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The teachers' mathematics literacy ability for solving uncertainty problems on a PISA adaptation test

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Abstract. In research related to PISA, students have earned many portions as research subjects. However, research on teachers is rarely conducted. It is widely believed that there is a link between students' ability and teachers' ability. This study aimed at describing teacher's solution on PISA adaptation test. The PISA adaptation test consists of 13 questions from 4 scopes. However, this research focuses on the scope of uncertainty consisting of 3 test questions. In this study, the subjects were 7 teachers who were randomly selected from a Junior High School. This study adopted Cobb and Koeno's model of design research. The finding showed that all teachers responded correctly in the scope of uncertainty at level 2 and level 4. Moreover, the results revealed that 42,86% of teachers achieved level 5 and 28,57% teachers achieved level 6. Therefore, to improve the quality of students it is necessary to improve the quality of teachers.

1. Introduction

Student achievement was closely and directly related to the mathematics and pedagogical skills of elementary teachers [1, 2]. There was a significant relationship between teachers' perceptions and knowledge achieved by students [1, 2]. In this study teachers' perceptions were defined as (1) teacher paradigm in the learning process of mathematics, and (2) teacher attention to students' math skills [1, 2]. The teacher's attention to the students' mathematical skills was dependent on the teacher's mathematical knowledge [1, 2]. Based on the opinion, the ability of teachers in managing the process of learning to teach mathematics and solve mathematics problems was one of the determinants of student success in completing the PISA test. In research related to PISA, students have earned many portions as research subjects. However, research on teachers is rarely done. This study aimed to describe the Junior High School teachers' solution on PISA adaptation tests in quantity, space and shape, change and relationship, and uncertainty area, but in this paper, researchers will only describe the results of the research for teachers' solution on PISA adaptation tests in the uncertainty area [3, 4, 5].

The literacy of mathematics was the ability of the individual in understanding mathematics and applying it in daily life [6]. Using mathematical literacy, students could understand and apply the role of mathematics in the context of real life. [2, 7, 8]. According to Jan de Lange, the ability of a person to identify and understand the role of mathematics in real life, to make accurate judgments, use and involve mathematics in various ways to meet the needs of the individual as a reflective, constructive and devoted citizen called the literacy of mathematics. The following matters affect mathematical literacy skills, including: (1) the thinking and reasoning mathematically ability, (2) the argument logically ability, (3) the communicating mathematically ability, (4) the problem model ability, (5) the

proposing and solving problem ability, (6) the representing idea ability, and (7) the using symbol and formal language ability [7, 9].

PISA problems related to students' mathematical literacy have 6 levels [3, 10]. Based on the research of Julie [10], 83.33% students achieved level 4 and 38.89% of students achieved level 5. Furthermore, this study will also look at whether there is a correspondence between the teacher's ability and these results.

2. The Research Methodology

Two of design research characteristics were process-oriented and oriented to usability [11]. A design of a test that adapted from PISA was developed by the researcher. In addition, the teacher's solution for the test was described. Therefore, this study may be classified in the design study.

One of this study aims was to describe the teachers' solution on PISA adaptation tests. The steps that researchers did in this research can be seen in the chart below.
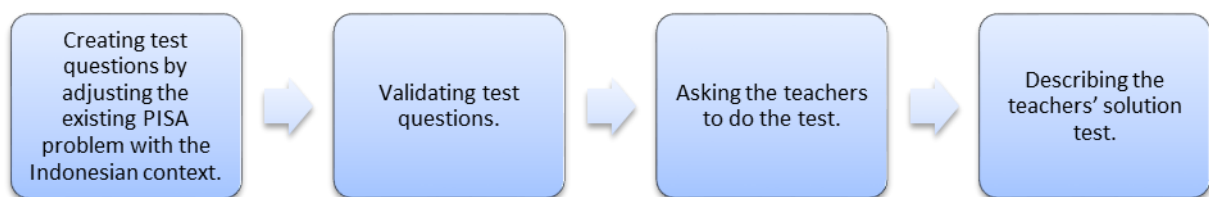
Figure 1. Research step

This test contained 13 questions, namely: (1) 3 questions for quantity, (2) 3 questions for uncertainty, (3) 3 questions for change and relationship, and (4) 4 questions for space and shape. The test was done by the teacher within 90 minutes.
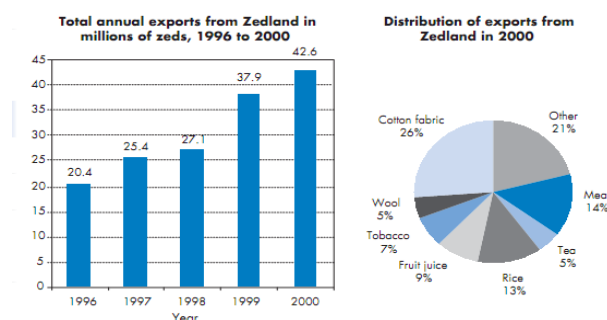
This research used 7 Junior High School teachers as the subject of research in Yogyakarta and surrounding areas. The selection of schools as the subjects of this study was conducted randomly proportional, then the best teachers from each school were selected as research subjects.

3. The Results and Discussion

In this paper, the research results that would be presented were the result of the PISA adaptation test on the uncertainty area [3, 4, 5]. The research result were described as follow:

Problem 1. The charts below show information about exports from Zedland, a country that uses zeds as its currency (see Figure 2).

a. What is the total value (in million zeds) of exports from Zedland in 1998?
b. What is the value of fruit exported from Zedland in 2000?

    A. 1,8 million zeds.   D. 3,4 million zeds.
    B. 2,3 million zeds.   E. 3,8 million zeds.
    C. 2,4 million zeds.

Figure 2. Distribution of exports from Zedland
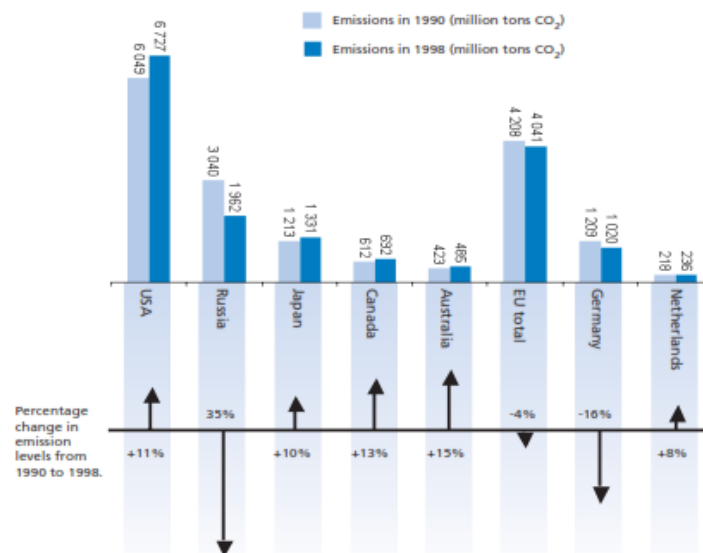
Teacher's answer for problem 1a:
The total value (in million zeds) of exports from Zedland in 1998 was 27.1. There were seven teachers who made solutions like this solution. Teachers' answer as above could be categorized in level 2 math literacy skills, because they must chose the relevant information about exports in 1998 from the chart.

Teacher's answer for problem 1b:
The value of the fruit is exported from Zedland in the year $2000 = \frac{9}{100} \times 42,6 = 3,834$ million zeds$\approx$ 3,8 million zeds. The answer was E. There were seven teachers who made solutions like this solution. Teachers' answer as above could be categorized in level 4 math literacy skills, because they must integrate different representations from chart 1 and chart 2, and then link the information that they need that were data of fruits and data export in year 2000.

Problem 2. Many scientists fear the increasing levels of CO_2 gas in Earth's atmosphere caused by climate change. The following diagram shows that the level of CO_2 emissions in 1990 (see bright bars) in some countries (or territories), emissions levels in 1998 (see dark bars), and percentage changes in emission levels between 1990 and 1998 (indicated by arrows and percentage).
a. In the diagram, you can read that in the USA, the increase in CO_2 emission level from 1990 to 1998 was 11%. Show the calculation to demonstrate how the 11% is obtained.
b. Mandy analysed the diagram and claimed she discovered a mistake in the percentage change in emission levels: "The percentage decrease in Germany (16%) is bigger than the percentage decrease in the whole European Union (EU total, 4%). This is not possible, since Germany is part of the EU." Do you agree with Mandy when she says this is not possible? Give an explanation to support your answer.

Figure 3. The level of CO2 emissions in 1990

Teachers' answer to problem 2a:
The increased CO2 emission levels from 1990 to 1998 is $= \frac{(6727-6049)}{6049} \times 100\% = \frac{678}{6045} \times 100\% = \frac{67800}{6045}\% \approx 11\%$. There were seven teachers who made solution like this solution.
Teachers' answer as above could be categorized in level 5 math literacy skills, because they must did some following action:
1) Choose data that they need that was the emission data of USA, namely: emission of CO_2 in 1990 was 6049 and emission of CO_2 in 1998 was 6727,

2) Choose the formula that satisfies real situation, and the percentage changing was $\frac{newdata - olddata}{olddata} \times$ 100%.

3) Compare and evaluate the result of the formula that they made with 11%.

Teachers' answer to problem 2b:

1. The teacher did not agree with Mandy opinion because he did not know the percentage of other EU member states. There was the possibility of other EU countries that percentage CO2 emission levels was more than4%. There were two teachers who made solution like this solution.
   Teachers' answer as above could be categorized in level 6 math literacy skills, because:
   a. They could utilize information that was the percentage decrease in Germany was 16% and the percentage decrease in EU was 4%, to be conceptualized.
   b. They also could formulate and communicate their thoughts precisely and in accordance with the original situation that the percentage decrease in EU was 4% not mean that all of the percentage decrease EU countries was 4%.
2. The teacher agrees with Mandy opinion because the percentage of all countries in the EU was 4%.
   There was one teacher who made solution like this solution.
3. There was one teacher who agrees with Mandy opinion without a reason.
4. There were three teachers who did not answer this question.

Problem 3. In a country, a number of polls are conducted to find out support for an upcoming presidential candidate. Four newspapers conducted a poll with results as presented in Table 1.

Table 1. Results of the vote for newspapers.

Newspaper name	Result of vote	Information
Newspaper 1	36.5 %	The poll was conducted on January 6 to 500 randomly selected people from voting citizens.
Newspaper 2	41.0 %	The poll was conducted on January 20 to 500 randomly selected people from voting citizens.
Newspaper 3	39.0 %	The poll was conducted on January 20 to 1000 randomly selected people from voting citizens.
Newspaper 4	44.5 %	The poll was conducted on January 20th to 1000 readers by phone

Which newspaper gave the best predictions about the number of voters, if the elections take place on 25 January? Give three reasons to support your answer!

Teachers' answer to problem 3:

1. The best prediction is Newspaper 3.
   The reason was: (a) the poll was conducted at a time that is closer to the election time, so the owner of the voting option was assumed to be more secure with his choice and ready to make his choice, (b) the samples were more than others, then the poll results will be more valid, and (3) polls conducted on citizens who have voting rights. There were two teachers who made solution like this solution.

Table 2. Teachers' ability in the uncertainty area for the PISA adaptation test.

Problem	Teacher's achievement level	Reasoning	The number of teacher	Percentage
1a	Level 2	The teachers could choose the relevant information about exports in 1998 from the chart.	7	100,00%
1b	Level 4	The teachers could integrate different representations from chart 1 and chart 2, and then link the information that they need that were data of fruits and data export in 2000.	7	100,00%
2a	Level 5	The teachers could did some following action: a. Choose data that they need that was the emission data of USA, namely: emission of CO_2 in 1990 was 6049 and emission of CO_2 in 1998 was 6727, b. Choose the formula that satisfies real situation, and the percentage changing was $\frac{newdata - olddata}{olddata} \times 100\%$, c. Compare and evaluate the result of the formula that they made with 11%.	6	85,71%
	Could not answer		1	14,29%
2b	Level 6	The teachers could did some following action: a. They could utilize information that was the percentage decrease in Germany was 16% and the percentage decrease in EU was 4%, to be conceptualized. b. They also could formulate and communicate their thoughts precisely and in accordance with the original situation that the percentage decrease in EU was 4% not mean that all of percentage decrease EU countries was 4%.	2	28,57%
	Could not be leveled		2	28,57%
	Could not answer		3	42,86%
3	Level 5	The teachers could did some following action: a. Develop models and specifying assumptions for complex situations b. Choose, compare, and evaluate problem solving strategies for complex problems related to the models.	3	42,86%
	Could not be leveled		4	57,14%

2. The best prediction is Newspaper 3.
   The reason was: (a) respondents were selected at random, (2) more respondents, and (3) respondents were selected from citizens who have voting rights. There was one teacher who made solution like this solution. Teachers' answer as above could be categorized in level 6 math literacy skills, because the teachers were able to do the following activities:
   a. Develop models and specifying assumptions for complex situations
   b. Choose, compare, and evaluate problem solving strategies for complex problems related to the models.
3. The best prediction was Newspaper 4.
   The reason was: (a) the result was the largest percentage, (b) the polling time was close to election time, and (c) the number of respondents taken more than newspapers 1 and 2. There were four teachers who made solution like this solution.

Table 2 summarizes the results obtained by the teacher. From the table, it can be seen that the teachers have been able to reach level 2 and level 4. Some teachers have been able to reach level 5 and 6, but not all teachers were able to achieve it. Based on the research of Julie [10], 83.33% students achieved level 4 and 38.89% of students achieved level 5.These results correspond to the results of this research, that were 100,00% of teachers achieved level 4 and 42,86% of teachers achieved level 5. Therefore, to improve the quality of students it is necessary to improve the quality of teachers.

4. Conclusions

From the above explanation, it can be concluded that all teachers could solve one level 2 and one level 4 uncertainty problems. One of the seven teachers has not been able to complete a first level 5 uncertainty problem. Four of the seven teachers have not been able to complete the second level 5 uncertainty problems. Five of the teachers have not been able to complete an uncertainty problem for level 6. This means the teachers were still having difficulties with the PISA problems level 5 and level 6. Therefore, the quality of teachers needs to be improved in order to be able to assist students to reach the maximum level in PISA.

Acknowledgments

References
[1] Campbell, Patricia F, et. all. 2014 *Journal for Research in Mathematics Education* **45** 419
[2] Julie H 2017 *International Journal of Science and Applied Science: Conference Serie*s **1** 55
[3] Julie H, and Marpaung Y 2012 *Widya Dharma* **23**
[4] OECD 2012 *Assessment Framework. Key Competencies in Reading, Mathematics and Science* (Paris: OECD)
[5] OECD *2013 PISA 2012 Results: What students know and can do. Student Performance in mathematics, reading, and science* (Paris: OECD)
[6] Ojose, B 2011 *Journal of Mathematics Education* **4** 89
[7] Christiansen, I B 2006 P*ythagoras* **64** 6
[8] Stacey K 2011 *Journal Mathematics Education* **2** 95
[9] Wijaya A 2016 *IndoMS Journal Mathematics Education* **7** 73
[10] Julie H, Sanjaya F and Anggoro A Y 2017 *AIP Conf Proc* **1868** 050026
[11] Akker, Den J V, Gravemeijer K, McKenney S, and Nieveen N 2006 *Educational Design Research* (New York: Taylor and Francis Group)