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Students' Mathematical Connection Error in Solving PISA Circle Problem

Vivi Rachmatul Hidayati, Subanji, Sisworo*

Universitas Negeri Mataram, Indonesia
*vivirachman@unram.ac.id

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Abstract: Mathematical connection is one of the competencies in NCTM that students need to have. Mathematical connections can help students understand material and mathematical concepts easily. In addition, mathematical connections can help students in solving mathematical problems. Even so, mathematical connection errors are still made by some students. Mathematical connection errors made by students when solving geometry problems, especially about circle. The purpose of this study is to describe the mathematical connection errors made by students in solving problems adapted from PISA problems focusing on circle material. This research method is descriptive-qualitative. Prospective subjects are 20 of 8th grade students in one of the junior high schools in Malang who have studied about circle. Based on the distribution of answers, two subjects were selected in this study. After going through the interview process, the data obtained in the form of work results and interview transcripts. Based on the results of research, mathematical connection errors made by research subjects in the form of not being able to use mathematics in mathematical problems; can't find connections between topics in mathematics; unable to understand the representation of concepts in mathematical problems; and draw relationships between procedures on mathematical problems

Keywords : Mathematical connection; PISA Problem; Circle

Introduction

Mathematics learning outcomes of junior high students are still not good. This is confirmed by the result of study showing that students still experience some difficulties in solving mathematics problems. Tella (2007) states that student performance and learning outcomes in mathematics in school are quite poor. This is supported by Lestari, Hasbi, & Lefrida (2016) who conducted tests on junior high school students to solve a problem and get the conclusion that students still experience errors in solving mathematics word-task. Students also make mistakes in solving problems (non-routine task) (Timutius, Apriliani, & Bernard, 2018).

Wijaya, van den Heuvel-Panhuizen, Doorman, & Robitzsch (2014) suggested that as many as 38% of students made mistakes in understanding PISA mathematics problems that were contextual. As many as 42% of students have difficulty in changing contextualized problem sentences into mathematical models. This is supported by data that students experience errors in solving PISA problems at levels 5 and 6 (Edo, Ilma, & Hartono, 2013). This shows that students are still lacking in solving mathematical problems. PISA problems in mathematics in level 5 and 6 focus on students' ability to solve complex problems, mathematical modelling, and information generalization (Stacey, 2011).

One of the mathematical topics studied in school is geometry. There is previous research that shows that there are difficulties experienced by students in understanding the topic of geometry (Gal & Linchevski, 2010); (Adolphus, 2011). One of the mistakes that occur is misconception about geometry (Özerem, 2012). Based on a study of geometric learning difficulties, circle material is one of the material that is considered difficult by students to understand (Fabiyi, 2017).

Based on the results of previous studies, students have difficulty in solving contextual PISA circle problems (Hidayati, Subanji, & Sisworo, 2017). Middle school students still experience errors in solving circle problems. These mistakes include being wrong in understanding the problem information, not solving the problem systematically, and not understanding the picture (or any other presentation) that is in the problem (Timutius et al., 2018). MTs student also experienced a number of errors in solving the problem about elements related to the circle. The error is that some of the students are unable to use mathematical concepts and are unable to carry out the problem solving procedure correctly (Apriliawan, Gembong, & Sanusi, 2013).

Mathematical modelling is an activity that requires the ability to associate mathematical information of a problem. Associating information is an important aspect of mathematics learning in which there are activities in the form of understanding concepts, explaining the relationships between concepts, and applying them to algorithms in solving problems (NCTM, 2000). The activity is related to the standard of mathematics learning that was initiated by NCTM, namely the mathematical connections (Wulandari, Mulyati, & Dwiyana, 2017). Student mathematical connection standards include knowing and using connections between mathematical concepts; understand how mathematical concepts are interconnected and formed with each other to produce a coherent whole form; and knowing and applying mathematics to contexts outside mathematics (NCTM, 2000).

Most middle school students have poor mathematical connection skills. Most students cannot find the relationship of several mathematical concepts needed to solve a problem (Surya, 2017). The results of the study were also stated by Fauzi (2015) that students have not very good mathematical connection skills, even for students who have high cognitive abilities. Students are still having trouble getting and processing mathematical ideas to solve problems. Not only that, but students also have difficulty in using more than one mathematical concept that is interconnected to solve geometry problems. Furthermore, students are also still confused about the relationship between word-problems with mathematical ideas (Prihastanto & Fitriyani, 2017).

Errors or weaknesses of mathematical connections that occur in students are very unfortunate. This is because the ability of mathematical connections allows students to have a wider knowledge of mathematics and related matters (K. E. Lestari, 2014). With broader knowledge, students will be able to solve mathematics tasks or story-problems properly. This is in line with the result study conducted by Rohendi (2012) that the ability of mathematical connections is part of higher-order thinking abilities that can help students solve mathematical problems.

There are some indicators regarding the ability of mathematical connections (Sumarmo, 2002). Indicators of mathematical connection capability are as follows.

1. Finding relationships between representations of concepts and procedures
2. Understanding the relationship between topics in mathematics

3. Using mathematics in everyday life
4. Understanding the representation of concepts or procedures that are the same or equivalent
5. Finding the relationship between a procedures to another in the equivalent mathematical representation.
6. Using connections between topics in mathematics and with other subjects.

These indicators will appear to students when solving mathematics word-problems. This is different from the reality in the field that in learning process, students still consider mathematics as a field of study where there are separate topics (Rohendi & Dulpaja, 2013).

Based on the explanation above, errors in solving geometry problems still occur. One of the topics of geometry that is still considered difficult is the circle. This is supported by the existence of research on the problem-solving circle problems. These mistakes can be seen from the perspective of students' mathematical connection abilities. Therefore, the purpose of this study is to describe the students' mathematical connection errors in solving problems adapted from PISA problems with the focus of the circle material topic.

Method

This research method is qualitative-descriptive. Prospective subjects of this study were 20 8th grade junior high school students in one of the junior high schools in Malang who had studied circle material. 20 prospective research subjects were asked to complete the questionnaire. Based on the results of student work, two students were chosen as research subjects. The research subjects were chosen based on the diversity of errors made based on mathematical connection indicators.

The research subjects explained the problem solving process verbally and in writing. Researchers can provide interventions in the form of questions if the subject's explanation is unclear. This is done to dig deeper into the way students solve problems. The results of the interview in the form of audio and student work. The results of the interview are made into transcripts and reduced as needed.

The research instruments were researchers, question sheets, interview guidelines, and voice recording devices. The question sheet is a circle problem that was adapted from the PISA problem. The question sheet contains problems regarding circles that are contextual and have one other material element (ie speed, distance, and time) in their solution.

The question sheet instrument and interview guidelines were validated by two validators, each one was an expert validator and a practitioner validator. Expert validators and practitioners were respectively mathematics lecturers and mathematics teachers. Based on the results of the validation by the two validators, the results were obtained that the question sheet instrument and interview guidelines were declared valid.

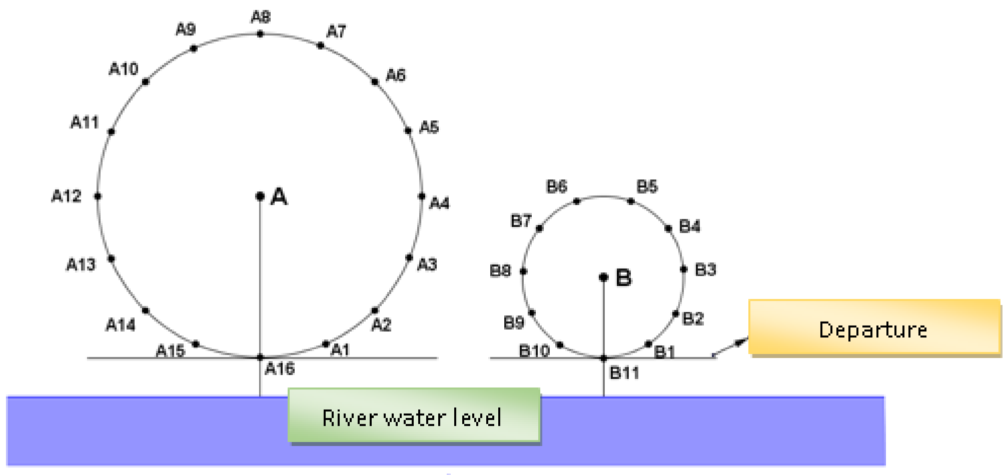


Figure 1 Problem Picture

There are two Ferris wheel in Surakarta City Amusement Park. The big Ferris wheel is called the Ferris wheel A centered on A and the small Ferris wheel as the Ferris wheel B is centered on B. The departure platform is 10 meters above the river's surface. Point A8 is 150 meters from the river's surface. The height of B from the departure stage is equal to half of the height A from the departure stage. The Ferris wheel rotates counterclockwise from A16 for Ferris A and B11 for Ferris B. Ferris wheel A rotates about 11 meters per minute and Ferris B is about 8 meters per minute. Andika rides the Ferris wheel A and Fitri rides the Ferris wheel B. Andika and Fitri rides the Ferris wheel at the same time. If Andika is at point A12 then where is Fitri at that time? (Set π = 22/7).

Result and Discussion

There are two subjects examined how they are in solving the problem sheet given. The first subject is referred to as S1 and the second subject is referred to as S2. Both subjects completed the Question Sheet. After solving the problem, students were interviewed by researchers. The following are the results of the research conducted. S1 encountered several errors in resolving PISA problems. S1 experienced an error in determining the radius of Ferris wheel A and B. S1 did not realize that there was a distance between the surface of the water and the stage of departure as long as 10 m. S1 though that the diameter of the Ferris wheel A is 150 m (which is the distance of point A8 from the surface of the river water), so the diameter of Ferris Wheel B is half of 150, which is 75 m. The following is a picture of the work of S1.

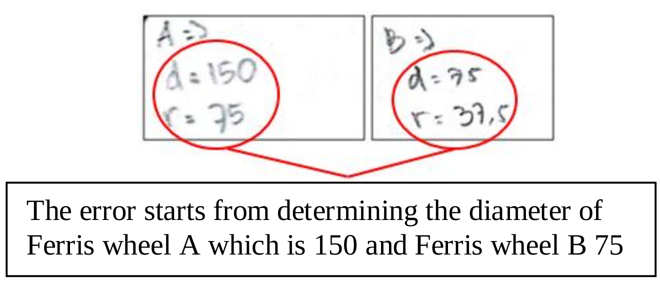


Figure 2 S1's Work when Looking for Ferris Wheel A and B Diameter

Based on Figure 2, S1 experienced an error in understanding information about the distance between the departure stage and the river water level. This shows that S1 experienced a mathematical connection error on the indicator using mathematics in everyday life. Students cannot connect the problems of daily life with mathematical concepts. S1 is less thorough in understanding problems and unable to connect with mathematical concepts correctly. This is by the results of the study which revealed that one of the students 'mathematical connection errors was in the form of students' inability to understand mathematical problems properly (Warih, Parta, & Rahardjo, 2016)

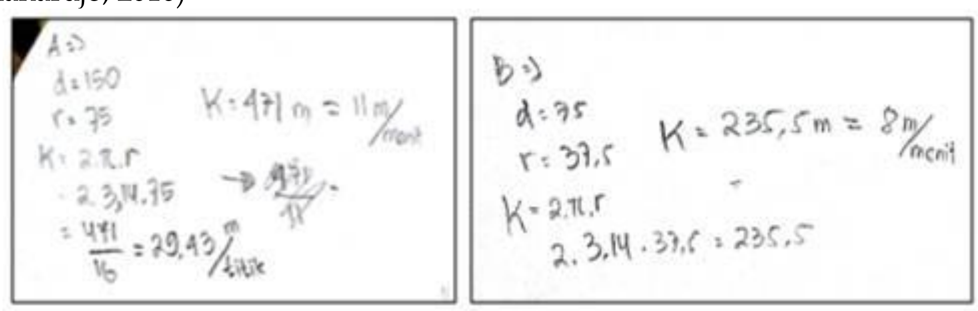
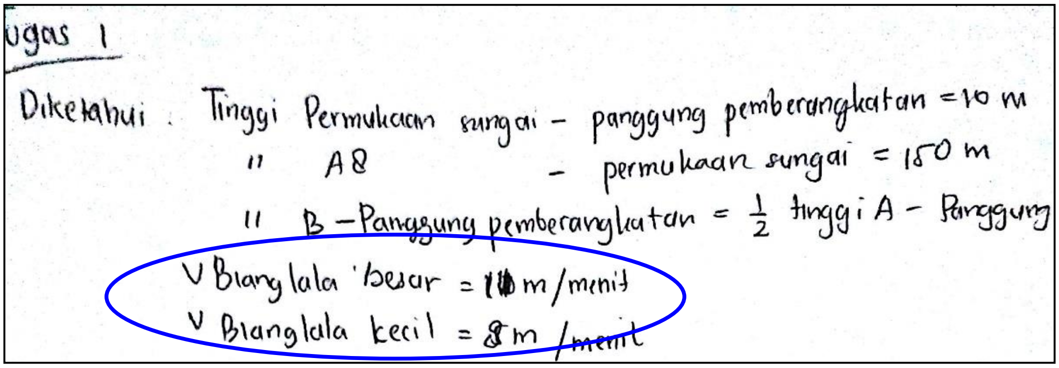


Figure 3 S1's Work when Determining Circumference of Ferris Wheel A and B

S1 also made a mistake in determining the circumference of the A and B (red ellipse marks). Next, S1 made a mistake in determining the distance between points on Ferris A. Figure 3 shows the results of the work of S1 when determining the perimeter of Ferris wheel A and B. S1 has gone through the appropriate procedure in determining the circumference of Ferris wheel A and B despite the wrong result. S1 has understood the information that the diameter of Ferris wheel A is half of the Ferris wheel diameter B based on the sentence problem "the height of B from the departure stage is equal to half of the height A from the departure stage". This means that S1 can find the relationship between concept representations on the PISA circle problem. In this case S1 has fulfilled one indicator of a mathematical connection (Sumarmo, 2002).

Based on Figure 3 above, S1 made a mistake in determining the circumference of the A and B due to the initial error in determining its diameter. Next S1 determined the distance between points on the A and B (blue ellipse marks). When asked why S1 sought the distance between points on the A and B Ferris wheel, S1 was unable to give a reason. Finally, S1 cannot continue solving PISA problems. This is because S1 is not able to draw relationships between several concepts on the problem to solve the PISA problem. S1 cannot make a connection between the circumference of the circle, the length of the track, as well as speed, distance, and time. This causes S1 to not know the next completion step. This is in accordance with Mousley (2004) which states that one of the important things in students' mathematical connections is their ability to connect between mathematical concepts in solving a problem.


ugas 1

Diketahui : Tinggi Permukaan sungai – panggung pemberangkatan = 10 m
" A8 – permukaan sungai = 150 m
" B – Panggung pemberangkatan = ½ tinggi A – Panggung
V Bianglala besar = 11 m/menit
V Bianglala kecil = 8 m/menit

Translation:

Known:

- River water level – departure platform = 10
- Height of A8 – river water level = 150 m
- The height of B – departure platform = ½ of height of A – departure platform
- Velocity of big ferris wheel = 11 m/minutes
- Velocity of small ferris wheel = 8 m/minutes

Figure 4 S2 when Writing Information on PISA Problems

S2 could find all the information that is on the problem. S2 wrote the river's water level from the departure stage, A8's height from the river's water level, and the velocity of the spinning wheel A and B (symbolizing velocity with v, in the blue ellipse in Figure 4). S2 also wrote the height of B from the departure stage is half of the height of A from the departure stage. There is one information that was not written by S2 that is the Ferris wheel's turning direction. S2 considers that the direction of rotation of the Ferris wheel A and B is clockwise. S2 misunderstood the concepts that exist in the problem information. Information in the form of "counter-clockwise rotation" is misunderstood by S2. S2 has an error in understanding the concept representation of rotating counter-clockwise. This is consistent with the mathematical connection indicator described (Sumarmo, 2002).

S2 was able to determine the circumference of the Ferris wheel A. S2 determined the distance between points on the Ferris wheel A. S2 then determined the length of the path traversed by Andika. S2 sought the time taken by Andika to get to point A12. After getting the time Andika passed while riding Ferris A, the S2 decided that the duration of Andika's time was the same as that of Fitri. S2 determined the "Fitri distance" in question is the path Fitri traversed with speed and time information. Even so, S2 did not write the results well and was confused in determining the next completion step (red ellipse in Figure 5). The following is S2's work.

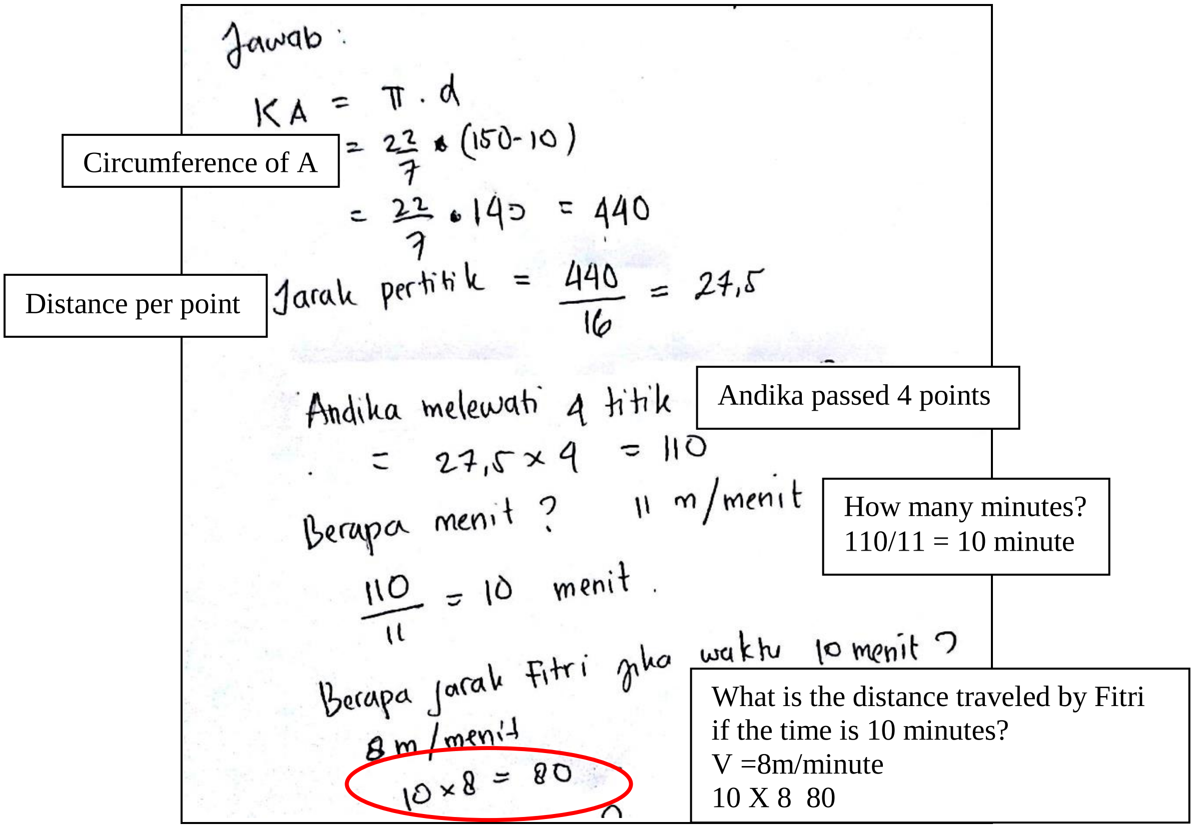


Figure 5 S2' work Determines the Length of the Trajectory Transversed by Fitri

Based on Figure 5, S2 has done several stages of problem solving well. S2 has searched around the Ferris wheel A and B; S2 has also sought the length of the track that has been traversed by S2 by involving the concepts of distance, speed, and time; and looking for the distance between points on each Ferris wheel. This means that S2 has done several indicators in students' mathematical connections. S2 can use mathematics on PISA math problems. S2 is also able to find relationships between various mathematical concepts and procedures. Mathematical connection errors made by S2 include not being able to find a connection between one procedure and another. By the indicators mentioned by Sumarmo (2002), that one good indicator of a student's mathematical connection is when he can find relationships between mathematical procedures in solving problems.

Conclusion

Mathematical connection ability is one of the things students must have. This is also very useful when students face contextual problems, such as PISA problems. Even so, mathematical connection errors are still made by some students in solving PISA math problems. Mathematical connection errors made by students in the form of not being able to use the mathematics of everyday life, concretely is in the form of not being able to digest information on contextual mathematics problems. Besides, other mathematical connection errors are in the form of not being able to draw relationships between mathematical topics in solving PISA problems. Another mistake is not being able to understand the representation of mathematical concepts that exist in the PISA problem. Students also experience an error that is not finding a connection between one and another procedure on the representation of the PISA circle problem.

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