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STUDENTS' MATHEMATICAL REPRESENTATION ABILITY IN SOLVING PISA PROBLEM

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Abstrak

Penelitian ini bertujuan untuk mendeskripsikan kemampuan representasi matematis siswa dalam menyelesaikan soal PISA. Penelitian ini menggunakan deskriptif kualitatif. Partisipan penelitian ini adalah 28 siswa kelas IX A SMP Negeri 01 Bengkulu Utara. Pengumpulan data dilakukan melalui tes kemampuan representasi, angket dan wawancara. Teknik analisis data yang digunakan adalah reduksi data, penyajian data, dan penarikan kesimpulan. Melalui analisis data yang telah didapatkan, ditemukan bahwa siswa mampu menyelesaikan soal PISA namun masih mengalami kesulitan dalam menyajikan representasi matematis terkait solusi dan penyelesaian soal PISA. Banyak siswa yang mampu menyelesaikan soal-soal PISA yang diberikan dengan melakukan perhitungan yang benar dan logika yang benar. Namun, siswa masih memiliki kemampuan representasi verbal yang rendah. Hal ini ditunjukkan dengan siswa masih mengalami kesulitan dalam menuliskan apa yang ada di pikiran mereka secara tepat. Selain itu, sangat sedikit siswa yang menyelesaikan soal dengan menggunakan representasi simbol dan sangat sedikit siswa yang mampu menyajikan representasi visual dengan benar. Sebagian besar grafik yang dibuat oleh siswa masih kurang tepat atau salah sama sekali.

Kata kunci: PISA; representasi matematis; representasi symbol; representasi verbal; representasi visual.

Abstract

This study aims at describing students' mathematical representation ability in solving PISA problem. Qualitative research was used in this study. Participants of the research were 28 students of IX A at junior high school 01 North Bengkulu. Data collected through representation ability skill test, questionnaire and interview. The data analysis technique used was data reduction, data presentation, and drawing conclusions. Data analysis revealed that students were able to solve PISA problems but still face some difficulties in presenting mathematical representations related to the solutions of PISA problem. Many students are able to solve the PISA questions having been given with the correct calculations and reasonable logic. Unfortunately, they have a low verbal representation ability. It is showed when students face difficulty writing down what is on their minds precisely. Furthermore, very few students solve the problem using symbol representation. In addition, very few students are able to present visual representations correctly. Most of the graphs made by students are still imprecise or totally incorrect.

***Keywords**: Mathematical representation; PISA; symbol representation; verbal representation; visual representation.*

INTRODUCTION

Mathematics becomes a subject at school which is interesting yet get avoided the most by the students. Mathematics is crucial for the advancement of science, technology, and communication (Utami et al., 2019). Through the mathematics

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learning process, students can practice logical, analytical, abstraction, critical, and creative thinking (Nugroho et al., 2019). In learning mathematics, students are expected to have mathematical literacy. According to OECD (2019) indicators of mathematical literacy ability consist of: 1) Formulate the situation mathematically, 2) Apply concepts, facts, procedures and mathematical reasoning, and 3) Interpret, apply, and evaluate mathematical results. Thus, those ability are useful for student to solve mathematical problem.

Although mathematical literacy is considered as important aspect in learning mathematics, many students in Indonesia are still in the category of low mathematical literacy (Rifai & Wutsqa, 2017; Sari & Wijaya, 2017; Simarmata et al., 2020; Widianti et al., 2021; Wijaya, 2016; Yuniati et al., 2020). As for this result, many students are lacking of mathematical representation ability (Johar & Lubis, 2018; Utami et al., 2019) in which representation is one of the aspects of mathematical literacy.

Mathematical representation is one of the key concepts in mathematics learning that helps learners to easily interpret and solve problems (Supandi et al., 2018). Representation is a mathematical ability which is showed from expressing mathematical ideas including problems, statements, definitions, etc. in various ways (Susilawati, 2020). Representation involves changing an idea into a new form such as the graph or physical model to the symbols, words or sentences (The National Council of Teachers of Mathematics, 2000). Mathematical representation ability includes among others: (1) Creating and use the representation for compose, record, and communicate mathematical ideas, (2) Choose, use, and translate each representation math to solve problems, (3) Using the presentation model and interpret the physical, social, and mathematical phenomena (Ulfa et al., 2019).

Mathematical representation can be presented both in visual and non-visual representation. As for visual representation, it can be appeared as charts, tables, sketches/drawings, and diagrams. Meanwhile for non-visual representations, it comes as a form of mathematical equations and models (Minarni et al., 2016). From those two kinds of representation, representation can be classified into three (Fitrianna et al., 2018; Kartini, 2009), namely: 1) visual representation (pictures, graphic charts, or tables), 2) symbolic representation (mathematical statements/mathematical notation, numeric/algebraic symbols), and 3) verbal representation (written text/words).

In mathematics instruction, representation is crucial because it helps pupils understand abstract mathematical ideas or concepts (Samsuddin & Retnawati, 2018). The importance of mathematical representation and connection skills for students is very important assist students in understanding mathematical concepts in the form of pictures, symbols, and words written (Noto et al., 2016). Representation in mathematics learning can help students build skills understanding and description the extent to which students understand the concept a mathematical material (Purnama et al., 2019).

Due to its importance and urgency, teacher needs to design the method and learning strategy to develop students' mathematical representation during the mathematics learning process

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(Hanifah, 2016; Utami et al., 2019). In order to realize this, teacher has to notice which part of representation that is not mastered by students yet. Therefore, because of its connection to the mathematical literacy aspect, a study on students' mathematical representation in solving PISA problem needs to be conducted. Through this study, teacher can find out how is students' representation while solving PISA problem so that teacher can help students to improve it by conducting an effective and meaningful learning process in the class room.

METHOD

The method used in this study was qualitative research using phenomenological approach. The subjects of this study were 28 students in IX A of junior high school 1 in North Bengkulu. To collect data research, data collection techniques were carried out as follows:

1. Individual written test which consists of 3 PISA questions. The instrument was chosen based on the indicators of PISA which required the representation in solving its problem. The written test was validated by a validator who is a lecture in mathematics department. The written test was tested in a small group before given to the sample class. After some revisions were done, the written test was given to the sample test.
2. Questionnaire were given to the students to analysis their difficulties in deciding the strategy regarding the representation they were viewing in solving PISA problem. The questionnaire had been validated by a validator who is a lecture in mathematics department.
3. Interviews were conducted to the students to strengthen the analysis of students' representation in solving PISA problem which has been known from written test and questionnaire.

The data analysis technique used was data reduction, data presentation, and drawing conclusions. After the data was collected through the written test, the data was classified according their answer. After that, the data was being compared to the questionnaire to see how is students' perspective in solving the PISA problem. The student who is included in one of the criteria below is interviewed in order to gain more relevant data.

1. Students who incorrectly answered the question or wrote incomplete solution.
2. Students who correctly answered the question
3. Students who answered the question correctly but they made some mistakes in writing the solution
4. Students who incorrectly answered the question but they had the direction to answer the question correctly.

The question given to the student for the written test can be seen in Table 1.

Table 1. PISA question for written test

Number of Question	Question	PISA's Indicators
1	Cars made of Balinese orange peels are one of the traditional toys for Indonesian children. Anton wants to make some of these toy cars for the children around his house.	- applying mathematical facts, rules, algorithms and structures when finding solutions

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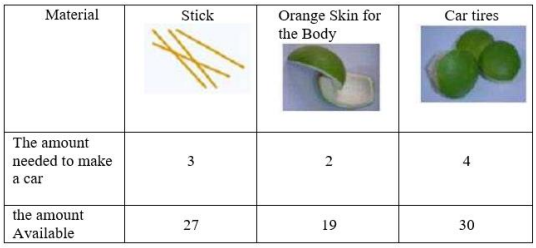
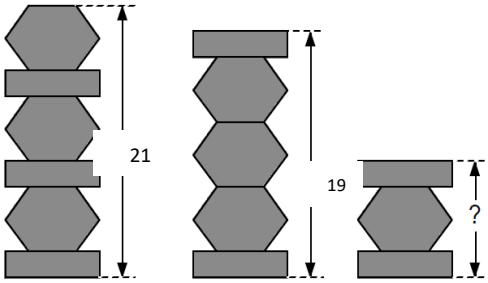
Number of Question	Question	PISA's Indicators
	The materials needed to make the car are as listed in the table below. Find out how many cars can Anton make from the available materials? give your reasons! 	- explaining why a mathematical result or conclusion does, or does not, make sense given the context of a problem
2	The picture below are 3 towers that have different heights and are composed of two shapes, namely hexagons and rectangle. What is the height of the shortest tower in the picture above? 	- representing a situation mathematically, using appropriate variables, symbols, diagrams and standard models - manipulating numbers, graphical and statistical data and information, algebraic expressions and equations, and geometric representations - applying mathematical facts, rules, algorithms and structures when finding solutions
3	Mentari Shop's revenue always increases by IDR 100,000 from the previous month's revenue for 3 consecutive months, after which the shop has decreased by 10% from the previous revenue and in the sixth month it has increased again by 20% from the previous revenue. If Mentari Shop's income in the first month is IDR 1,000,000.00, how much will Mentari Shop's income be for six months? Draw a graph of Mentari shop's revenue growth	- making mathematical diagrams, graphs and constructions and extracting mathematical information from them - applying mathematical facts, rules, algorithms and structures when finding solutions

RESULT AND DISSCUSSION

From the first question given to the students, it was obtained that ten out of 28 students give a correct answer without explain the reason behind it, thirteen out of 28 students could answer the question correctly and give a good reason why the answer can be true. Unfortunately, four out of 28 students failed neither to give the correct answer nor give the reason for the possible answer. From the questionnaire it can be known that 25 students stated that this question was easy and can be solve logically. Student's answer which was correct without giving any explanation can be seen in the Figure 1.

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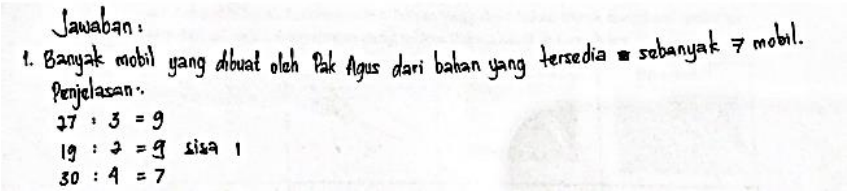

Figure 1. Student's answer without giving any explanation

Figure 1 shows that this student can give a correct answer but on the other side, this student failed to give a verbal representation. S1's work showed ambiguity that can lead the reader to a wrong conclusion. An interview was conducted to know his thought about this matter. From the interview with S1 it was known that S1 believed he already wrote the correct and accurate answer including the reason why S1 thought so. Based on the written test, it can be seen that S1 gave a correct answer but she made a wrong calculation. S1 wrote "$30:4=7$" which was incorrect mathematically. Apparently, the reason why S1 wrote that was because S1 knew 28 materials can be used to make 7 cars meanwhile the 2 other materials cannot be used, so S1 didn't mind them. After the interview section, S1 realized that he could not wrote so since it might confuse the reader even though the final answer was correct.

Based on the interview section it can be known that S1 has difficulties in writing verbal representation even though he knew how to obtain the correct answer and conclude that answer. As for this result, S1 could Apply facts, rules, algorithms, and structures math when find solution but had difficulty to explain why the results or mathematical conclusion made sense or not makes sense.

An example of a correct answer can be seen from the Figure 2.

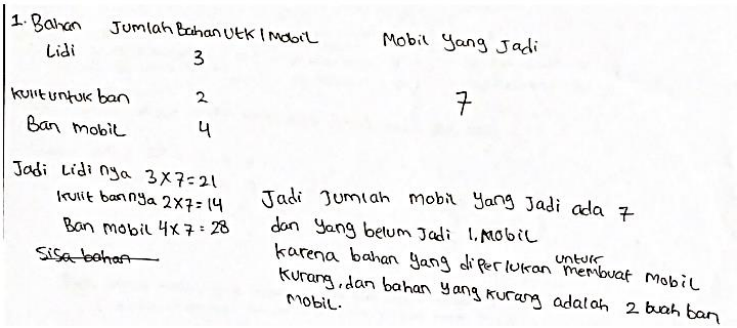

Figure 2. Student's correct answer for the question number 1

From the Figure 2, it can be seen that this student could write the verbal representation correctly. This student didn't make any calculation errors and could give an explanation why the material Anton has only possible for him to make 7 cars. For this case, this student can fulfil the indicator of the first question well. Thus, this student both could apply facts, rules, algorithms, and structures math when find solution and able to explain why the results or mathematical conclusion made sense. So that, this student has a good verbal reasoning.

Besides giving the correct answer and incomplete answer, there were some students who give completely

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incorrect answer. One of the student's works which showed incorrect answer can be seen in the Figure 3.

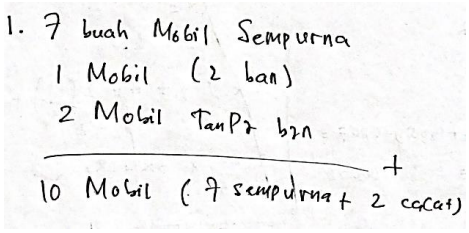

Figure 3. Student's incorrect answer for number 1

From the Figure 3 it can be said that S2 made a wrong interpretation about a car mention in the question even though from the questionnaire this student stated that this problem was easy and he had no problem in solving this problem. To deepen the reason behind his answer, an interview was conducted. From the interview that was carried, S2 stated that from the materials provided, he can make 7 perfect cars and 3 imperfect cars. The reason why he wrote so was because he got confused with the question, he was not sure if he should consider to use all materials or he should ignore the materials which cannot be used to make a perfect car. After reading the question once more time, S2 point out one condition that made him realize the question was for a perfect car not the imperfect one, the statement in the question was "for one car we need 3 sticks, 2 orange skins, and 4 tires." Even though he was indecisive with that condition, he was later found out that if the condition is not fulfilled, it cannot be called as a car. Thus, he knew the correct answer for this question is 7 cars.

Through the interview it can be said that S2 lack in interpretation thus lead him in a lack to do the verbal representation in order to complete the answer to solve the problem number 1. He was not able to understand the problem clearly and cannot apply the concepts in everyday life (Noto et al., 2016). Students who have struggle to represent a problem verbally will find difficulties to solve problems (Sukmaningthias et al., 2016). Thus, S2 did not have a good verbal representation because he failed to give the reason why the results or mathematical conclusion made sense.

For the second question, it can be known that 26 out of 28 students can successfully solve the problem and 22 students stated that this question was easy and can be solved without a thoughtful difficulty. For this question, many students solve the problem using the same method, that was by subtracting the first tower (the highest tower) to the second tower. That was how the students got the height of rectangle and did the other subtracting to get the height of hexagon. However, these students are able to fulfil the indicators of the second question including manipulate numbers, graphics, data as well geometric representation and apply facts, rules, algorithms, and structures math when find solution. Students' answer for this type of solution can be seen from the Figure 4.

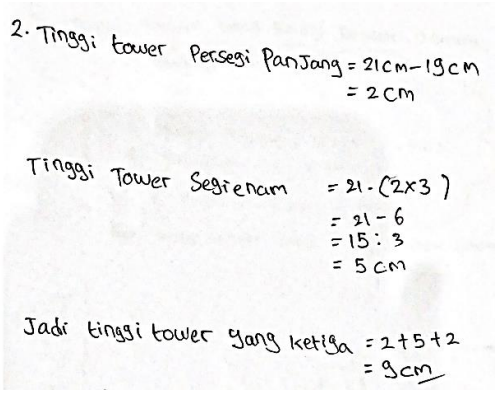

Figure 4. Student's correct answer for number 2

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Figure 4 showed that the student got the shortest tower by doing the subtracting. Nevertheless, this student served the solution without giving any symbol representation. From the questionnaire, this student said that this question was easy because it can be solved by the help of her logic when she saw the problem. That was the reason why this student did not use any symbol representation while solving the second problem. On top of that, the other student served different type of correct solution using symbol representation. This solution can be seen in Figure 5.

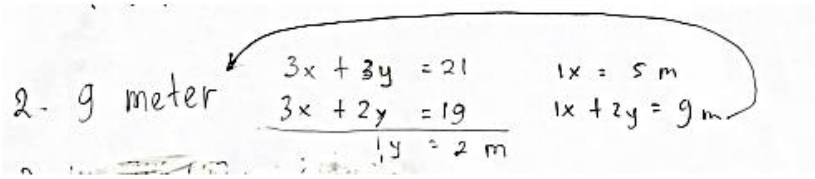

Figure 5. Student's answer for number 2 using symbol representation

From the Figure 5 it can be known that this student executed the symbol representation well. This student can solve the problem by involving the model mathematical expression correctly. This student used the symbol "y" to represent rectangle and used the symbol "x" to represent the hexagon. By solving linear equations of two variables, this student was able to find the height of each rectangle and hexagon. That was how this student got the height of the shortest tower. This, this student can fulfil all the indicators for the second question including the indicator for symbol representation.

Even though most of the students expressed the second question as an easy problem, there were some students who were failed to give a correct answer due to miscalculation, misinterpretation, or having a low understanding of representation. One of the students who solved the problem incorrectly due to misinterpretation and low understanding of representation can be seen from the Figure 6.

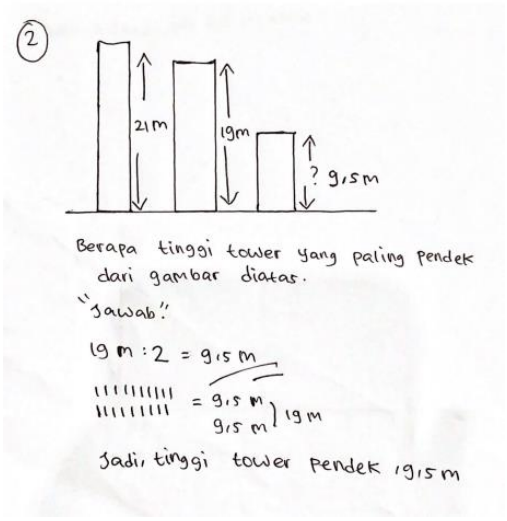

Figure 6. Student's incorrect answer for number 2

From the Figure 6 it can be seen that this student wrongly considered the shortest tower was a half high of the second tower. Even though shortest tower from the picture in the problem seems like a half high of the middle tower, the student cannot directly divide the height of the second tower. Each shape has its own representation number so that the student needed to find the height of each shape, unless there was any additional information which led the reader to the conclusion that the shortest tower is a half of the

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second tower. To know the reason why this student wrote so, an interview was conducted. From the interview, S3 stated that she was confused with the question and she did not know how to find the correct and accurate solution. Because S3 had no idea how to solve it, she used her intuition by looking at the picture. The last tower is looked like a half of the second tower. That was why she came to the conclusion to estimate the height of the third tower as a half of the middle tower. Even though S3 noticed that the tower was built from rectangles and hexagons but S3 did not think they might have different height. After the interview section, S3 realized that each shape might have its own height but S3 could find a way how to find them.

From the interview, it can be known that S3 lack in interpret the problem and have a difficulty in understanding the existence of each shape that has represents different height. Lack of knowledge and understanding concept has an effect on representation mathematics possessed by students (Suningsih et al., 2021). S3 was not able to apply the concepts cannot use the procedures related to the specific representation (Noto et al., 2016). Thus, this student failed to fulfil the indicators of the second problem and has a low visual representation ability.

Different from the first question and the second question given to the student which seem quite easy for them, the problem number three seems to be difficult to be solved by the students. out of 28 students, only 8 students can solve this problem correctly, three students made an error calculation, and 17 students left the answer blank. From the questionnaire only three students stated that this question was easy, the rest or 15 students agreed to say that this problem was difficult.

Even though some of the students manage to give the correct answer, some of them still lack in drawing the graph which means they lack in visual representation. The sample of imperfect graph can be seen in the Figure 8.

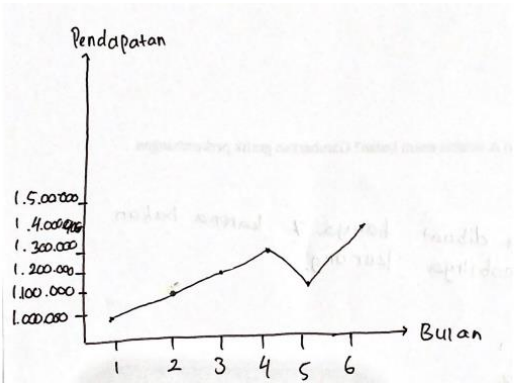

Figure 8. Imperfect graph for problem number 3

Figure 8 showed that the students still draw the graph without determine the right scale. Besides, the graph this student drew had unclear point since he did not write the number of the point which make the reader confused. This is in line with the statement that the representation ability that is least mastered by students is visual representation (Mulyaningsih et al., 2020). From this result, it was known that this student successfully applied facts, rules, algorithms, and structures math when find solution but failed to create charts, graphs and mathematical constructs. So that this student has a low visual representation.

An example of the correct answer followed by correct graph can be seen in Figure 9.

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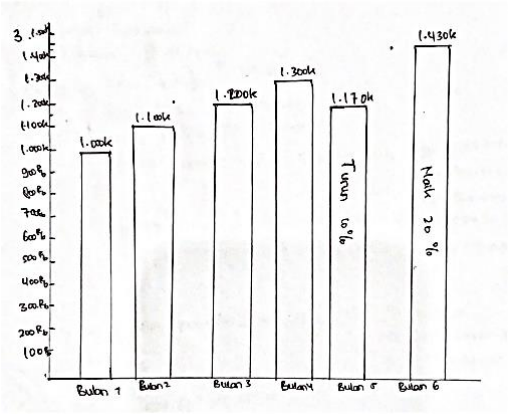

Figure 9. Correct graph for question number 3

From the Figure 9, it can be said that this student fulfils all indicators of question number 3 since he gives the correct answer and manage to draw the correct graph for the profit and loss. From the graph, it was safe to tell that this student made a right scale before draw the graph. This student also wrote the number of each bar chart to make the graph clear. This result means this student solve the PISA problem well and able to do the visual representation.

Unfortunately, there were many students who left the answer blank due to the difficulties they were facing when solving this problem. Most of the students already forgot the formula of profit and loss so it made them had no clue how to answer the question and draw the graph. This is in line with the complexity of the problems as well as the types of representation have an impact on representation errors (Johar & Lubis, 2018). For some cases, the students still understand how to calculate the profit and loss but they made calculation errors that lead them to a wrong answer and wrong graph drawing. It means, they are not able to apply the concepts, error in performing operations, and cannot apply the concepts in everyday life (Noto et al., 2016). This kind of error can be seen in Figure 10.

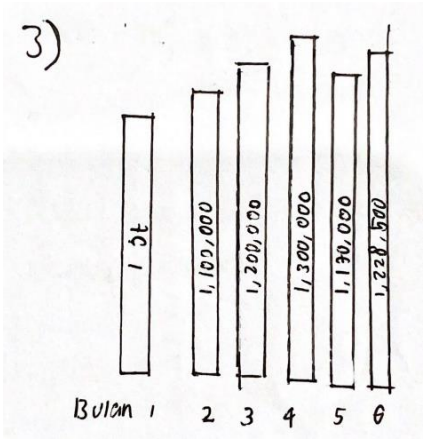

Figure 10. Incorrect graph for question number 3

Figure 10 clearly showed that this student has a low graph representation since he drew the graph incorrectly. This student did not put the scale for the graph which is totally incorrect. Besides, this student also made calculation error. This is in line with the statement while solving the word problem related to mathematical representation, students were difficult to understand the information in the problem, have not written the proper procedure to solve the problem, and lack of accuracy in doing calculation (Fitrianna et al., 2018). Because of this result, this student failed to solve the PISA problem and cannot fulfil the indicators of question number three. In addition, this student also has a low mathematical visual representation.

CONCLUSION AND SUGGESTION

The following are the results of data analysis in research regarding the mathematical representation ability in solving PISA problems from 28 students of IX A in junior high school 01 North Bengkulu. Overall, students were able to solve PISA problems but

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still experienced difficulties in presenting mathematical representations related to the completion and solutions of PISA questions. Most students are able to solve the PISA questions that have been given with the correct calculations and reasonable logic, but have difficulty writing down what is on their minds precisely. Besides, very few students solve the problem using symbol representation. Furthermore, very few students are able to present visual representations correctly. Most of the graphs made by students are still imprecise or totally incorrect.

For further research about representation, it was suggested to prepare the problem specifically for each representation. To be exact, the problem for visual representation can only be solved by using visual representation and so are for the other representation problems. By using these problems, the researcher can see completely how many students can solve the problem using representation he wants to know and deepen the discovery once the students have difficulty in using it.

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