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by Hapizah Hapizah

Submission date: 20-Jan-2020 04:34PM (UTC+0700)

Submission ID: 1244002315

File name: 18._Efriani_2018_J._Phys.__Conf._Ser._1097_012108.pdf (733.24K)

Word count: 4026

Character count: 21233

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To cite this article: A Efriani *et al* 2018 *J. Phys.: Conf. Ser.* **1097** 012108View the [article online](#) for updates and enhancements.**IOP | ebooks™**

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4 PISA like Mathematics Problems: a case of soccer context

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Abstract. The aim of this research was generating a valid and practical PISA like problem which is developed using soccer context in Asian games 2018. Researchers used design research with development study. This research consisted of two-stage namely preliminary and prototyping that included self-evaluation, expert review, one to one and small-group. This research involved 3 expert reviews and 15 years-old students of class X SMAN 10 Palembang which consisted of 3 students for one to one and 6 students for small group. Data collection techniques consisted of documentation, walkthrough, and interview. The problem that has been developed by researchers was about estimating the maximum height of the Sriwijaya Stadium rooftop. The result of the research stated that the problem developed had 1) valid seen from the compatibility with framework PISA that has linked the problem with daily life using soccer context in Asian Games 2018 and space and shape content 2) practical seen from student's understanding to the problem developed.

5 Introduction

Programme for International Student Assessment (PISA) is an international study which is conducted every 3 years to measure literacy ability of 15 years old students in reading, math, science, and finance [1]. Since 2000, Indonesia students have participated in PISA test, especially in mathematics literacy. However, Indonesian students always occupy the lowest position of many countries in attendance. In 2015, Indonesia ranked 63 out of 69 countries with a score of 386 which actually has an average international PISA score of 500 [2].

The causes of the low literacy ability of Indonesian students in the PISA study are less accustomed to working on non-routine problems, not accustomed to working on contextual problems and translating problems into mathematics, lack of problem solving ability and students accustomed to acquire and use formal mathematical knowledge in class [3, 4, 5, 6, 7]. However, literacy ability is an important ability in the student development process because literacy ability present mathematical concepts that can add students and teacher's mathematical mindsets [8].

According to Permendikbud [9], PISA result is also one of the external factors behind the curriculum change from KTSP to the curriculum 2013. So it can be said that the literacy ability in PISA is very important because it becomes the reference of curriculum development in Indonesia. This is in accordance with the definition of mathematical literacy that mathematical literacy is the ability of individuals to formulate, use and interpret problems in various contexts related to seven fundamental mathematical capability.

Based on that definition, literacy also uses context in the problem. The context used is tailored to the situation around students. The situation is not only limited to visible views but can also be imaginary and close to students [10]. The situation close to the student is applied in the form of a problem. Zulkardi recommends PISA given to students designed by teachers themselves so that it can



13 be used in learning mathematics in the classroom [11]. Therefore, the questions given to the students should be developed by the teacher in accordance with the context around students.

The context used in this study relates to the context of the sport at the 2018 Asian Games, one of which is a soccer. A soccer is one of the most popular games in the community. This is because soccer does not need equipment as other games introduced by the colonizers [12]. For soccer held in Palembang at the 2018 Asian Games is specifically for women's soccer. With the use of soccer such as players and the field is expected to help students in understanding the learning of mathematics. Based on daily Sumsel and several studies that have been conducted, it is said that learning mathematics using sports could make students love mathematics and also be memorial for Asian Games [13, 14, 15, 16]. Therefore, this article discusses the problem of PISA like using sports context in Asian Games 2018 especially soccer.

2. Method

7 The method used in the study is design research which had two stage: the preliminary and formative evaluation which included self-evaluation, expert reviews, one to one, small group, and field test [17,18]. The preliminary stage covered the analysis of research preparation and the design of PISA like mathematics problems based on 2015 PISA framework. At the self-evaluation, the researchers evaluated the PISA like mathematics problems that would be developed by herself and revised the item so that prototype 1 was obtained. Then at the expert reviews stage, prototype 1 was consulted to the experts and evaluated by the validation criteria of content, construct, and language. Along with the expert review, one to one stage was done with three students having various capabilities. Suggestions and comments from experts and students were taken into consideration to revise prototype 1 so that valid prototype 2 was obtained. Then at the small group stage, prototype 2 was tested to six students having various abilities in a learning process that fit the lesson plan (RPP) made. This stage focused on knowing the practicality of the problem. Students' suggestions and comments in the small group stage were taken into consideration to revise the prototype 2 so that the valid and practical of prototype 3 was obtained. Furthermore, in the field test, prototype 3 was tested on the research subject through the learning process to find out the potential effects of the PISA-like mathematics problems on the ability of students' mathematical literacy.

The subject in this study were tenth-grade students of senior high school number 10 Palembang which aged 15 years old. This study was conducted in October 2017 - November 2017. The data were gathered by means of the walkthrough at the expert reviews, observation of the video recording, interview during the learning process, and students' answer.

3. Result and Discussion

9 Development of PISA like mathematics problem done in two stages: a preliminary and prototyping stage (formative evaluation) that are comprised of self-evaluation, expert review and one-to-one, small group, and field test [17, 18]. In this article, researchers will discuss the small-group stage of formative evaluation.

3.1. Preliminary Stage

In the preliminary stage, the researchers analyzed the characteristic of the PISA problems, curriculum, and students' analysis. In analyzing the PISA problem is started with collect PISA problems from 2000 to 2012. Based on an email containing a researcher's question to one of the OECD members, the PISA problems of 2015 was not issued because one of the PISA problems of 2015 will be tested again in 2018. Furthermore, researchers collect PISA like problems that have been developed in recent years by other researchers. Then, the researchers analyzed the characteristics of the content, context, and the level of the mathematical ability in PISA framework so that the characteristics of PISA problems in mathematics domain and PISA items on space and shape content were obtained and used for the developing problems. The researchers also analyzed the curriculum used by the research school. The curriculum has used the curriculum 2013. While in the student analysis, the researchers identified students who would play a role in one to one and small group stage.

The reference problem used in this study is the 2006 PISA problem with code M535. M535 PISA problems used the context of twisted building on the ground floor. From the building on the ground floor asking about estimation the total height of the twisted building. Then, researchers make

paraphrase by changing the picture and reformulating the problem in another context which is adopted from Bairac's method [19]. So, it produces one PISA like the problem with soccer context in Asian Games 2018. The problem's questioning how to estimate the maximum height of the rooftop Sriwijaya Galore Stadium.

3.2. Preliminary Stage

3.2.1. Self-Evaluation

In this stage, the writers evaluated and examined the draft of the PISA-like problem. The developed problem was related to the context of soccer as a sport. This context is chosen because the soccer is close to the daily life of the students, not only male students who know soccer but also female students. The context of this problem is a personal and the content is space and shape especially using congruence or scale. The process in mathematics is interpretation. Solving the problems that have been developed can be done by estimating the maximum height of the roof of Gelora Sriwijaya stadium. One of them is to estimate the height of players close to the next stadium using congruence or scale or comparison to get answers. To estimate it in terms of the ability of mathematical literacy involved, students need the ability to interpret mathematical problems into mathematical sentences, students need the ability to think and reason mathematical problems. Thinking and reasoning are used in reviewing and relating the information, statements, and images that have been provided. The ability of representation in interpreting existing images and interpreting the mathematical results of the equations that have been made. Ability to formulate strategies to solve problems, students need to choose step by step to find solutions. Students also need to perform mathematical procedures in using the equation formula that has been made is the ability to use symbolic language, formal, techniques, and operations. Communication ability is needed to construct an explanation of the rationale for estimating the maximum height of the stadium roof. The level prediction for this problem is level 5. This is consistent with the characteristics of the PISA level 5 problem, shown from the problems that require students to work with models in complex situations, identify constraints and explain the allegations correctly. In addition, students can choose, compare and evaluate appropriate problem-solving strategies when dealing with complex situations. At this stage, the problem was in accordance with the PISA framework, so there was no revision. The problem at this stage was called prototype 1.

3.2.2. Expert Review and One to One

Expert review and one-to-one are done simultaneously. Expert review is the stage where the researcher involves several experts to examine the prototype of the instrument and then determine the strengths and weaknesses of the prototype that has been made [17]. Prototype 1 was analyzed and evaluated qualitatively by the validators in terms of content, constructs, and languages. The validation process in this stage was done in two ways were mail review and focus group [12]. Experts who acted as the validators by mail review were (1) Ross Turner (E1), the director of the Australian Council for Educational Research (ACER) and a MEG PISA staff, (2) Kaye Stacey (E2), the Chairman of MEG PISA from University of Melbourne, Australia, and (3) Ahmad Fauzan (E3), a lecturer in mathematics at the State University of Padang. While the focus group validation is done directly by the researchers along with several students and lecturers. There is one student who is focused on the researcher Dedi Yansen. He discussed the overall problem both in terms of content, constructs, and language. In addition, it was attended by several lecturers namely Zulkardi and Somakim but did not provide input on this developed problem. Along with the expert review stage, one to one stage is done with students who had various abilities (high (O1), medium (O2), and low (O3)). The comments and suggestions from the experts and the students in prototype 1 are presented in Table 1.

Table 1. Comments and Suggestions from Experts and Student.

<i>Expert</i>	<i>Comments and Suggestions</i>
E1	Agree with questions that ask for estimates, ask students to show their work, and explain how they make their estimates. However, for the scoring section, it is advisable to be very cautious in possible student responses. <i>"Your question asks for an estimate (very appropriate) and specifically asks students to show their work and explain how they made their estimation. This might be ok, but you will</i>

need to think very carefully about the wide range of possible approaches, and design a marking scheme that shows markers how to treat each of these possible approaches and their associated explanations.”

E2	agree with the problem and the solution “Nice solution and nice problem, but I think you will have to give students more support to know that this is what you want”
E3	Okay, fix the spaces in communication skills in the scribe section Images are less clear
O1	For the image is clear but for the word “high” which is calculated from where to? We recommend that the word height be made clear to the maximum height of the stadium from the bottom to the roof, and add map-scale information to make it easier to work.
O2	There should be information that is known from the problem
O3	Who wants to be measured from where to go, cannot be searched because of less information

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Based on the validation process at the expert review and one to one stages, the problem was maintained only for the scoring column to be corrected according to the expert's suggestion using PISA scoring rubric. For student suggestions adding scale is not accepted on the grounds that the added information will change the level prediction and not in accordance with the PISA framework. Here is a problem that has been revised, generated prototype II and will be validated in the small group stage.



Figure 1. Prototype 2.

3.2.3. Small Group

The problem in prototype 2 was tested in a small group stage on November 7, 2017. First, students were given the problem to be solved individually. During the process of the problem, students already understand the purpose of the problem but there are students who can not do the problem correctly because students do not understand how to do it so students were confused to determine how the process. In addition, the researcher noted the things that are the question about the problem being done and the researchers also interviewed the students to find out the responses, comments, and suggestions to find out what difficulties students are experiencing. Here, there are a variety of student answers:

Manusia pd gambar: 0,15 cm
 manusia pd sebenarnya: ± 160 cm
 s pd gambar: 5 cm
 s pd sebenarnya: X

$$\frac{0,15 \text{ cm}}{5 \text{ cm}} = \frac{160 \text{ cm}}{X}$$

$$= 0,15X = 800$$

$$X = \frac{800}{0,15}$$

$$= 1600 \text{ cm}$$

$$= 16 \text{ m}$$

Figure 2. Student's answer with higher ability.

From the answers above, the student is able to guess the answer to the problem. The student is able to solve the problem correctly and estimate the answers to various considerations and provide the right reasons. Researchers further investigate the reasons why students pick estimates by using players who are near the audience seat. Here's an interview trailer:

S: Miss, I use a comparison, I take the man in the picture that person who is close to a stadium

T: Why use the closest person to the stadium?

S: Because it can be compared, miss. man's height is not proportional to this stadium if using this one (the person who is far away from the stadium) we don't know how far the distance between that person to the stadium

T: oh ya okay

Based on the above interview that the student has known to estimate by using a player close to the stadium because when using a player away from the stadium there is an unknown distance of value while the average player's height is the same. From the problem answer an interview, the student who has higher reasoning ability can make consideration to answer the problem with logic. According to Hapizah [20] said that with the best reasoning, the student can do the best problem-solving. However, the student with the middle ability is still wrong to solve the problem. Here's the answer:

S: Panjang stadion pada gambar 5 cm
 1/3: Panjang manusia berbadan merah pada gambar
 160: Perkiraan tinggi manusia

$$\frac{1}{3} = \frac{160}{X}$$

$$X = 615 \text{ cm}$$

Anggapan menggunakan manusia berbadan merah dengan tinggi 1/3 cm pada gambar tinggi manusia sebenarnya adalah sekitar 160 cm

Figure 3. Student's answer with middle ability.

From the answers above, it appears that students can understand the problem contained. The student is able to predict answers to the problem. However, the student is not exactly choosing an estimate that will be the solution to the answer to the problem. As for the answers of students with low ability as follows:

Estimasi tinggi Mankawalacap = 20 kotak genteng
 1 Kotak KITA-KITA = $\frac{50 \times 30}{50 \times 30}$
 $P = 50$ $L = 30$
 $Q = 30$ $L = P \times Q$
 $= 50 \times 30$
 $= 1500 \text{ cm} \times 20 \text{ genteng}$
 $= 30000 \text{ cm}$
 $= 300 \text{ m}$

Figure 4. Student's answer with lower ability.

For students with low ability, students already understand the purpose of the given problem. However, students can not understand the meaning of the problem well. Thus, to answer the problem by estimating the counting part of the roof but can not estimate the logical answer to the problem. So the researchers interviewed the students:

T: Do you already understand the meaning of the problem?

S: Yes, I already understand the point is to have an estimate the maximum height of the stadium rooftop

T: How do you estimate?

S: The trick is to count the number of these boxes

T: Which boxes?

S: This one, 1,2,3.

T: How many boxes are there?

S: After counting, 20 boxes. After that, I thought that the tile was shaped rectangle. So I estimate the length 50 cm and width 30 cm ago. I count the area of the rectangle by the length of the width. The result is multiplied by 20 tiles.

T: Which do you count high or wide?

S: Of course height (while thinking) oh yes it should look for the width only because calculate the height

From the above interview, students do not understand the meaning of the problem well. So what is asked about does not match the answer. From the small group results, it was found that only 16.7% of students can solve the problem by estimating the answers with the right reasons, 16.7% of students can only estimate the answers but the reasons used in the estimates are not accurate and 66.7% of students can not estimate the answer appropriately. In addition, there are students who consider less information. This is relevant to the low PISA Indonesian student results [1]. Therefore, the need for special attention training Indonesian students to get used to doing PISA problems. This agrees with Charmila and Kohar by familiarizing students practicing PISA in classroom learning and providing problem banks about PISA [21,22].

In conclusion, the problems that have been developed can be categorized as valid and practical. Valid is depicted from the validator assessment, either construct, content or language. While the results of revisions based on comments/suggestions and answer sheets of students in one to one and small group show a practical problem developed. The problem is categorized as practically illustrated by the observation of small group trial, where all students data use the problem device well. Problems are developed according to the student's mind flow, given context is known for students, easy to read and does not lead to multiple interpretations.

The results of small group and student interviews so that the researcher did not revise the problem because the tested problem was understood by the students and for the students who considered the less information was not accepted because if the added information will change the characteristics of the problem according to the PISA framework.

4. Conclusion

Based on the problem development process has been generated about the development of PISA which is declared valid and practical. Valid assessed from the validator results at the expert review and one to one stage which states that the problem has been good in terms of content, constructs, and language. While the results of revisions based on comments/suggestions and answer sheets of students in one to one and small group show a practical problem developed. Problems developed are also considered practical from the small group stage. Problems are developed according to the student's mind flow,

given context is known for students, easy to read and does not lead to multiple interpretations. After analyzed from the results of student answers and interviews, valid and practical problem is not of language or problem but the lack of understanding of student concepts about the material being studied.

5. Acknowledgments

The author would like to thank Ross Turner, Kaye Stacey, and Ahmad Fauzan as validators in this study; Yunita as the model teacher in this study; Students of Senior High School Number 10 as research subjects.

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