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The Mathematical Literacy Teachers' Ability for Quantity Area on PISA Adaptation Test

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Abstract

One of goals of this research was to make descriptions about the mathematical literacy ability of the junior high school teacher for the PISA adaptation test in the quantity area. There were four steps that did by the researchers to get the data, namely: (1) to adapt the PISA test, (2) to validate the test, (3) to ask junior high school teachers to do the adapting PISA test, and (4) to describe the mathematical literacy teachers' ability for quantity area. There were four areas in the PISA test for mathematics i. e. quantity, space and shape, change and relationship, and uncertainty, and six levels. In the test that we adapted form the PISA test, there were 13 questions. Seven teachers from seven junior high schools in Yogyakarta and surrounding areas to become our research subjects. The research type that used by the researchers was a design research developed by Cobb and Koeno. All teachers answer correctly at the quantity area on the level 1 - 4, but only four of seven teachers could solve one quantity problem for level 5. © 2018 Published under licence by IOP Publishing Ltd.

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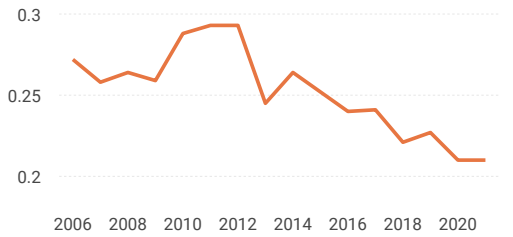

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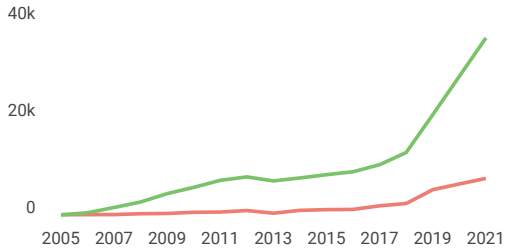

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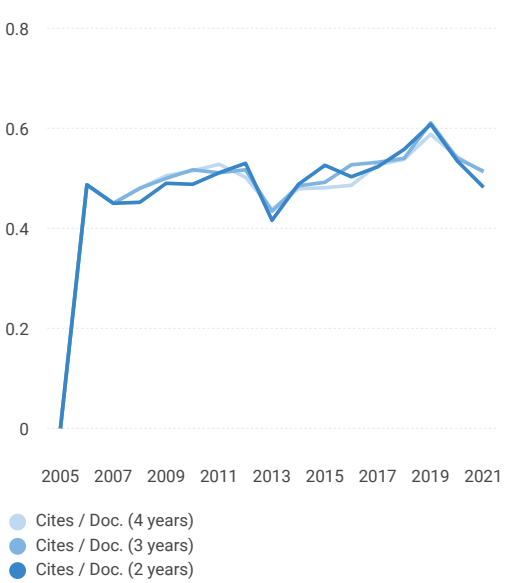

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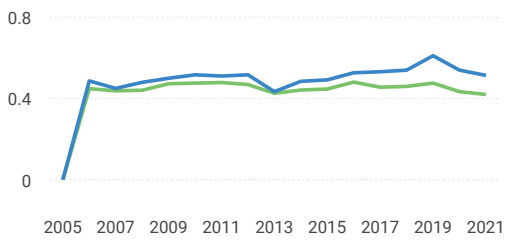

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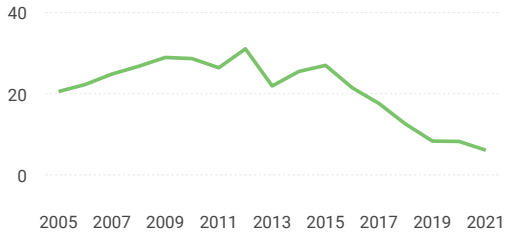

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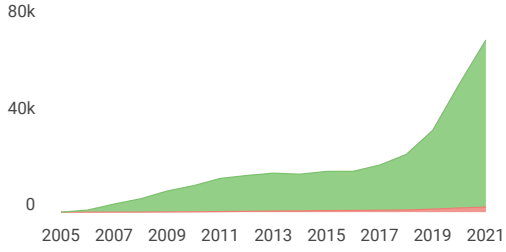

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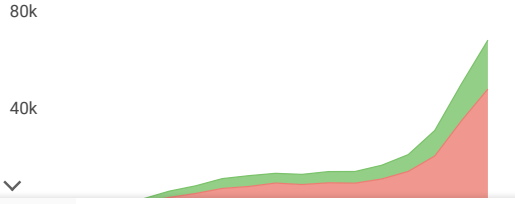

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PREFACE

The fifth International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS) is an annual conference organized by the Faculty of Mathematics and Natural Science, Yogyakarta State University, Yogyakarta, Indonesia and successfully held from 7 to 8 May, 2018. The theme of the 5th ICRIEMS is revitalizing research and education on mathematics and science for innovations and social development. The conference was a forum for researchers, educators, students, policy makers, and practitioners to achieve the innovation and social development through research and education on mathematics and science, as it is accentuated by the theme of this conference. The scope of this conference covers the area of mathematics, chemistry, physics, biology, mathematics education, chemistry education, physics education, and science education. This proceeding contains 157 that have been carefully peer reviewed and selected from 575 papers submitted to the conference.

We would like to express our gratitude to the reviewers of these manuscripts, who provided constructive criticism and stimulated comments and suggestions to the authors. We are extremely grateful as organizers, technical program committee and editors and extend our most sincere thanks to all the participants of the conference for their fruitful work and their excellent contribution to the development of this conference proceedings. Our sincere gratitude also goes to the IOP Publishing editors and managers for their helpful cooperation during the preparation of the proceedings.

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The Mathematical Literacy Teachers' Ability for Quantity Area on PISA Adaptation Test

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Abstract. One of goals of this research was to make descriptions about the mathematical literacy ability of the junior high school teacher for the PISA adaptation test in the quantity area. There were four steps that did by the researchers to get the data, namely: (1) to adapt the PISA test, (2) to validate the test, (3) to ask junior high school teachers to do the adapting PISA test, and (4) to describe the mathematical literacy teachers' ability for quantity area. There were four areas in the PISA test for mathematics i. e. quantity, space and shape, change and relationship, and uncertainty, and six levels. In the test that we adapted form the PISA test, there were 13 questions. Seven teachers from seven junior high schools in Yogyakarta and surrounding areas to become our research subjects. The research type that used by the researchers was a design research developed by Cobb and Koeno. All teachers answer correctly at the quantity area on the level 1 – 4, but only four of seven teachers could solve one quantity problem for level 5.

1. Introduction

The purpose of the PISA test is to assess the math, science and language literacy of 15-year-old students. Mathematical literacy is the ability of students in (1) identifying and understanding the role of mathematics in human life, (2) making accurate estimates, and (3) involving mathematics to meet the needs of human life. Therefore, in the mathematics literacy test, the students' ability that is measured is the ability of students to use their mathematical knowledge to solve a set of mathematical problems related to human life in various contexts [1].

In 2018, Indonesia will follow the PISA test for the sixt time. The Indonesia achievement for PISA in 2012 and 2015 was presented in table 1[1, 2, 3]. These results generally improved, especially for mathematics, and scientific literacy.

Table 1. **The Indonesia achievement for PISA in 2012 and 2015**

Year	Mathematics Score	Sains Score	Reading Score
2012	375	382	396
2015	386	403	397

Skemp (2009) explained that there were two types of understanding that students have in the mathematics learning process, namely intrumental understanding and relational understanding. Understanding in instrumental understanding means knowing about how to use a rule or knowing how to use a formula to solve a problem, without understanding how the formula is derived, and why the

formula can be used to solve the problem [3]. According to Van den Heuvel-Panhuizen, M., and Drijvers, P. (2014). an instrumental understanding is also called mechanistic understanding. Because the undertanding meaning in the mechanistic understanding is students know about how to use a particular mechanism to solve a problem without understanding why the mechanism can be implemented to solve the problem [4]. Understanding in relational understanding means knowing about (1) the relationship between concepts in mathematics, (2) how to use a rule, (3) how to use a formula to solve a problem, (4) how the formula is derived, and (5) why can the formula be used to solve the problem [3].

The mathematics and pedagogical skills of elementary teachers were closely and directly related to the student achievement [5, 6]. There was a positive relationship between (1) teacher's the mathematics learning process believe, and (2) teacher attention to students' math skills and knowledge achieved by students [5, 6]. The teacher's mathematical knowledge influences on the teacher's attention to the students' mathematical skills [5, 6].

From the opinions and findings presented above, the researcher thought that it is important to know how the teachers' ability and understanding in solving the PISA adaptation test. The results of this study became important as a basis for determining the follow-up actions that need to be done in such a way that the achievement of Indonesian students in taking the PISA test becomes better. 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 factors of student success in solving the PISA test.

The goals of this research were to get a picture about the mathematical literacy ability of the junior high school for the PISA test. We limitted our results that we will present in this paper only for the quantity area.

2. The Pisa Test

B. Ojose (2011) said that an individual ability to construct mathematics through their life experience and to apply mathematics in their life is mathematical literacy [7]. If a student had it, then he or she would realize and understand the role of mathematics in his or her life [3, 5, 8, 9]. According to Jan De Lange, there were seven competencies would develop the mathematical literacy skills, namely: (1) the thinking and reasoning mathematically competence, (2) the argument logically competence, (3) the communicating mathematically competence, (4) the problem model competence, (5) the proposing and solving problem competence, (6) the representing idea competence, and (7) the using symbol and formal language competence [3, 10].

From the previous study results, it could be concluded that in order to survive in the 21st century, one must have what is called the 21st century skills, namely 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 [10, 11]. One component that can build 21st century skills is human ability in mathematical literacy.

3. Research Method

According to Akker, et. all, two of design research characteristics were process-oriented and oriented to usability [12]. This research could be classified in the design research, because in this study the researchers develop a design of a test that was adapted from PISA test and the researchers would describe teachers' solution for the test.

In the design study developed by Akker and Gravemeijer, there are three steps to be taken in developing a design: (1) design development, (2) design implementation, and (3) retrospective analysis [12]. In the first stage, there are two activities undertaken by researchers, namely (1) developing tests adapted from the PISA test, and (2) conducting expert validation of the tests developed by the researcher. The research process conducted by researchers could be seen in Figure 2.

In the adapting PISA test, there were four questions for space and shape, three questions for change and relationship, and three questions for uncertainty. The time given to teachers to take the test was 90

minutes. There were 7 junior high school teachers from different junior high school in Yogyakarta and surrounding areas who did the test and became the subject of this study. A proportional randomly technique was used in this research to choose these subjects.

Figure 1. Six levels in the PISA questions related to mathematical literacy of teacher

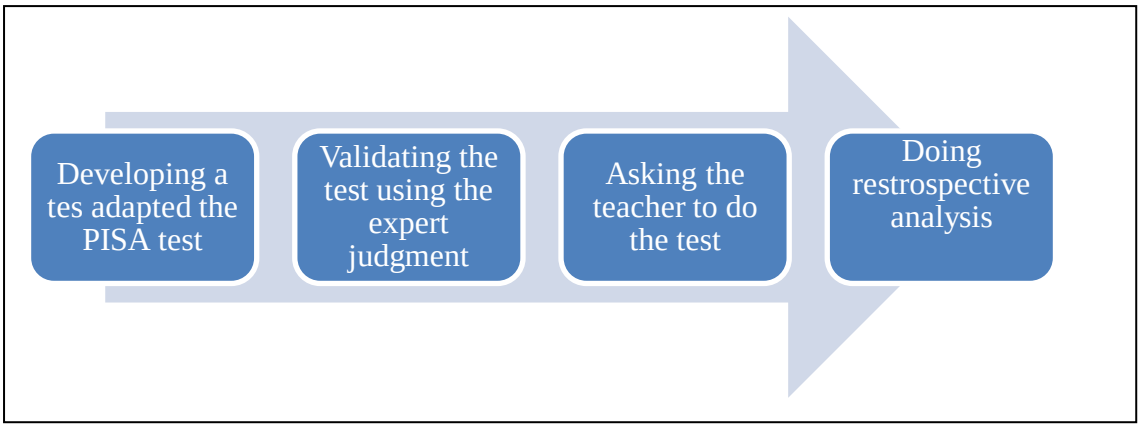

Figure 2. Stages of the research process

4. Results and discussion

The research results that would be presented in this paper were the result test for the PISA adaptation test on the quantity area. The results obtained were as follows:

Problem 1: Mei-Ling lived in Singapore. She was preparing to go to Indonesia for 3 months as an exchange student in a student exchange program. She needed to swap some Singapore dollars (SGD) with rupiah currency (IDR)

a. Mei-Ling found that the exchange rate between SGD and IDR was 1 SGD = IDR 9,800. Mei-Ling wanted to swap SGD 3,000 into IDR at this rate. How many IDR did Mei-Ling get from this exchange result?

b. Upon returning to Singapore after 3 months, Mei-Ling had IDR 9,360,000. Mei-Ling wants to swap the money back into SGD. The exchange rate has changed to 1 SGD = IDR 9,600. How much SGD did Mei-Ling get from this exchange result?

Teacher's answer to question 1a:

From the problem, the teacher obtained information that the exchange rate of 1 Singapore dollar is IDR 9,800. From this information, the teacher found the money earned by Mei Ling from the exchange of Singapore dollars to Rupiah. The teacher' way to get the Mie-Ling' money is multiplying the exchange rate of 1 Singapore dollar with the value of money held by Mei Ling. So, from this process, the teacher got that the money was got by May-Ling = 3,000 x 9,800 = 29.4 million. There were seven teachers who made solution like this solution. Teachers' answer as above could be categorized in level 1 math literacy skills (look at the first level citeria in the figure 1), because the information required by the teacher to answer the question is already available in the question.

Teacher's answer to question 1b:

From the problem, the teacher obtained information that the exchange rate of 1 Singapore dollar is IDR 9,600. The teacher changed this information to 1 IDR = $\frac{1}{9600}$ SGD, so in order to obtain the Singapore dollar value obtained by Mei-Ling from this exchange result, the teacher multiplied the exchange rate of 1 rupiah with the amount of rupiah money owned by Mei-Ling. So, from this process, the teacher got the money was got by May-Ling was $\frac{9.360.000}{9.600} = SGD\ 975$. There were seven teachers who made solution like this solution. Teachers' answer as above could be categorized in level 2 math literacy skills (look at the second level citeria in the figure 1), because if teacher want to answer the problem, the teacher must have been able to understand that the meaning of 1 SGD = IDR 9,600, and could change that information to 1 IDR = $\frac{1}{9600}$ SGD. The change of information caused the teacher to answer that the money was got by Mei-Ling = $\frac{1}{9600} \times 9.360.000 = \text{SGD } 975$. An example of teacher's answer for problem 1 could be seen in figure 3.

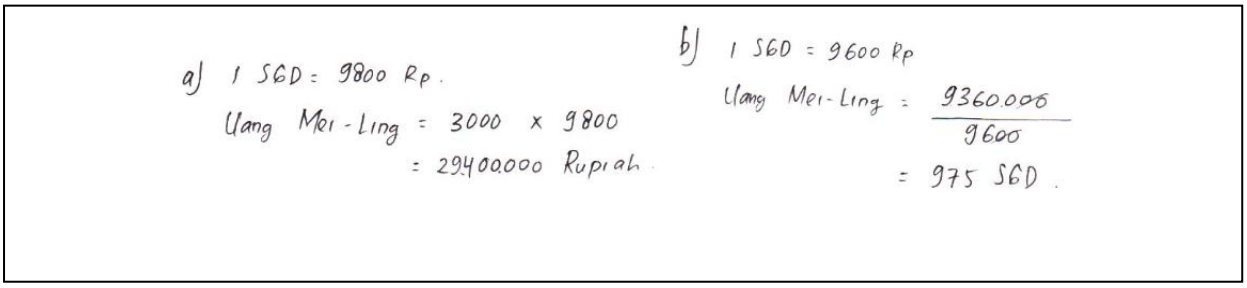

Figure 3. An example of teacher's answer to problem 1

Problem 2: An automotive magazine used a ranking system to assess new cars, then this magazine give award the "Best Car" on the car that earned the highest total score. Five new cars were being assessed and the results obtained were as follows:

Car	Security Features (S)	Fuel Efficiency (F)	Exterior Appearance (E)	Interior (T)
Ca	3	1	2	3
M2	2	2	2	2
Sp	3	1	3	2
N1	1	3	3	3
KK	3	2	3	2

The rating interpretation used by the magazine was as follows:
3 meant very good, 2 meant good, and 1 meant enough

a. Known that automotive magazine used the following formula to calculate the total score of a car, i.e. total score = 3S + F + E + T. Calculate the total score of the car "Ca"!
b. The car manufacturer "Ca" felt the judgment was unfair. Make a formula, in such a car "Ca" got the highest total score. The formula should contain all the variables S, F, E and T. Make that formula by filling in the positive numbers at the points in the following formula: Total score = ... S + ... F + ... E + ... T. Explain why you were convinced by using the formula, then the company "Ca" would get the highest score!

Teacher's answer to question 2a:

1. From the problem, there were information about (1) the number of components assessed, (2) the value of each component of each car, and (3) how to calculate the total score of each car based on the four assessment components. To obtain the score obtained by Ca car manufacturers, the teacher must find the value of each assessment component for the Ca car manufacturer and enter the value of each component into the total score formula. So, from this process, the teacher got that Total score for "Ca" = 3 × 3 + 1 × 1 + 1 × 2 + 1 × 3 = 9 + 1 + 2 + 3 = 15. There were seven teachers who made solution like this solution. Teachers' answer as above could be categorized in level 2 of the mathematical literacy skills (look at the second level citeria in the figure 1), since the teacher has extracted relevant information to answer this question and the teacher has been able to run a simple algorithm in calculating the total score of the Ca car.

Teacher's answer to question 2b:

1. From the problem, the teacher got information about (1) the number of components were assessed, (2) the lowest value of each component, i.e. 1 and the highest value of each component, i.e. 3, and (3) the value of each component of each car. In order to determine the total formula of the score that would make the Ca car producer get the highest total score, then the teacher should analyze (1) on the assessment component where the Ca car producer receives the lowest and highest rating, and (2) analyze the highest weights that can be assigned to each component. After obtaining the results of the analysis, the teacher can find a new formula for the total score. From this process, the teacher got that the total score formula = 3 × S + F + E + 3 × T. If the rule was used, then Ca would get the total score = 3 × 3 + 1 + 2 + 3 × 3 = 9 + 1 + 2 + 9 = 21. Teachers' reasoning was Ca were superior in S and T features, so it needed to be given a high score in those features. Why the coefficients were 3? Because the coefficients of the S and T features that could help Ca to get the highest total score so it

needed to be given the highest score (the teachers had an assumption that the highest coefficient of each feature was 3 and the lowest score of each feature was 1). There were four teachers who made solution like this solution. Teachers' answer as above could be categorized in level 5 of mathematical literacy skills (look at the fifth level citeria in the figure 1), because the teacher could give the rules that made the company "Ca" to get the highest total score, and could explain logically the reason why they were convinced by using the formula, then the company "Ca " would get the highest score. The reason that they said was very logic, that the highest score obtained by the company "Ca" was in the components S and T, while the score less obtained by the company "Ca" was in the components F, and E, then for the highest total score of the company's car "Ca", they should give the highest weight to the S and T components, and should give the lowest weight to the components F, and E.

2. Total score = S + 3 × F + E + 3 × T. If the rule was used, then company Ca would get the total score = 3 + 3 × 1 + 2 + 3 × 3 = 3 + 3 + 2 + 9 = 17. The teacher's reasoning: If I filled with another positive number, the score obtained Ca would be less than 17. There was one teacher who made solution like this solution. The teacher has not been able to provide rules that make the company "Ca" to get the highest score. The teacher gave the highest weight to the T component. In component F, the value of the firm "Ca" is 1, but the teacher gave the highest weight, i.e. 3. If this was done, then the value achieved by the company "Ca" not the highest. Teacher's answer as mentioned above could not be leveled.
3. The number of features were rated every car was 4, the highest score of each feature was 3, then the maximum total score that could be obtained each car was 3 × 4 = 12. The number of cars rated were 5, then the total score for all cars was = 5 × 3 × 4 = 60. So, the weight for each feature was $= \frac{total\ skor\ semua\ mobil}{total\ skor\ tiap\ mobil} = \frac{60}{12} = 5$,, so the formula of the total score was = 5 × S + 5 × F + 5 × E + 5 × T. There was one teacher who made solution like this solution. The teacher has not been able to provide rules that make the company "Ca" to get the highest score. Teachers could explain that there were four components that go in the assessment and the maximum value of each component was 3. The teacher was not precise in determining which components should be given high weight for the company "Ca" to get the highest total score. The weights made by teacher was the same for each component, this has not caused the company "Ca" to get the highest score. Teacher's answer as mentioned above could not be leveled.
4. There was a teacher who did not answer this question.

An example of teacher's answer to problem 2 could be seen in figure 4.

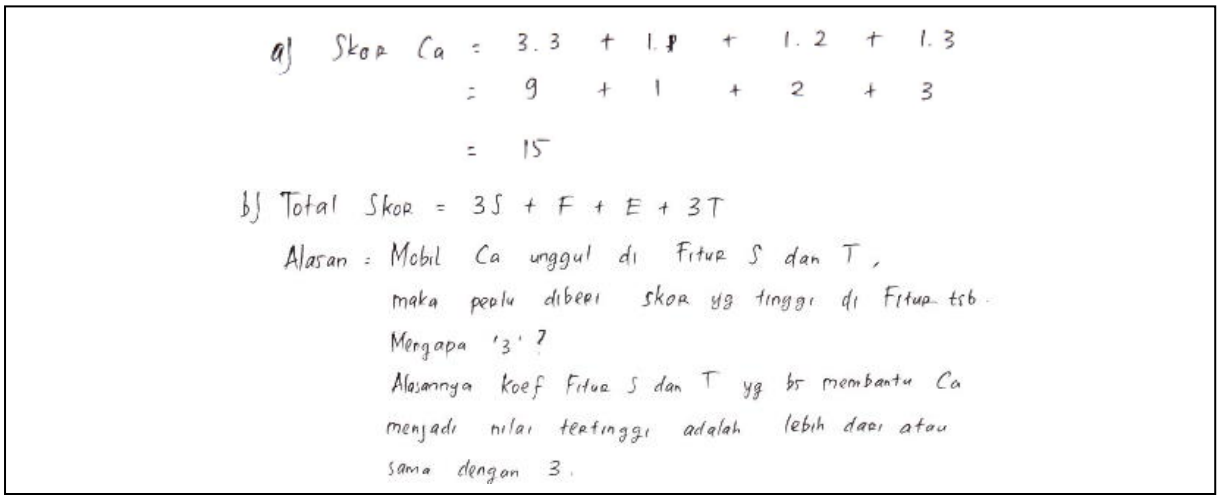

Figure 4. An example of teacher's answer to problem 2

Problem 3: Erik was a skateboarding enthusiast. He visited the "SKATERS" shop to check prices. In the store, he could buy a complete skateboard. He could also buy per component, such as a board, a set of wheels (4 pieces), a set of trucks (2 pieces) and a set of hardware then assemble their own skateboard. The price list in the store was as follows:

Product	Price (IDR)	Picture
Complete	82.000 or 84.000	
Board	40.000, 60.000, or 65.000	
A set of wheels consisting of 4 wheels	14.000 or 36.000	
A set of trucks consists of 2 trucks.	16.000	

If Erik wants to assemble his own skateboard, how many the minimum price and the maximum price he should pay? Explain your answers!

Teacher's answer to question 3:

1. The information in the problem 3 were (1) to make the skateboard board required four components; (2) there were two price options for each component, (3) the price of each component, and (4) there were two price options for a complete skateboard board. To obtain a minimum or maximum price of one skateboard board, the teacher must select the minimum or maximum price of each component and exclude the minimum or maximum price of one complete skateboard board. So, from this process the teacher got that a minimum price of one board skateboard was IDR 80,000 and the maximum price of one board skateboard was IDR 137.000. There were seven teachers who made solution like this solution. Teachers' answer as above could be categorized in level 3 of math literacy skills (look at the third level citeria in the figure 1), as the teacher could explain that the minimum price would be obtained if they took each component of the skateboard at the lowest price and the maximum price would be obtained if they took each component at the most price high. An example of a teacher's answer to problem 3 could be seen in Figure 5.

The results obtained by teachers could be summarized as in the table 2.

Table 2. The teachers' ability in the quantity area for the PISA adaptation test

Problem	Level	Teacher's Achievement Level	The number of teacher	Percentage
1a	Level 1	Level 1	7	100,00%
1b	Level 2	Level 2	7	100,00%
2a	Level 2	Level 2	7	100,00%
		Level 5	4	57,14%
2b	Level 5	Could not answer	1	14,29%
		Could not be leveled	2	28,57%
3	Level 3	Level 3	7	100,00%

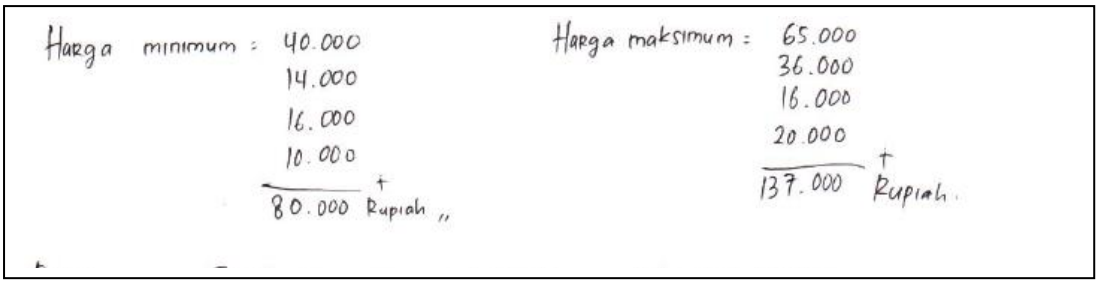

Figure 5. An example of teacher's solution for problem 3

5. Conclusions

From our previous discussion that could be concluded some conclusions, namely: (1) all teachers could solve one quantity problem for level 1, (2) all teachers could solve two quantity problems for level 2, (3) all teachers could solve one quantity problem for level 3, (4) four of seven teachers could solve one quantity problem for level 5, (5) two of seven teachers have not been able to complete a quantity problem for level 5, and (6) one of seven teachers has not been able to complete a quantity problem for level 5

6. Acknowledgments

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