Students’ Errors in solving the PISA mathematics problem using Newman’s error categories

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Abstract. The purpose of the study is to analyze the students’ errors of a junior high school student in solving the Program for International Student Assessment (PISA) mathematics problem. Then, it will be analyzed that what kinds of students’ errors regarding Newman’s error categories, which were connected to the PISA’s stage of mathematization. The Newman’s error categories are comprehending a task, transforming the task into a mathematical problem, processing mathematical procedures, and interpreting or encoding the solution regarding of the real solutions. The participants were two students of junior high schools. According to the finding of this study, all of the students are making error in transformation and process skills. While the second student is also making comprehension error, no student is doing a mistake in encoding.

1. Introduction

Program for International Student Assessment (PISA) is one of the major international studies of mathematics, science, and reading to 15-year-olds in educational programmes. The primary aim of the PISA assessment is to determine the extent to which young people have acquired the broader knowledge and skills in mathematics, science, and reading that they will need in adult life (Organisation for Economic Co-operation and Development [OECD] [1]. One of The PISA studies is assessing students’ mathematical literacy.

Mathematical literacy is one of the mathematical competencies that important for the student. It needed to solve his/her daily life problems, both inside and outside of school. Mathematical literacy is an individual’s capacity to formulate, employ, and interpret mathematics in a variety of contexts [1] [2]. Furthermore, in an interview in Mathematics and Democracy, Ewell (2001) was asked about mathematical literacy, he agreed that mathematical literacy is less formal and more intuitive, less abstract and more contextual, less symbolic and more concrete [3].

According to PISA study, Indonesian students’ mathematical literacy have lower achievement in PISA 2000 to PISA 2015. Even though, not many researchers are trying to know what factors affecting students’ mathematical literacy is still in the bottom position among other countries. In overseas, many researchers analyze what can improve students' mathematical literacy, such as analysis of textbooks for 9th-grade students in Iran and Australia [4], teacher's understanding of a concept [5] [6], tool analysis evaluation [7] [8]. While In Indonesia, some researchers researched in PISA study like what Lutfianto et al. (2013), Wijaya et al. (2014), Ahyan et al. (2014), and Novita & Putra (2016) did. Lutfianto et al. analyzed unfinished
student in solving PISA contextual mathematics problem [9], whereas Wijaya et al. analyzed student’s errors in solving context-based PISA [10]. Then, Ahyan et al. developed the PISA-like problem of change and relationship content [11], and Rita and Putra did studying how PISA-like problem supporting student’s creativity [12]. In this study, it is a purpose to analyze the students’ errors of a junior high school student in solving PISA mathematics problems.

2. Method

2.1. Participants

The study was conducted in the academic year 2018-2019 at a junior high school in East Lombok, Indonesia. The participants were two students of 9th-grade. The participants selected based on teacher information of their mathematical achievement.

2.2. Data Collection

The test was used in collecting data. A test form used four PISA mathematics problem that developed by OECD [13]. The sample of the test can be seen in table 1. The participants answered the questions in 100 minutes.

| Unit               | Question                                                                                                                                 |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Flash disk         | Ashfa has a flash disk that store videos and photos. The flash disk has a capacity of 16 GB (16,000 MB). The graph below shows the current disk of his flash disk. |

![Flash Disk Graph]

Question 1 (Q1):

Ashfa wants to transfer a photo folder of 5,600 MB onto his flash disk, but there is not enough free space on the flash disk. While he does not want to delete any existing photos, he is happy to delete up to two video folders. Ashfa’s flash disk has the following size video folders stored on it.

| Video Folder | Size  |
|---------------|-------|
| Folder 1      | 1,690 MB |
| Folder 2      | 1,200 MB |
| Folder 3      | 1,280 MB |
| Folder 4      | 880 MB  |
| Folder 5      | 960 MB  |
| Folder 6      | 1,280 MB |
| Folder 7      | 1,200 MB |
| Folder 8      | 2,000 MB |

By deleting at most two video folders is it possible for Ashfa to have enough space on his flash disk to add the photo folder? Show your answer!

| Ice-cream Shop | The picture below is the floor plan for Ashfiya’s Ice-cream Shop. She is renovating the shop. The service area is surrounded by the serving counter. |
Note: each square on the grid represents 0.5 meters x 0.5 meters.

Question 2 (Q2):
Ashfiya wants to put new edging along the outer edge of the counter. What is the total length of edging she needs? Show your work!

Question 3 (Q3):
Ashfiya is also going to put new flooring the shop. What is the total floor space area of the shop, excluding the service area and counter? Show your work.

Question 4 (Q4):
Ashfiya wants to have sets of tables and four chairs like one shown below in her shop. The circle represents the floor space are needed for each set.

For customers to have enough room when they are seated, each set (are represented by the circle) should be placed according to the following constraints:
- Each set should be placed at least 0.5 meters away from walls.
- Each set should be placed at least 0.5 meters away from other sets.

What is the maximum number of sets that Ashfiya can fit into the shaded seating area in her shop? Draw the sets according to your answer!

2.3 Data Analysis
Descriptive research was employed in this study. In analyzing the data, we used Newman’s error categories which connected to the PISA’s stage of mathematization. The students with both no responses and correct answers do not include in this analysis. Table 2 below shows the Newman’s error categories.

| Newman’s error categories | Stage in PISA’s mathematization |
|---------------------------|----------------------------------|
| Reading: Error in simple recognition of words and symbols | - |
| Comprehension: Error in understanding the meaning of a problem | Understanding the problem situated in reality |
| - | Organizing real-world problems according to mathematical concepts and identifying relevant mathematics |
3. Results and Discussions

3.1. Student’s Comprehension Error

There are three indicators of students’ comprehension error namely misunderstanding the instruction, misunderstanding the keyword, and failure in selecting information. Based on data, student 2 (S2) did the comprehension error in solving question 4 (Q4). S2 understood the meaning of Q4, but he ignored the information in the question. The information that ignored is each set should be placed at least 0.5 meters away both from walls and from other sets. The figure 1 below shows the comprehension error of S2.

3.2. Student’s Transformation Error

There are four indicators of students’ transformation error namely procedural tendency, taking too much account of the context, wrong mathematical operation/concept, and treating a graph as a picture. Based on the data, student 1 (S1) did transformation error in solving both question 2 (Q2) and question 3 (Q3). She did not use mathematical concept correctly in transforming the real problem into a mathematical problem. In Q2, she did multiplication of 0.25 x 7 in determining hypotenuse of Counter, while in Q3 she did not understand how to identify the area of all the boxes (Figure 2). She discovered the area of each a box first, then he multiplying each a box by the number of the boxes in both the length side and width side. She did not think that Pythagoras theorem can use to determine the hypotenuse of Q2. Otherwise, S2 was able to connect the problem using Pythagoras theorem (Figure 3).
3.3. Student’s Process Skills Error

There are four indicators of students’ process skills error namely algebraic error, arithmetical error, measurement error, and unfinished answer. Based on the data, S1 made process skills error in solving Q3. She made a mistake in measuring the length of the hypotenuse of Counter that caused she got an error in counting the area of (Figure 4). Further, S2 also made process skills errors in solving Q4 because he could not solve the problem until the end (Figure 5).

3.4. Student’s Encoding Error

An indicator of the student’s encoding error is an impossible or not realistic answer. Based on the data, no student made encoding error. All of their answers are realistic according to the problems and the questions.

4. Conclusions

Students’ error often occurs in both transformation and process skills errors. It because of the students doing obstacles in transforming contextual problems or real problems into mathematical problems. Even though, no student makes the encoding error.

References

[1] OECD, 2013 PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving, and Financial Literacy Paris: OECD Publishing.

[2] OECD, 2017 PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematics, Financial Literacy, and Collaborative Problem Solving Paris: OECD Publishing.
[3] Ewell P T, 2001, Numeracy, Mathematics, and General Education, in Mathematics and Democracy: The case for quantitative literacy, L. A. Steen, Ed. (United States of America: The Woodrow Wilson National Fellowship Foundation), p. 37–48.

[4] Gatabi A R Stacey K and Gooya Z, 2012 Investigating grade nine textbook problems for characteristics related to mathematical literacy Math. Educ. Res. J. 24 p. 403–421.

[5] Bansilal S, 2011 Unpacking Mathematical Literacy Teachers ’ understanding of the concept of inflation African J. Res. Math., Sci. Technol. Educ. 15, 2 p. 179–190.

[6] Bansilal S and Mkhwanazi T W, 2014 Mathematical Literacy teachers ’ engagement with contextualised income tax calculations Pythagoras 35, 2 p. 1–10.

[7] Long C Bansilal S and Debba R, 2014 An investigation of Mathematical Literacy assessment supported by an application of Rasch measurement Pythagoras 35, 1 p. 1–17.

[8] Tout D and Gal I, 2015 Perspectives on numeracy: reflections from international assessments ZDM Math. Educ.

[9] Lutfianto M Zulkardi and Hartono Y, 2013 Unfinished Student Answer in PISA Mathematics Contextual Problem J. Math. Educ. 4, 2 p. 188–193.

[10] Wijaya A Heuvel-Panhizen M van den Doorman M and Robitzsch A, 2014 Difficulties in solving context-based PISA mathematics tasks: An analysis of students ’ errors Math. Enthus. 11, 3.

[11] Ahyan S Zulkardi and Darmawijoyo, 2014 Developing Mathematics Problems Based on PISA Level of Change and Relationships Content Jou 5, 1 p. 47–56.

[12] Novita R and Putra M, 2016 Using Task Like PISA’s Problem to Support Student’s Creativity in Mathematics J. Math. Educ. 7, 1 p. 31–42.

[13] OECD, 2013 PISA 2012 Released Mathematics Items Paris: OECD Publishing.