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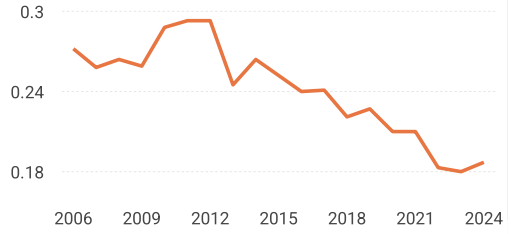

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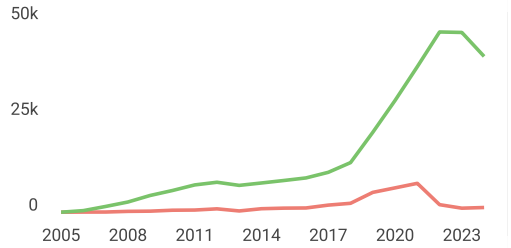

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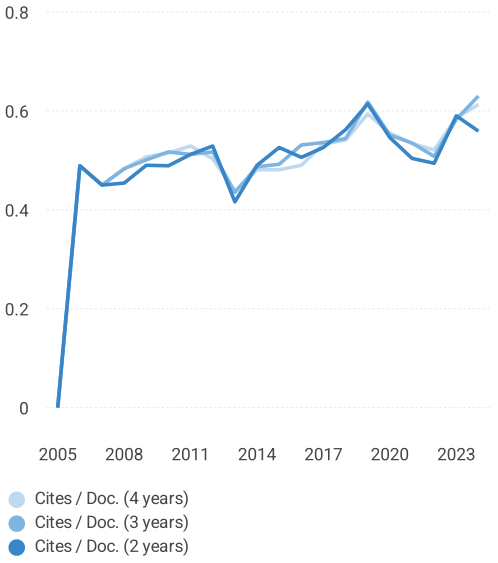

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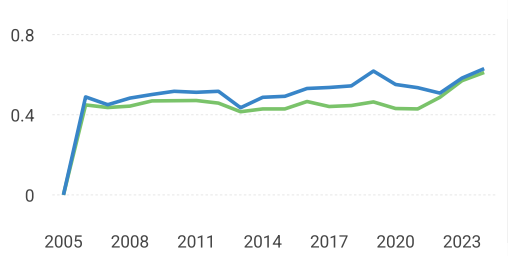

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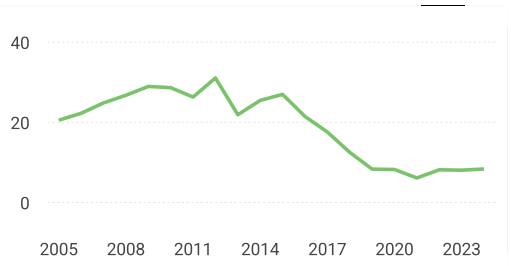

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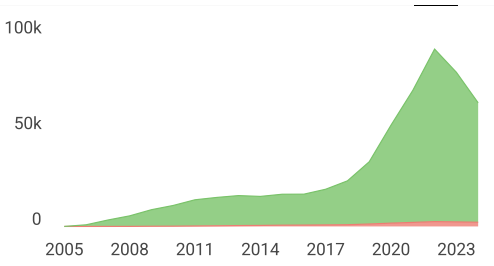

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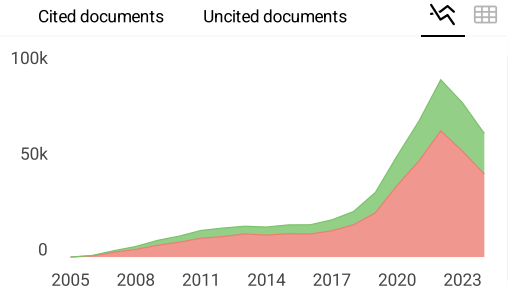

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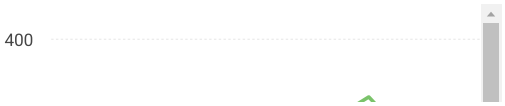

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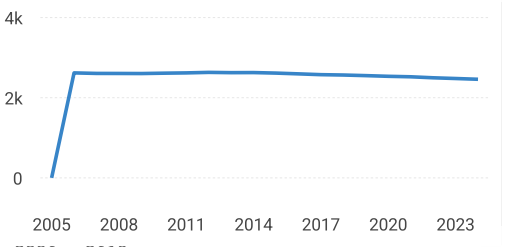

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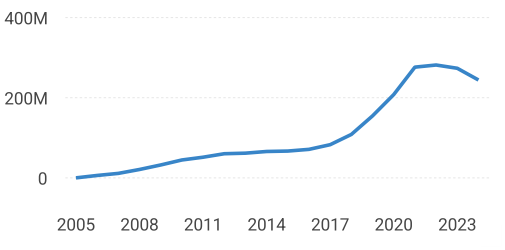

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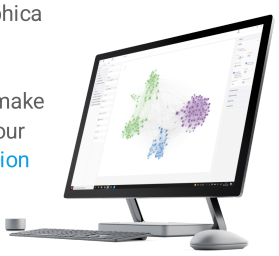

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The teacher's mathematical literacy for the change and relationship problems on the PISA adaptation test

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Abstract. There is evidence suggesting that teachers are one of the factors influencing student's performance in solving mathematical problems. However, the study on Indonesian teacher's ability to solve PISA's mathematical problems is inadequate. Therefore, this study aimed to examine Indonesian teachers' ability in solving PISA-adapted mathematics problems for the topic of change and relationship. This study employed a case study research design involving seven mathematics teachers from various schools in Yogyakarta. They were required to solve PISA-adapted mathematics problems classified into four areas, namely Change and relationship, Space and Shape, Uncertainty, and Quantity. The results showed that: (1) all teachers could solve the first level problem, (2) all teachers could solve the first problem at the third level, (3) five teachers (71.43 %) could solve the second problem at the third level, (4) two teachers (28.57 %) could solve a third problem at the third level, (5) six teachers (85.71 %) could solve the fourth problem at the third level, (6) four teachers (57.14 %) could solve the first problem at the fourth level, and (7) Six teachers (85.71 %) could solve the second problem at the fourth level.

1. Introduction

Mathematical and pedagogy abilities of primary teachers were directly and positively related to their students' achievement [1,2]. Teachers' perception also significantly correlates with the students' knowledge [1,2]. The teachers' perception in this study was defined as (1) the paradigm of teachers of mathematics teaching and learning process, and (2) teachers' concern of students' mathematics achievement is closely related to teachers' mathematical knowledge [1,2]. Teachers' paradigm on the settlement of mathematical models and learning organization supported teacher mastery of the mathematics knowledge and the pedagogy [1,2]. Thus, one of the determinants of students' success in solving the PISA test is teachers' ability in managing the mathematics teaching and learning process and solving mathematical problems.

In 2015, Indonesia followed the PISA test for the fifth time and the ranking Indonesia for PISA tests were 63 for mathematics, 62 for science, and 64 for reading from 70 countries. These results generally improved, especially for mathematics, and scientific literacy. In the PISA test at 2012, ranking literacy in mathematics and science was 65 and 64, while the areas of reading literacy in 61 of 65 countries. The average score on the PISA tests at 2015 were as follows 386 for math, 403 for science, and 397 for reading. The average score on the PISA tests at 2012 were as follows 375 for math, 382 for science, and 396 for reading [3,4]. PISA test involved four content namely (1) the

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quantity, (2) space and shape, (3) change and relationship, and (4) uncertainty and data [3, 4, 5]. There were six levels in the PISA questions related to mathematical literacy of students [1].

In 2017, Hongki et al. [6] revealed that 55.56 % of junior high school students achieved level 5 for change and relationship problem. Furthermore, 77.78 % of junior high school students achieved level 2 for change and relationship problem. These results lead us to the question: how is the teacher's mathematical literacy ability for the change and relationship problems?

Currently, studies that related to teacher's abilities in solving PISA-adapted mathematics problems are considered limited. Therefore, the objective of this paper was to describe the junior high school teacher ability for the PISA adaptation test in the quantity, space and shape, change and relationship, and uncertainty domain. This paper only describes the teachers' ability to solve the adaptation PISA test in the change and relationship domain.

If a student is equipped with mathematical literacy skills, he/she would understand the role of mathematics in his/her life [2,7,8]. Mathematical literacy is an individual's ability to identify and understand the role of mathematics in the world, to make an accurate assessment, use and involves mathematics in various ways to fulfill the individual needs as a reflective, constructive and filial citizen [5,8]. The following competencies would form the mathematical literacy skills, namely: (1) the mathematical thinking and reasoning competence, (2) the logical argument competence, (3) the mathematical communicating competence, (4) the problem model competence, (5) the proposing and solving problem competence, (6) the representing idea competence, and (7) the using of symbol and formal language competence [5,8].

Mathematical literacy was important because in the 21st century humans not only required a content knowledge, but also required skills that called as 21st century skills. The 21st skills include critical thinking and problem solving, creativity and innovation, communication and collaboration, flexibility and adaptability, initiative and self-direction, social and cross-cultural, productivity and accountability, leadership and responsibility, and information literacy [8,9]. Mathematical literacy became one of the components necessary to build 21st century skills [5].

2. Method

This research was design research. The goal of this study was to describe teachers' mathematical literacy for the change and relationship problem on PISA adaptation test. This goal was achieved by the following procedures:

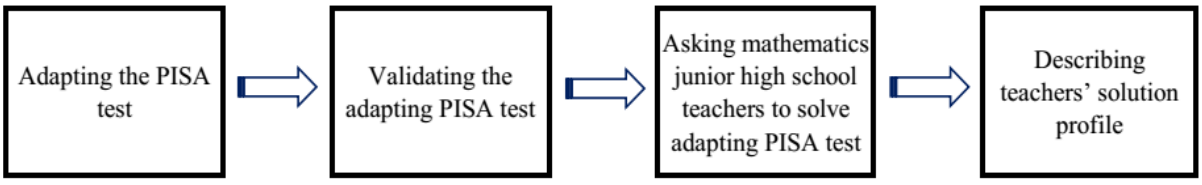
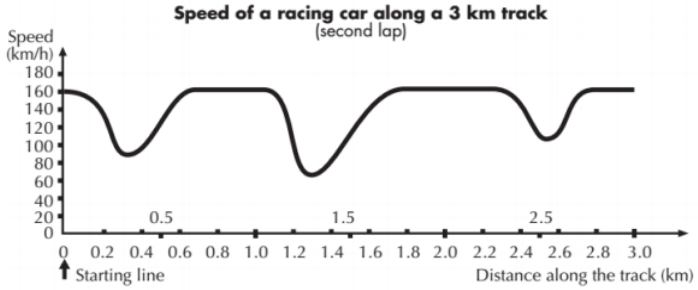


Figure 1. Research procedures.

This procedures followed research steps introduced by Akker [10]. The PISA adaptation test consisted of three change and relationship problems, four space and shape problems, two uncertainty problems, and four quantity problems. The subjects of this research were seven junior high school teachers in Yogyakarta and surrounding areas. The school was selected randomly, and each subject was the best teacher from the selected schools.

3. Results and discussion

This graph shows how the speed of a racing car varies along a flat 3 kilometer track during its second lap.



a. Where was the lowest speed recorded during the second lap?
   A. at the starting line. C. at about 1.3 km.
   B. at about 0.8 km. D. halfway around the track.
b. What can you say about the speed of the car between the 2.6 km and 2.8 km marks?
   A. The speed of the car remains constant. C. The speed of the car is decreasing.
   B. The speed of the car is increasing. D. The speed of the car cannot be determined from the graph.

Figure 2. Problem 1.

3.1. The teacher's answer for problem 1a

According to the graph presented in Figure 1, horizontal axis represented the distance along the track, and vertical axes represent cars' speed. Therefore, the lowest speed is represented as the deepest valley on the graph. Thus, the answer to the question is C. All teachers answered the question correctly. They can answer questions involving familiar contexts where all relevant information is presented, and the questions are clearly defined. Thus, we can conclude that all or 100% of teachers were in the first level.

3.2. The teacher's answer for problem 1b

At the interval (2.6, 2.8), the graph was increasing monotone. Thus, the answer is B, because the speed of the car was increasing. All teachers answered the question correctly. They can answer questions involving familiar contexts where all relevant information is presented, and the questions are clearly defined. Thus, all or 100% teacher are in the first level. The following was the example of the teacher's answer for problem 1a and 1b.

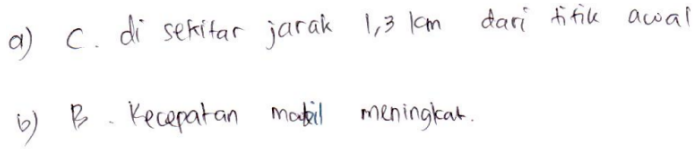


Figure 3. The example of the teacher's answer for problem 1a and 1b.

People living in an apartment building decide to buy the building. They will put their money together in such a way that each will pay an amount that is proportional to the size of their apartment. For example, a man living in an apartment that occupies one fifth of the floor area of all apartments will pay one fifth of the total price of the building.

a. There were three apartments in the building. The largest, apartment 1, has a total area of 95 m^2. Apartments 2 and 3 have areas of 85 m^2 and 70 m^2 respectively. The selling price for the building is 30 billion rupiah. How much should the owner of apartment 2 pay? Show your work.
b. Circle Correct or Incorrect for each of the following statements:

Statement	Correct / Incorrect
A person living in the largest apartment will pay more money for each square meter of his apartment than the person living in the smallest apartment.	Correct / Incorrect
If we know the areas of two apartments and the price of one of them we can calculate the price of the second.	Correct / Incorrect
If we know the price of the building and how much each owner will pay, then the total area of all apartments can be calculated.	Correct / Incorrect
If the total price of the building were reduced by 10%, each of the owners would pay 10% less.	Correct / Incorrect

Figure 4. Problem 2.

3.3. Teacher's answer for problem 2a

Generally, all teachers used the same technique to solve this problem. First, they counted the total area of the apartment, that is 95 m^2 + 85 m^2 + 70 m^2 = 250 m^2. After that, by using worth comparison, they counted the price of apartment 2. The result was IDR 10.200.000.000 or some teacher simply wrote 10.2 M. From this solution, we knew that teachers can interpret agreement between apartment buyer and seller and represent it by using comparison. Thus, we can conclude that all or 100% teacher was in the level 3.

Table 1. Teacher's answer of problem 2a.

Statement	Answer
A person living in the largest apartment will pay more money for each square meter of his apartment than the person living in the smallest apartment.	Incorrect
If we know the areas of two apartments and the price of one of them we can calculate the price of the second.	Correct
If we know the price of the building and how much each owner will pay, then the total area of all apartments can be calculated.	Incorrect
If the total price of the building were reduced by 10%, each of the owners would pay 10% less.	Correct

3.3.1. Teacher's answer for problem 2b.1. Four teachers answered "incorrect" for question 2b.1 and three teachers answered "correct" for this problem. Thus 57.14% teachers were in the level 4 because they can construct and communicate the reasons why they answer "incorrect" based on their interpretation of proportional understanding. About 42.86% teacher could not be leveled.

3.3.2. Teacher's answer to problem 2b.2. Five teachers answered "correct" for question 2b.2, one teacher answered "incorrect" for this problem and one teacher did not answer the question. Thus 71.43% of teachers were in the level 3 because they can communicate their interpretation of given

information in the problem, the result of their thinking, and the reason for their answer. About 14.29 % teacher could not be leveled, and 14.29% teacher did not answer the question.

3.3.3. Teacher's answer for problem 2b.3. Two teachers answered "incorrect" for question 2b.3, four teachers answered "correct" for this problem, and one teacher did not answer the question. Thus 28.57% of teachers were in the level 3 because they can communicate their interpretation of given information in the problem, the result of their thinking, and the reason for their answer. About 57.14% teacher could not be leveled, and 14.29% teacher did not answer the question.

3.3.4. Teacher's answer for problem 2b.4. **S**ix teachers answered "correct" for question 2b.4, and one teacher answered "incorrect" for this problem. Thus 85.71% teachers were in the level 4 because they can construct and communicate the reasons why they answer "correct" based on their interpretation of proportional understanding. About 14.29% teacher did not answer the question.

In 1998 the average height of both young males and young females in the Netherlands is represented in this graph. According to this graph, on average, during which period in their life are females taller than males of the same age?

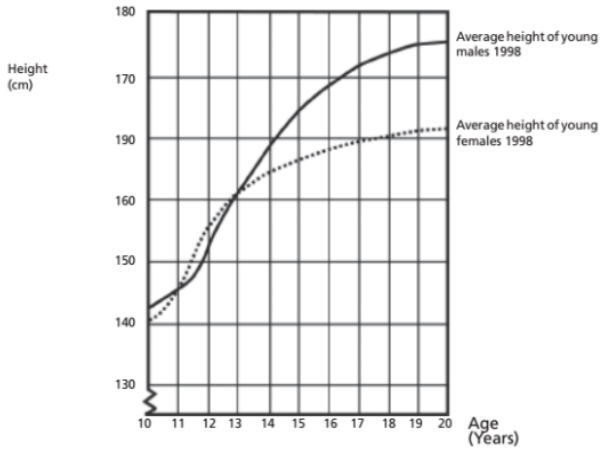


Figure 5. Problem 3.

3.4. Teacher's answer to problem 3

From Figure 5, we knew that the graph of the average height of young males in 1998 is above the graph of the average height of young females 1998 before 11 years old or after 13 years old. It means that at that period, males are taller than females of the same age. During period 11 – 13 years old, the graph of the average height of young males in 1998 is under the graph of the average height of young females in 1998. It means that at that period females are taller than males of the same age. Five teachers answer the question correctly. They claim that females are taller than male in the period 11 – 13 years old. Therefore, those five teachers were in the third level or 85.71% of the teachers are in the third level because they can communicate their interpretation of given information in the problem, the result of their thinking, and the reason of their answer. One teacher gave a different answer. She stated that females are taller than male at the age of 11 and 14 years old. Unfortunately, she didn't give any reason for her statement. Therefore, we can't level this teacher. The following is the example of the teacher's answer:

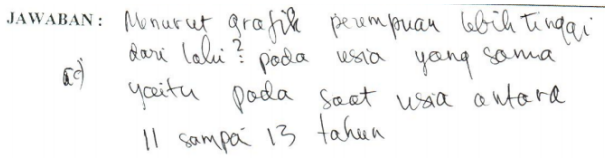


Figure 6. The teacher's answer to problem 3.

The result obtained by the teachers could be summarized in Table 2:

Table 2. The teachers' ability for the change and relationship problems for the PISA adaptation test.

Problem	Teacher's Achievement Level	Reason	The number of teachers	Percentage
1a	Level 1	Teachers can answer questions involving familiar contexts where all relevant information is present, and the questions are clearly defined.	7	100 %
1b	Level 1	Teachers can answer questions involving familiar contexts where all relevant information is present, and the questions are clearly defined.	7	100 %
2a	Level 3	The teacher can interpret the agreement between apartment buyer and seller and represent it by using comparison.	7	100 %
2b.1	Level 4	Teachers can construct and communicate the reasons why they answer "incorrect" based on their interpretation of proportional understanding.	4	57.14 %
	Could not be leveled	-	3	42.86 %
2b.2	Level 3	Teachers can communicate their interpretation of given information in the problem, the result of their thinking, and the reason for their answer.	5	71.43 %
	Didn't answer the question	-	1	14.29 %
	Could not be leveled	-	1	14.29 %
2b.3	Level 3	Teachers can communicate their interpretation of given information in the problem, the result of their thinking, and the reason for their answer.	2	28.57 %
	Didn't answer the question	-	1	14.29 %
	Could not be leveled	-	4	57.14 %
2b.4	Level 4	Teachers can construct and communicate the reasons why they answer "correct" based on their interpretation of proportional understanding.	6	85.71 %
	Didn't answer the question	-	1	14.29 %
3	Level 3	Teachers can communicate their interpretation of given information in the problem, the result of their thinking, and the reason for their answer.	6	85.71 %
	Could not be leveled	-	1	14.29 %

From the table above, we knew that teacher's ability in solving problem level 1 - 4 is good. Furthermore, from [1,2] we knew that teacher's mathematical abilities were related to student's achievement. These facts were chance for us to upgrade student's literacy ability by choose appropriate pedagogy to teach them.

4. Conclusions

Based on the results, it can be concluded that: (1) the first level one problem could be solved by all teachers; (2) the first level three problem could be solved by all teachers; (3) the second level three problem could be solved by five or 71.43 % teachers; (4) the third level three problem could be solved by two or 28.57 % teachers; (5) the fourth level three problem could be solved by six or 85.71 % teachers; (6) the first level four problem could be solved by four or 57.14 % teachers; (7) the second level four problem could be solved by six or 85.71 % teachers.

Acknowledgments

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