Student strategy in solving PISA problem through realistic mathematics education approach

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Abstract. The PISA assessment shows that Indonesia ranked under international standard from the year 2000 until 2012. Student strategies were identified as part of student problem-solving in PISA problem. In solving the PISA problem, students have to translate the daily life problem into the mathematics language, solve and re-translate it into the everyday language. Realistic Mathematics Education (RME) is an approach that emphasises mathematics as student daily life activities to be associated as the primary point into the learning context. This study was conducted to determine student strategies in solving the PISA problem through the RME approach. This study was held through three meetings; two meetings for the learning process and one for the assessment. The data were collected by conducting a test on a total of 29 seventh grade students in Banda Aceh as well as interviewing five of them. The results revealed that there are some student strategies used in solving the PISA problem through the RME approach. The strategies are look for a pattern, make a drawing or diagram, guess and check, and work backwards.

1. Introduction
Programme for International Student Assessment (PISA) is an international assessment of reading, mathematics, and science literacy competencies of 15-year-old students. The PISA problem contains level 1-6 of Bloom’s taxonomy and requires student problem-solving ability to solve it [1]. PISA assesses the ability of students to analyze, give reasons, and interpret mathematical problems within various situations [2]. The results of PISA show that Indonesia ranked under international average since 2000 and has no significant increase [2]. The Indonesian students were only able to solve the PISA problem at level 1-3 of Bloom’s taxonomy. Almost 70% of Indonesian students were only able to solve level 2 for all topics of PISA questions in 2009 [3].

One of the aspects identified in PISA is the student problem-solving strategy [4]. The problem-solving strategy is a technique that will be used to facilitate the solving of the problem(s) effectively. The strategy used should be dynamic, nonlinear, and flexible. Using the right strategy makes students more easily solve mathematical problems. Students with good creativity will have and employ the right strategies in solving the problems. The development of student creativity has a relationship to their experience gained from the social environment [5]. The student experience from the social environment is related to the student strategies in problem-solving.

Realistic Mathematics Education (RME) is a mathematical approach that was firstly developed in Netherland and used Freudenthal view; mathematics associated with the reality and as the human activity [6], [7]. The RME uses student experience as the main point in the learning process. Learning
through RME approach begins with presenting the realistic problems that are familiar to students. The RME also involves students actively in the learning process and relates students’ knowledge to their real-life experience [8]. Previous studies indicate that the RME approach is positively associated with student achievement [8], [9]. However, only a few studies relate the RME to the student strategy in problem-solving. In this study, the RME was used to analyse students’ strategy in solving the PISA problem.

2. Method
The quasi-experimental design was used as the method in this study. The study was conducted in a junior high school in Banda Aceh that has joined the mathematics literacy contest (MLC). Not all students in this school have joined the MLC, including the seventh-grade students who were the subject of this study. A number of 29 seventh-grade students participated in this study. This study was held during three meetings; two meetings for the learning process and one for the assessment. During the learning process, the teacher taught the students the PISA questions through the RME approach. The problems given in the learning process were different from those given in the assessment, but both of them have an equal difficulty level. The data were collected through a test and interview at the third meeting. The test was carried out in 40 minutes and followed by interviewing five students. The interview was conducted only for several students who already employed various strategies in solving the questions. This interview was undertaken to make sure and clear which strategy used by the students along with their reasons.

The questions used in the assessment were the PISA questions including four contents (change and relationship, space and shape, quantity, uncertainty and data) as well as four contexts (personal, occupational, societal, and scientific). Question 1, 2, and 4 are in the reproduction competency cluster, and question 3 is in the reflection competency cluster. The PISA questions used in this study were translated into Indonesian. The translation has been validated by two supervisors as the validators.

After collecting the data needed, the researchers tabulated them in the table form. Then, the descriptive analysis was utilized by the researchers to interpret the data and draw a conclusion from them.

| Strategy                        | Indicator                                                                 |
|---------------------------------|---------------------------------------------------------------------------|
| Act it out                      | Students perform the actions described in the problems, or they manipulate objects |
| Make a drawing or diagram       | Students depict the relationship among the different pieces of information in a problem in a more obvious and more precise way. Then, rather than drawing detailed pictures, it is more required only to draw what is essential to represent the problem. |
| Look for a pattern              | Students find the information and use it to find the pattern relevant to the problem given. |
| Construct a table               | Students view and clarify the lost information by making a table. They also classify substantial information using the table. |
| Guess and check                 | Students guess the solution based on their experience on the aspect related to the problem. The student guesswork must be tested by a number of logical reasons. |
| Work backwards                  | Students present the final results and write about things that have been taken and experienced before. |
| Solve a similar but simpler problem | Students solve a complicated problem by solving a similar but simpler problem first. |

Table 1. Student strategy indicators [5].
3. Results and discussion

Based on the test results conducted on the 29 students after the learning process through the RME approach, some student strategies in solving the PISA problems are revealed, as shown in Table 2.

**Table 2. Student strategies in solving the PISA problems.**

| Strategy                     | Student strategy percentage | Percentage average |
|------------------------------|----------------------------|--------------------|
| Act it out                   | 0 %                       | 0 %                |
| Make a drawing or diagram    | 0 %                       | 0 %                |
| Look for a pattern           | 13.79 %                   | 0 %                |
| Construct a table            | 0 %                       | 0 %                |
| Guess and check              | 13.79 %                   | 0 %                |
| Work backwards               | 10.34 %                   | 0 %                |
| Solve a similar but simpler problem | 0 %                   | 0 %                |
| Substitute the formula*      | 51.27%                    | 82.75%             |
| Incomplete answer*           | 0%                        | 31.03%             |
| Do not answer the question at all* | 10.34%                 | 68.96%             |
| Summary                      | 100%                      | 100%               |

* Not a part of problem solving strategies [5]

According to the student answer sheets, some students are found to either answer the questions using strategy, answer the questions by substituting the formula, answer the questions incompletely, or answer no question at all. By conducting the interview, we know that some of the students were able to understand and solve the problems given, some were only able to understand but could not solve the problems, and some others did not understand and solve the problems.

Question 1 is the PISA question tested in 2015. It is regarding the uncertainty and data content, societal context, and diagram theme. The students solved this question using several strategies; look for a pattern (13.79%), guess and check (13.79%), and work backwards (10.34%). This results revealed the differences with the research conducted by Zuhra. She states that most of the students are used to the strategy of calculating all possibilities systematically (45.16%) in solving PISA problem for uncertainty and data content, followed by identifying the problem (27.96%) and making a drawing or diagram (17.20%) [10]. Sample factors might contribute to the accomplishment of the strategy used [11].

![Figure 1: The student answer using the look for a pattern strategy for question 1.](image-url)
Figure 1 shows that Student 18 (S18) answered question 1 using the look for a pattern strategy. S18 responded to this question by giving attention to the question then analysed the CD decreasing for each month. In accordance with the interview results, S18 declared that he understands the problem in question 1. The problem-solving process started with observing the diagram given and predicting the decrease of the CD sold for every month. Furthermore, he predicted that the decline in the CD sold every month is the same; as such, he concluded that the decrease from June to July is the same as before. Finally, S18 was able to determine the number of CD sold in July.

Question 2 is the question of PISA 2012. It covers the quantity content, scientific context, and sailing ship theme. The student only used the make a drawing or diagram strategy (10.34%) in solving question 2. The Figure 2 shows that one of students answer using make a drawing or diagram strategy.

![Figure 2](image)

**Figure 2.** The student answer showing the make a drawing or diagram strategy for question 2.

In figure 2, subject 29 (S29) answered question 2 by identifying the information given. In accordance with the interview results, S29 had never solved question 2, but he had ever addressed the same problem as in question 2 so that he understood how to solve it. S29 solved the problem by making a drawing and identifying the information in term of percentage of the wind speed on the shipping screen by 25% of the wind speed on the deck of the ship. Furthermore, the result obtained was summed with the wind speed on the deck of the ship.

Question 3 is the PISA question tested in 2009 and has space and shape content, personal context, and walking theme. Question 3 is at the sixth level of Bloom’s taxonomy, including the reflection competency cluster and non-routine problem. All of the students felt that the question was complicated and could not answer it. No one used the strategy in solving question 3. Indonesian students are only able to solve the problem in PISA at level 2 [3]. Based on the answer sheet and interview on Student 10 (S10), it shows that S10 had never found this question before and could not solve the problem. Some of the students rarely find PISA questions because they are limited; hence, the teacher should more frequently produce questions equal to the PISA questions [12].

Question 4 was tested in PISA 2012 as the change and relationship content, occupational context, and lighthouse theme. The students solved this question with two strategies: look for a pattern (24.13%), and make a drawing/diagram (10.34%). Student using make a drawing or diagram strategy is shown in Figure 3.
In accordance with the student answer sheet and interview results, Student 16 (S16) used the make a drawing or diagram strategy. S16 drew a diagram showing that from the flashes of the light can be seen directly how many seconds appear in a minute. S16 used this strategy to make him more easily analyse the problem. In other hand, there were students used the looking for pattern strategy, one of them is shown in the Figure 4.

In Figure 4, subject 7 (S7) viewed the number of flashes of light and the darkness in every five seconds. It turned out that the incident repeated in the second and subsequent five seconds. Thus, S7 could determine the flash of light in a minute. S7 selected this strategy because he did not recognise any other one.

Question 1, 2, and 4 are the PISA questions that are included in the employe cluster and routine problem. Students only solved each question with a maximum of two strategies. The strategy is not only influenced by the approach used in learning, but also other components such as the problem given. Students do not have various strategies for solving routine problems. Meanwhile, the non-routine problems stimulate the application of multiple strategies and trigger the exploration of relations among the variables [13].
4. Conclusion
There were only four strategies used in solving the PISA problems through the RME approach: look for a pattern (9.48%), make a drawing or diagram (5.17%), guess and check (3.44%), and work backwards (2.58%). Most of the students did not use various strategies, and even some others did not use them at all. We suggest that teachers construct and teach non-routine problems sustainably so that students can solve them by using various strategies.

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