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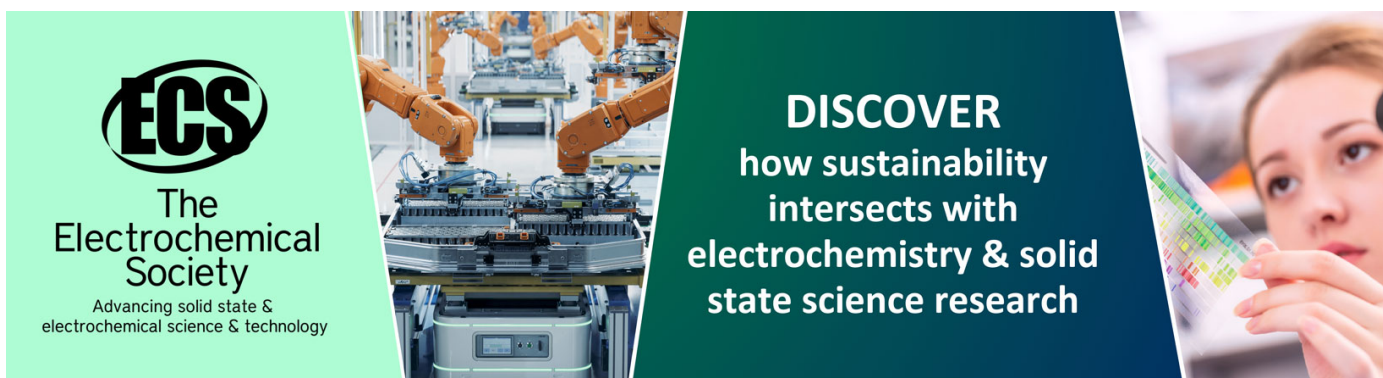
Students' Mathematical Connection Ability in Solving Real-world Problems

To cite this article: A G E Putri and D U Wutsqa 2019 *J. Phys.: Conf. Ser.* **1320** 012066

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Students' Mathematical Connection Ability in Solving Real-world Problems

A G E Putri^{1*}, D U Wutsqa²

¹ Mathematics Education Department of Graduate School, Yogyakarta State University, Jl. Colombo No. 1 Depok, Sleman, D. I. Yogyakarta, Indonesia 55281

² Mathematics Education Department, Yogyakarta State University

*Corresponding author E-mail: andigusmauliaekaputri.2017@student.uny.ac.id

Abstract. Being able to solve a variety of mathematical problems is one of the main factors and indicators that reflect the success of mathematics learning, including real-world problems. In solving real-world problems, students need a mathematical connection to be able to choose and use a mathematical concept that fits properly with conditions given in the problem. Therefore, it is important to observe students' mathematical connection in order to improve their mathematical achievement. This study is qualitative descriptive which aimed to describe the ability of eighth-graders' mathematical connections in solving real-world problems. The subjects of this study were 29 students of a Private Junior High School in Bantul Yogyakarta. Mathematical connection test was employed for collecting the data. Based on the analysis result, students' mathematical connection falls in the low category. Students' difficulties in solving real-world problems were restricted to understanding the problem and connecting the problem with relevant mathematical concepts.

1. Introduction

Real-world problems refer to problems that contain the daily life context and are relevant to everyday situations or close to the life situations [1,2]. In mathematics, a question will be a problem if there are no certain ready rules or algorithms that can be directly applied to solving the question [3]. Real-world problems in mathematics are quite diverse, in terms of the type or level of complexity, or the characteristics of the problem. According to [1], the main criterion that needs to be considered from real-world problems is having to describe the situation with the help of symbols, word and general events that usually occur every day. However, these daily problems can be arranged in various contexts, where the context used is based on real situations.

The Program for International Student Assessment (PISA) sets real-world problems into four types of real-life contexts namely personal, occupational, scientific, and societal [4]. Based on the types of the context, the problem situation is not limited to daily activities but each type has its own domain. Therefore, in solving real-world problems, students need a mathematical ability that connects problems and mathematics. In its application, mathematics has been applied in various problem-solving efforts [5]. In this case, students need a mathematical connection to be able to choose and use a mathematical concept that fits properly with conditions given in the problem. This corresponds to one of the mathematical connection roles: enabling students to apply mathematics in real life, while real-world context provides self-opportunities for the student to connect what they are learning to their own environment [6].



Eli, Mohr-Schroeder and Lee stated, “mathematical connection is a link or bridge in which prior or new knowledge is used to establish or strengthen an understanding of the relationship between or among mathematical ideas, concepts, strands, or representations” [7]. The statement shows that mathematical connection is a fundamental ability and must be possessed by students. Having connection ability, students will have no difficulties in understanding, learning or solving mathematical problems. The learning process without involving connections requires students to learn and remember too many isolated concepts and skills. On the contrary, the existence of a connection can help students building new knowledge. Mathematical connection involves recognizing and using relationships between mathematical ideas, understanding how mathematical ideas relate to and build on one another to produce a coherent whole, recognizing and applying mathematics both in mathematics and outside the context of mathematics [6]. According to [8], learning activities related to mathematical connections include; (1) understanding representations that are in accordance with mathematical concepts and algorithms; (2) determining the relationship between various concept representations and algorithms; (3) understanding the relationship between mathematical ideas; (4) applying mathematics in real life and in other disciplines; (5) finding the relationship between procedures in the appropriate representation; (6) using connections between mathematical ideas and other disciplines.

Basically, mathematics learning is integrated and sustainable where each topic is interrelated and multilevel, as one of the mathematical characteristics listed in the [9], there is a relationship between one lesson and another, in which the lesson learned after fulfilling or mastering the previous lesson. This shows how topics in mathematics are interrelated. As outlined by in mathematics learning there are prerequisite topics or concepts as a basis for understanding and mastering topics or concepts that will be studied next [10]. The statement indicates that mathematical connection plays an important role in mathematics learning, especially in constructing new understandings based on prior knowledge by connecting interactions between mathematics topics/ideas learned. Connection helps students see mathematics as a coherent interconnected whole. Therefore, the student can understand the relationship between topics/ideas in mathematics.

Mathematical connection helps to shape students' perceptions by seeing mathematics as an integrated part of their lives, so they can use and apply mathematics in solving problems [11]. Solving a problem means students must have an adequate conceptual understanding so they will understand the information they got and able to determine what mathematics they will use. This corresponds to [12], mathematics has various concepts and formulas that can be applied to solve mathematical problems. When students faced the problems, they necessary to connect concepts or formulas then combine them to solve problems. In connection with solving real-world problems, [13] stated several related strategies such as presenting and stating problems in a clear form, formulating alternative hypotheses and procedures that are expected to be used to solve the problem, test hypotheses and do work to obtain solutions and the solution obtained may be more than one, if one solution is obtained then the next step is to re-examine whether the solution is correct but if more than one solution is obtained, it is necessary to choose which solution is the best.

In addition, there are seven modelling steps that can be applied in solving real-world problems as stated by [14], understanding, simplifying/structuring, mathematizing, working mathematically, interpreting, validating, and exposing. Thus, to solve real-world problems students need to follow several processes simply can be sorted as follows such as understanding the problem, modeling problems, solving problems, then drawing conclusions based on the problem given.

Based on the description above, the process of real-world problem solving is influenced by the students' mathematical connection. However, several studies showed students' mathematical connection was still relatively low. Siregar and Surya showed the percentage of two indicators about students' mathematical connection ability, first indicator about the relationship between mathematics and daily life is 51.11% and the second indicator about the relationship between objects and mathematical concepts are 17, 78 % [15]. Another study by [16] also revealed that the mathematical connection ability of students was still below average, the average percentage of mastery was 63% of inter-topic

mathematical connections, 41% of connections among mathematical topics, 56% mathematical connection with other lessons, and 55% mathematical connection with life.

Meanwhile, [17] conducted a survey to test 8th grade students' skills in connecting mathematics with real life, the results of their research showed that the level of students ability in connecting mathematics with real life is not in sufficient level, most students only connecting real life with numbers and shapes (40.3%). Another study by [18], concluded that students' difficulties in solving math word problems according to mathematics teachers are students struggled with representation and understanding the problems (51%), students' ability to make a plan to solve the problem (31%) and lack of vocabulary knowledge (10%). This current study aims to describe the ability of mathematical connections of eighth-graders in solving real-world problems.

2. Method

This study is a qualitative descriptive in nature. The subjects of this study were 29 students of a Private Junior High School in Bantul Yogyakarta. A mathematical connection test is employed to collect data on the ability of mathematical connections of eighth-graders in solving real-world problems. The test questions used in The Mathematics Literacy Contest on November 19th, 2011 held in seven cities: Jakarta, Surabaya, Yogyakarta, Medan, Palembang, Makassar, and Banjarmasin. Data of the mathematical connection ability were analyzed using the scoring guidelines. Guidelines for test scoring is modified from [19]. The scoring guidelines refer to Table 1.

Table 1. Scoring guidelines for mathematical connection ability tests.

Score	Criteria
0	No answer.
1	Using formal/informal information, identification with limited understanding, unclear connections, incomplete or non-systematic solutions.
2	Using formal/informal information correctly, identifying elements with less understanding, unclear connections, incomplete and not systematic solutions.
3	Using formal/informal information correctly, identifying elements with clear understanding, but incomplete connections, almost complete and systematic solutions.
4	Using formal/informal information correctly, identification of elements accompanied by understanding, using appropriate concepts, complete and systematic solutions.

3. Results and Discussion

3.1. Result

Based on the students' responses, it was found that the percentage of students who gave the correct answer for the first and second question respectively were 46.55% and 55.17%. The first question was dominated by score 2 while the second question was dominated by score 3. The distribution of mathematical connection score obtained by students in solving real-world problems is presented in Table 2.

Table 2. Percentage distribution of scores tests students' overall mathematical connection abilities.

The percentage of who scored students	First question (Cake)	Second question (Earth Water Region)
0	0,00	0,00
1	13,79	34,48
2	86,21	31,03
3	0,00	41,38
4	0,00	0,00

Based on Table 2, in the first problem, there are 86.21% of students get a score of 2 which is a fairly large number, this score is obtained by most students because their responses have not been shown a clear connection between the problems given with the appropriate mathematical concepts to be applied to the problem. It is coupled with the fact that students' understanding of the problems that are given is lacking.

More specifically, some of the students' responses will be described to figure out their mathematical connections ability and the process of solving their problems. The first question can be seen in Figure 1.

Cake. A cake factory provides two types of disc-shaped cakes with the same thickness, but different sizes. Small and large cake surfaces respectively 10 cm and 15 cm in diameter. If each small and large cake is sold for IDR 10,000 and IDR 15,000 respectively, which one is more worthwhile, buying three small cakes or two large cakes? Explain your answer.



Figure 1. Question 1

Student's answer sheets:

A. $10.000 \times 3 = 30.000$
 B. $15.000 \times 2 = 30.000$
 Jadi Sama-Sama menguntungkan karena harganya yang sama yaitu Rp 30.000,00

Therefore, both are equally worthwhile since the prices are same, Rp 30.000,00

Figure 2. Student's answer sheet

jawab

Rp 10.000,00 Rp 15.000,00

3 small cakes
 3 kue yg kecil: $10 \times 3 = 30$

2 large cakes
 2 kue yg besar: $15 \times 2 = 30$

Sama, dari kedua kue yg berdiameter yang berbeda antara kue yang besar dan kue yang kecil sama. Tidak ada yang lebih menguntungkan.

The large and small cakes are same. No cakes are more worthwhile than others.

Figure 3. Student's answer sheet

jawab

Diket: Permukaan kue yang kecil dan besar masing-masing berdiameter 10 cm dan 15 cm. Dan di jual masing-masing dengan harga 10.000 dan 15.000.

Di tanya: Manakah yang lebih menguntungkan, membeli 3 kue yg kecil atau dua kue yang besar.

Jawab: harga 1 kue yg kecil $10.000 \times 3 = 30.000$
 harga 1 kue yg besar $15.000 \times 2 = 30.000$

Jadi, yg lebih menguntungkan adalah kue yg kecil karena dari harga yg sama lebih banyak kue yg kecil dari pada yg besar.

Therefore, the smaller cakes are more worthwhile because the same amount of money can afford more smaller cakes.

Figure 4. Student's answer sheet

From samples of students' answers to the first question, we can conclude that students' responses to the problem were generally the same. Students' answers were only oriented to cake's prices, students only considered the costs needed to buy three small cakes or buy two large cakes, they skipped information about the size of the two cakes and ignored the concrete information of a circular cake in addition to the question, in which this information could lead them to the mathematical concept to be applied, the area of circle. This implied how students do not fully understand the information contained in the problem. Limited understanding makes it difficult for them to connect to the situation with the right mathematics, thus causing students to draw conclusions that are less relevant to the problems given.

Furthermore, in the second problem, students' answers are in the range of scores 1-3 with a relatively the same percentage but still dominated by the students who received a score of 3 by 41.38%. The second problem on the test question can be seen in Figure 5.

Earth water area. Thirty percent of the earth's surface is covered by land and the rest is by water. Ninety-seven percent of water is seawater and the rest is fresh water. How much is the surface of the earth covered in fresh water? write down your reasons.



Figure 5. Question 2

Student's answer sheets:

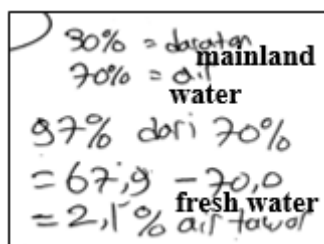


Figure 6. Student's answer sheet

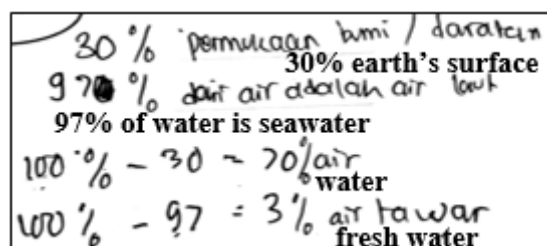


Figure 7. Student's answer sheet

From two samples of students' answer above, we can conclude that students are able to present the situation to the problem in the form of mathematics correctly. Student's answer in Figure 6 shows that the student already has an understanding of the situation on the problem. He is also able to connect among the information he gets to draw conclusions, the students obtained correct results about the percentage of fresh water but he did not write a complete and systematic solution. As with the student answers in Figure 7, the student answer sheet shows that students have obtained information regarding the percentage of all water on the earth's surface and were able to determine the percentage of fresh water based on the percentage of known seawater information, but he could not link the two informations to answer questions on the problem so that the solution that he obtained was incomplete.

3.2. Discussions

The results showed that the mathematical connection of students is still low, two mathematical connection problems of indicators applying mathematical concepts in real-world problems showed that students have difficulties in understanding the problem, choosing appropriate mathematical concepts or procedures in solving problems and there are still some students who were unfluent procedurally. This was consistent with [19], who classified students' difficulties in solving math word problems into three types, such as text difficulties (ie. difficulties that refer to the words used in the problem), unfamiliar contexts, and using inappropriate strategies. The results of this study indicate that the participants in this study belong to one of these categories, that is using inappropriate strategies.

The fact is the lack of understanding of students and their inability to link the problems situation with mathematics made students apply strategies which were inappropriate and causing the results and conclusions obtained were also incorrect. Relevant with [17] finding that 8th graders' skill of connecting mathematics to real life is dominated by level 1 (40.3%) and level 2 (23.3%), where students at level 1 were only able to connect real life situations given in the context of numbers and geometric shapes because these two are the most familiar mathematics in everyday life. Meanwhile, at level 0 showed that students could not establish mathematical connections correctly and this caused students inability to understand mathematical concepts in a meaningful way. Another relevant research with this paper is the research conducted by [15], she stated that the ability of students' mathematical connections in solving mathematical relationships with everyday life only 51.11%, which is said that student's mathematical connection ability was not yet complete. The results of this study also show results that are not much different from the previous researches, that the ability of students' mathematical connections in solving real-world problems is still limited.

4. Conclusion

The results showed that the percentage of students' mathematical connection ability in completing two real-world problems with applying mathematical concepts in real-world applications as the indicator was still low, only fulfilled 46.55% for the first question while the second question fulfilled 55.17%. In completing the real-world problem the students were restricted to understanding the problem and connecting the problem with the relevant mathematical concepts.

Suggestions for future research are for researchers to also find out and discuss the challenges experienced by students in solving real-world problems, besides that it is suggested for further research to find ways to improve the ability of junior high school students' mathematical connections in completing the real-world problem.

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