 2016; Selvia, Awaludin, and Andrari 2019).This of course will affect how student achievement in class. The results of previous studies indicate that mathematical representation is one of the abilities that can determine or affect mathematics learning achievement either directly or indirectly with a significant value of 9.42% (Mandur et al., 2013). This shows how important representation is in building students' understanding and knowledge through student activities in constructing the representation of a problem. However, representation is only considered as a complement when delivering material, not the main focus (Irsyad Nur Fariz, Diah Gusrayani, 2017). This is also explained in previous research which explains that mathematical representation skills are still low, especially in visual representations (Purnomo & Mawarsari, 2014). Whereas mathematical representation is an important reference for a teacher in planning appropriate learning strategies so that students are able to understand mathematical concepts and problem solving abilities.

Mathematical representation is closely related to solving numerical problems (Selvia et al., 2019b). Currently, Indonesia has made numeracy the focus of transformation in reasoning-based mathematics education and learning. This is confirmed by the Ministry of Education and Culture's move to replace the National Examination and focus on numeracy in the Minimum Competency Assessment (Kemendikbud, 2020). Numeration is the knowledge and skill that includes the use of numbers and mathematical symbols when a person solves problems, analyzes information, and makes decisions (Han et al., 2017a). In addition to analyzing, solving numeracy problems also requires students to be able to represent the given context. In using numeracy skills, a person is required to be able to understand, and use mathematical concepts in solving problems in various contexts. In addition, they are also required to be able to provide an explanation through reasoning in solving it (Qosim et al., 2015). The numeracy ability of Indonesian students, which is shown through the results of the 2015 PISA test, indicates that Indonesian students are still at the bottom rank in the scope of Southeast Asia (Han et al., 2017b).

By looking at the explanation, it can be seen that there is a relationship between representation and numeration. So, researchers are interested in conducting a study with the aim of describing how students' mathematical representation abilities in solving numeracy problems in the context of work?

METHOD

This is descriptive qualitative research which describes students' mathematical representation skills in solving numeracy problems. The subjects in this research consist of 12 students from Grade 10 Mathematics-Expertisement Program, MAN 1 Jember. To gather the data, researchers used a test, which is numeracy problems with profession context, observation, and interview techniques. The question in the test was taken and adapted from PISA, therefore researchers did not validate the question sheet. To analyze the data, researchers used the theory of Miles, Huberman, and Saldana, which consist of data collection, data condensation, data display, and conclusions (Sukendar et al., 2019). The research design can be seen in the Figure 1.

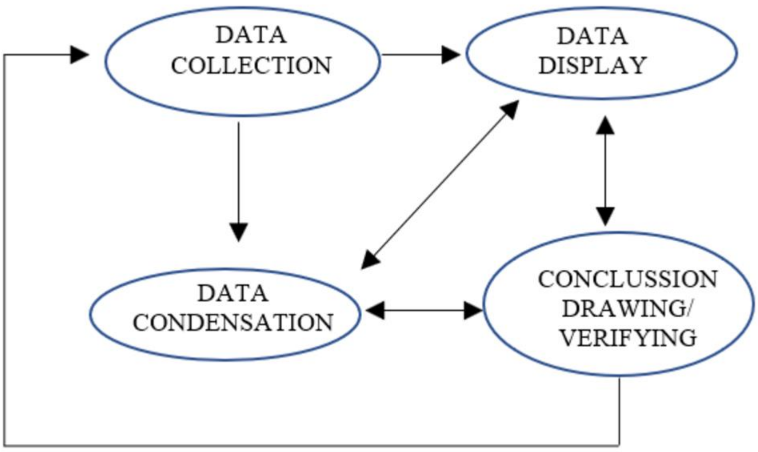


Figure 1. Research flow

In this research, every types of representation then symbolized into certain variables such as *Ve* means, *Vi* means isual representation, *M* means proposing mathematical model, *Eks* shows External representation, and *Int* shows Internal representation.

Meanwhile, to check the validity of this research, researchers used techniques-triangulation which was checking the consistency among those three methods. The indicators in describing students' mathematical representation skill can be shown in Table 1.

The Table 1 then used to analysed students' mathematical representation skills in solving numeracy problems.

Table 1. Indicators of students' mathematical representation skills

Mathematical representations	Indicators
Verbal representation (Ve)	1. Rewrite the information given in the question and restate the questions into their own words/sentences form 2. Rewrite their solutions about the problem into sentences/words form 3. Give reasons for the solution in the form of sentences/words
Visual representation (Vi)	1. Transform the information given in the question and represent the questions into their visual forms such as graph, chart, figure, illustration, etc. 2. Rewrite their solutions about the problem into their visual forms such as graph, chart, figure, illustration, etc
Symbolic representation (M)	1. Rewrite the information given in the question and restate the questions into their mathematical expression, mathematical equations, and mathematical models. 2. Write their solutions about the problem into their mathematical expression, mathematical equations, and mathematical models.

RESULTS AND DISCUSSION

Numeracy problem which was used in this research is about determining how many woods are needed to make a fence of several forms of a land. The problem can be seen in Figure 2.

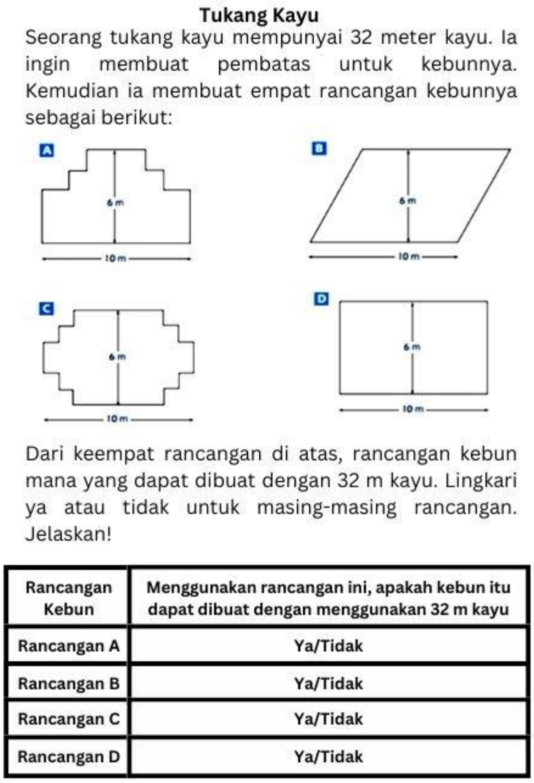


Figure 2. Numeracy problem with profession context

It can be seen from Figure 1 that students are asked to determine which land has 32 m for its perimeter. The perimeter is used to find how many woods are needed to make a fence. Beside that, they were also asked to give the reasons why they chose that answer. That problem is categorized in the profession context of PISA. From all subjects, 12 people, some of them have similar strategies in solving the problem. Therefore, they can be classified into several groups of mathematical representation skills. Those can be seen in Table 2.

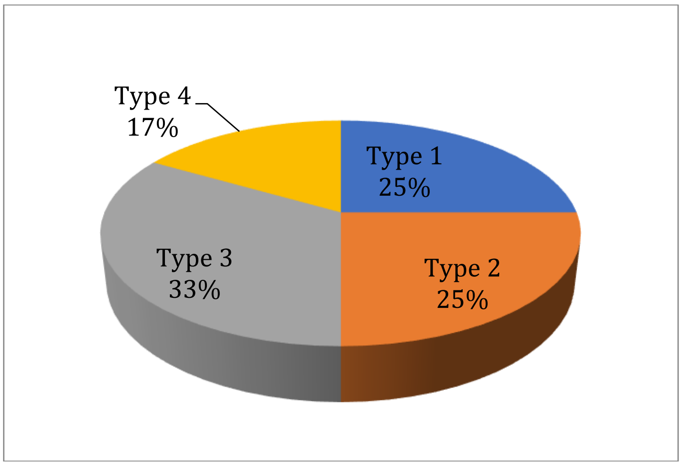
Table 2. The classification of students' mathematical representation skills in solving numeracy problems

Subs	**Types of mathematical representation**				
	Ve	Vi	M	Eks	Int
S1	-	√	-	-	√
S2	√	√	√	√	√
*S3**	√	√	-	√	√
*S4**	-	√	-	-	√
S5	√	√	-	√	√
*S6**	√	-	-	√	√
*S7**	√	√	√	√	√
S8	√	-	-	√	√
S9	√	-	-	√	√
S10	-	√	-	-	√
S11	√	√	√	√	√
S12	√	-	-	√	√

Notes: Ve = verbal representation
Vi = Visual representation
M = proposing mathematical model
Eks = External representation
Int = Internal representation

Based on those categorization, it can be seen that some of mathematical representation appered when students solve the problem. The internal-external is work together and completing each other to show their reason in solving mathematical problems (Faruq et al., 2016; Mainali 2021). However, some of them do not perform in the same times. Students have to perform their representation depends on their personal condition, such as personality (Thalhah et al., 2020). Based on table 2, as well, there is a unique result. There are some students that were able to make a visual forms, however, they failed in performing correct visualization. Further, Debrenti says that they are failed in performing their external representation (Debrenti, 2013).

According to those data, it can be seen that there 4 types of mathematical representation appear in the class. Among 12 students, then we clasified as Figure 3. It can be seen from the Figure 3 that in the mathematics class, type 3 of mathematical representation is dominated by 33%. Meanwhile, only 25% among those can used their multiple representation in solving the numeracy problems. Due to the similarity among those subjects, researchers tried to classify and then pick S4, S6, S3, and S7 then describe their mathematical representation as follows.



Note: Type 1 =All (Multiple representation)
Type 2 = vi, in
Type 3 = ve, ex, in
Type 4 = ve, vi, ex

Figure 3. The distribution of Matematical Representations Style.

Strategy S4 in solving perimeter problems (profession problem)

After S4 tried to find the answers of the problems given, S4 puts forward the answers as shown in Figure 4.

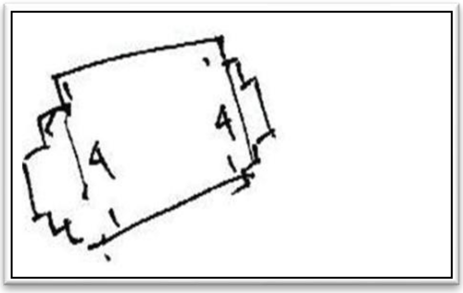


Figure 4. S4's answer about the perimeter of a garden (original answer)

Figure 4 above shows that S4 performs the solution by using his illustrations. This strategy was used to solve that problem. S4 tried to re-draw the questions, in Part C, by showing his strategy. He said that, by pointing out his picture, "some parts of the picture can be broken into a unit: 1, 1, 1, 1, therefore this part must be 4, and the remaining one must be 2". Moreover, S4 gives further reasons such as "if all these segments were compressed/slid to the side, I would get a perimeter of 32 m". This is also done on similar objects, namely by imagining and compressing/shifting each side to the side, as in Part A. Obviously, for Part D, S4 can easily determine the perimeter is 32 m, because it is a rectangle. However, while testing part B, S4 started to feel confused. S4 illustrated that the figure is a parallelogram. S4 cannot determine with certainty what is the perimeter of the parallelogram with a base length of 10 and a height of 6. When asked whether Part B has a perimeter of 32 m? He replied not sure, but it seemed to be more than 32 m. S4 tried to apply a similar strategy with Part A and C, but it doesn't work because there are no (straight) parts that can be compressed/slid to form a rectangle. When explaining, the S4 includes an image as shown in Figure 5.

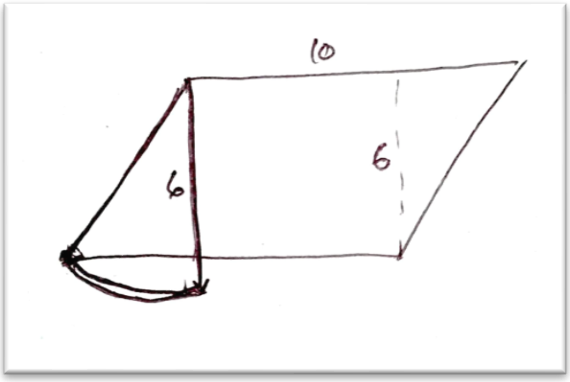


Figure 5. S4's illustration when he performs further explanation during interview

When trying to shift/compress, S4 estimates that the hypotenuse will exceed the distance of 6 m as stated in the problem. So he can only guess (with a feeling) that if it is shifted it should be longer then caused all sides to be more than 32 m. Based on what S4 wrote, S4 fulfills the ability to represent geometrically and verbally, both internally and externally.

Based on the main answer and further answer that, S4 tends to answer what is asked from the questions. He does not give further and detail explanation in his sheet, moreover he answer with an unclear strategy. It shows that he is bit failed in performing external representation (Debrenti, 2013). Further, he added that actually he cannot explain through a writing well, however he understands and is able to find the reason, and he tends to be an introvert person. This relates to some research that introverts tend to be bad in their external mathematical representation (Awaludin et al, 2021; Selvia, Awaludin, and Andrari 2019).

Strategy S6 in solving perimeter problems (profession problem).

Figure 6 is the answer and reason for S6 in solving this problem.

Figure 6. S6's answer in solving the problems

After the researcher asked how to solve the problem, S6 explained that the question number 6 Part A has a length of 10. If the length is 10 even though it is directed to follow the pattern, it must be 10 too, if the height is 6, even though the right and left sides follow this pattern, the length is 6, then the length is 6 too. Part C is also the same. For B, it's the sloping side so you have to find the slope first. If you think about it, it's probably more than you know. When asked to prove the strategy, S6 imagines that he is carrying a thread, and tries to pull it according to the pattern formed in the picture. During the interview, S6 tried to demonstrate how he did on the pictures he had obtained, how to use string to determine the perimeter of the garden.

Even though S6 does not give further explanation (on his answer sheet), he can give a reason about his decision. He stated his reason into very simple statement but it is briefly explain how he think about the solution. This still can be said that he reach his external representation (Zhe 2012; Dahlan and Juandi 2011). After researchers conducted the interview, then it can be seen that his answer came from his original reasoning. From his strategy above, it can shows that internal representation works on his mind by imagining the thread (Faruq et al., 2016).

Strategy S3 in solving perimeter problems (profession problem)

After S3 tried to solve the perimeter problem, S3 presented the answer as shown in Figure 7.

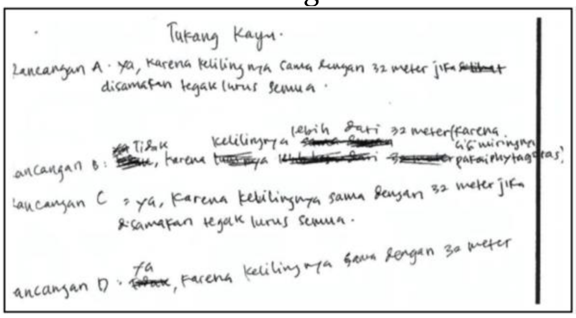


Figure 7. Solution proposed by S3

Based on Figure 7, S3 tries to present the final answer he has. S3 directly mentions the reasons why Part A, C, and D meet the requirements while B does not. Verbally, he explained that gardens Part A and C have the same character, namely that there are sides that can be rearranged and become perpendicular copies. Meanwhile, Part D is clear, according to him, because it is a rectangle whose perimeter can be determined directly. Figure B does not meet, because S3 realizes that the hypotenuse of a parallelogram is longer than the upright side of a rectangle that has a width of 6. He said that this was influenced by the Pythagorean theorem which was used to determine the length of the hypotenuse (the hypotenuse must be longer) from the other sides of a right triangle. It shows that he works mentally in his mind because he does not write or calculate in his answer sheet, however, he can perform his reason through the interview process (Komala and Suryadi 2018; Zhang 1993)

Strategy S7 in solving perimeter problems (profession problem)

The strategy carried out by S7 is more detailed than the strategies of other friends. The solution proposed by S7 looks like Figure 8.

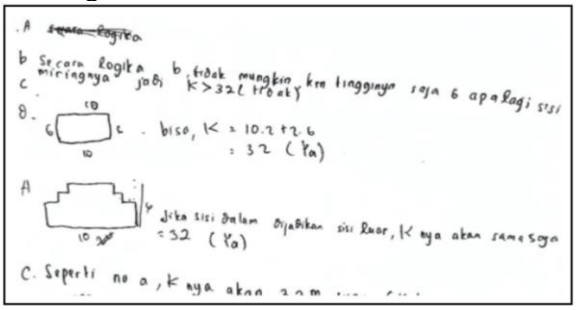


Figure 8. Solution proposed by S7
Pemecahan masalah S7

During an interview with S7, he revealed the reason why form B did not meet the criteria. For Part C and D, he imagined that later it will also be intact. For B, which has 6 for the hypotenuse and 10 for the base as parallelogram, can not be 32 for its perimeter. A parallelogram is different from a rectangle because it has a hypotenuse. The sloping side must be bigger than the perpendicular side so it must be more than 32 m. At first, S7 imagined using the logic he had, but next S7 tried to make a proof of what he said, which is shown in Figure 6. S7 provides details and calculates in detail to prove that form B does not meet the criteria.

Based on her answer, it shows that S7 can perform various mathematical representations. She was able to perform visual, verbal, and proposing mathematical model well. It shows that she reached a multiple mathematical representations which presents verbally, visually, and proposing the mathematical model (Hansen & Mavrikis, 2014). It shows that her interest in solving the problem is quite high by completing her strategy into several proofs (Dreher et al., 2016b).

To sum up, all of the subjects reached some parts of mathematical representations indicators. S4, for instance, she shows that she can transform the information given in the question and represent the questions into their illustration (*Vi_1*). However, she failed to explain it externally. She just answer it directly during the interview (*Int*). Compare to her, S7 shows better solutions and reasons. She used all the indicators of mathematical representations which is stating into her own figures (*Vi_2*), making reasoning through correct sentence (*Ve_3*), doing calculations based on her mathematical models (*M_2*). Furthermore, she is able to explain her reasons during the interview. Meanwhile, S3 shows that she can give reasons for the solution in the form of sentences/words (*Ve_3*) and use visual forms in her solution (*Vi_2*). Then, S6 are able to show his final solution in the form of his own explanation by writting his reasons (Ve3). Therfore, it shows that he can solve it both internally and externally.

CONCLUSIONS AND SUGGESTIONS

Based on that discussion, there are several types of mathematical representation during solving numeracy problems in the profession context. Among those 12 students, 33% is categorized as type 3, 25% is categorized as type 1 and 2, and the remaining percentage is type 4. Type 1 performs multiple mathematical representations both internal and external as well as all types of external representation. While types 2 performs visual and internal representations, while types 3 shows verbal, external, and internal representations. Meanwhile, the last type is verbal, visual, and external representations. The failure of performing external mathematical representations is caused by students' personality and tendency in using oral explanation.

This research, of course, has some limitations especially in the number of respondents. In the future research, scholars should conduct a research with a larger respondents in the similar topic. Moreover, to make this result fruitfull, other researchers can try to design mathematics learning activities to train students' mathematical representation skill such that when students solve numeracy problems, they will not face any difficulties.

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