

## DEVELOPING SIXTH LEVEL PISA PROBLEMS IN LOWER SECONDARY SCHOOL: SPACE AND SHAPE

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### *Abstract*

*According to Indonesian curriculum, some of the goals of learning mathematics are: students are able to (1) reason mathematically, (2) solve mathematics problem, (3) manipulate mathematically, (4) do analysis. But, based on the previous research and the rank of PISA, many weaknesses were traced when students did the mathematics problems in high level. This condition causes of students never practiced with the problem in high-level. To train students' ability to do the high-level problems in mathematics, required the development of problems such as high-level. This study aims to develop sixth level PISA problems which valid and practical. The content of problems which developed is content "space and shape". The researchers use design research using the type of development study to reach the objective of this study. This study consists of two stages, which are preliminary and prototyping (formative evaluation) stages. The preliminary stage, researchers conducted several activities that analyzing the students that will be the subject, analyzing curriculum, and analyzing the PISA problems which developed. The prototyping stage consists of self-evaluation, expert reviews, one-to-one experiments, small group experiment, and field test. The problems were tested to 28 seventh graders in SMPN 1 Palembang, Indonesia. The data were collected by test, interviews, and field notes. The result of this study is the sixth level PISA problems with content "space and shape" are valid and practical.*

**Keywords:** problems of level six PISA, space and shape, valid, practical, development research, lower secondary school

### **INTRODUCTION**

*Problem-solving* is a kind of problems that should be given to students to improve their capabilities. Problem solving-based problems can promote student's conceptual understanding, foster their ability to reason and communicate mathematically, and capture their interests and curiosity (Hiebert & Wearne, 1993; Marcus & Fey, 2003; NCTM, 1991; Van de Walle, 2003; NCTM, 2010). According to Indonesian curriculum, some of the goals of learning mathematics are: students are able to (1) reason mathematically, (2) solve mathematics problem, (3) manipulate mathematically, (4) do analysis. However, Bidasari (2012) found that many weaknesses were traced when students did the mathematics problems in high level. This condition causes of students never practiced with the problem in high-level. Furthermore, based on the result of Programme International Student Assessment (PISA) 2012, Indonesia ranked 64 out of 65 countries, which participated in the test. The low result of PISA were caused by the

low of capability to solve non-routine or high level problems. Besides, the evaluation system in Indonesia still use the low-level problem so that student use formal knowledge in class (Stacey, 2010; Wu, 2011; Novita, Zulkardi, & Hartono, 2012; Kertayasa, 2014).

The sixth level is the highest level in PISA. There are a lot of skills that students should be used to resolve this problems. According to the principles of assessment in the PISA mathematics, essential skill needed in learning mathematics is the ability of mathematical literacy. Students are approved to have literacy ability if they are able to analyze, reason and communicate mathematical ideas and skills effectively. They are also needed to be able to solve and interpret non-routine or high level problems in mathematics. To train students' ability to do the high-level problems in mathematics, required the development of problems such as high-level. Maharrani (2014) found that problems in the textbook lesson more procedures and are still in the low level. Therefore, the researchers develop problems of level six PISA. One of content in PISA is content "space and shape". The research question is *how to develop sixth level problems with content space and shape which valid and practical at lower secondary school?*

### THEORETICAL FRAMEWORK

#### Programme International Student Assessment (PISA)

According OECD (2013a), Programme International Student Assessment (PISA) is an international assessment organized by the countries who are members of the OECD (Organization for Economic Co-operation and Development). There are four mathematics content categories in PISA, which are: (1) Quantity, (2) Change and relationships, (3) Space and shape, and (4) Uncertainty and data. The present study, focuses solely in space and shape. This content is related to geometry lessons. Problems around space and shape asses students' ability to recognize shapes, look for similarities and differences in various dimensions and forms of representation. Besides, this content is related to identify the characteristics of an object in relation to the position of the object (OECD, 2013b). PISA has six levels. The following are six levels in PISA according OECD (2013).

**Table 1.** Proficiency scale descriptions for mathematics (2003-2009)

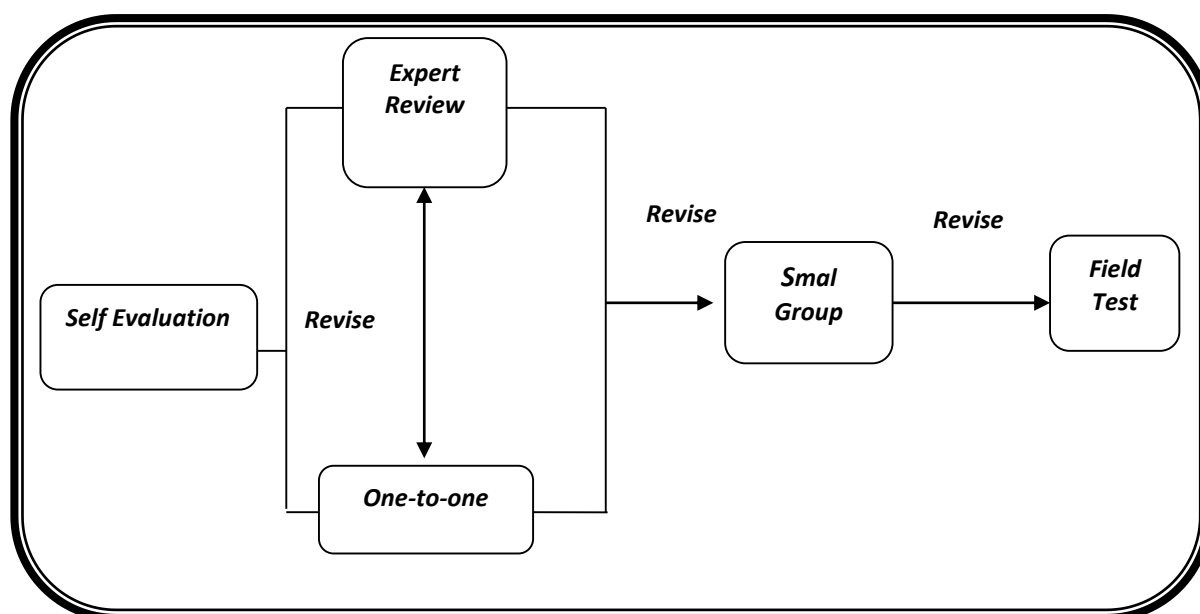
Level	Description
6	<ul style="list-style-type: none"> <li>• Students can do the conceptualization, generalization and use information based on investigate and modeling of complex problem situations.</li> <li>• Students can link different information sources with flexible and translate it.</li> <li>• Students are able to think and reason mathematically.</li> <li>• Students can apply in-depth understanding accompanied by technical mastery of mathematical operations, developing strategies and new approaches in dealing with new situations.</li> </ul>

- Students can formulate and communicate with the right actions and reflect on taking into account its findings, interpretations, opinions, and accuracy in a real situation.

(OECD, 2013b)

**METHOD**

This study is a design research using the type of development study. There are 28 seventh graders in SMPN 1 Palembang participated in this study. This study consist of two stages, there are preliminary and prototyping (formative evaluations) stages. In the preliminary stage, researchers conducted several analysis. Those analysis include analyzing the students that will be the subject, analyzing curriculum, and analyzing the PISA problems which are developed. The prototyping stage consists of self-evaluation, expert reviews, one-to-one experiments, small group experiment, and field test (Tessmer, 1993). Below is the flow design of formative evaluation types.



**Figure 1.** The Flow Design of formative evaluation (Tessmer, 1993: 16)

The technique of data collection in this study are test to student by give the sixth level PISA problems, interview to student who become the subject of research, questionnaire to find out students’ comments with respect to problems that was developed. The data analyzed from the student answer, then it accounted for valid and reliable.

**RESULT AND DISCUSSION**

In this part will discussed is the stage for development, which are preliminary and prototyping stage (formative evaluation).

## 1. Preliminary

At this stage, researchers conducted several activities that analyzing the students that will be the subject, analyzing curriculum, and analyzing the PISA problems which developed. Besides, researchers designed the draft and produce a device prototype instrument.


## 2. Prototyping

### a. Self Evaluation

At this stage, the researchers evaluate its own draft that created and produced the first prototype. The following is one of the problems which developed by the researcher.

### BEFORE REVISION

**Unit 1: CIRCUMFERENCE OF A CIRCLE**



A photograph of a large circular fountain in Jakarta, Indonesia. The fountain is a large circle with a central column and water spraying outwards. It is surrounded by a road with many cars and a red bus. The fountain is the central focus of the image.

A photographer wants to know the circumference of a circle in Jakarta through pictures which he took.

**Question 1:**

What strategy can be used by photographers to determine the circumference of the circle? Determine the circumference.

**Figure 2.** One of the problems which developed

### b. Expert Review

The first prototype submitted to the expert for validation. In this case, the experts are:

1. Prof. Kaye Stacey, professor of mathematics education at the University of Melbourne, Australia. She is the chairman of the Mathematics Expert Group (MEG) for the OECD PISA survey in 2012.

2. Dr. Ross Turner, director of the Australian Council for Educational Research (ACER). He is the head of the experts team in PISA.
3. Kamaliyah, M.Pd., researcher who have been researching on the PISA.
4. Ahmad Wachidul Kohar, M.Pd., researcher who have been researching on the PISA.

c. One to One

The researchers carry out one to one test to five students. During the test, the researcher asked whether the problems can understood by students or not, other than that the students also fill out questionnaires to give comment and suggestion for the problems in terms of language, images, tables, and figures.

**Table 2.** The comment or suggestion in expert review and one to one stage

<b>Validation Stage</b>	<b>Comment or suggestion</b>
<b>Expert review</b>	<ul style="list-style-type: none"> <li>• Which circle do you mean? The red painted lane on the roadway? The curb next to the roadway? The central ornament? The pond? You need to ask a clearer question.</li> <li>• I think it is probably formulate because there is a real world problem, and the difficult thing will be to find the mathematics and data that can be used.</li> <li>• Give caption about “Selamat Datang” monument</li> </ul>
<b>One to one</b>	I don’t know which circle do you mean.

The first prototype not only validated qualitatively, but also quantitatively. The first prototype were tested to some students in class which are the different students to field test students. After that, the researcher carried out validity and reliability analysis of each items.

Based on the result of validity and reliability tests, this item is valid and reliable, but researcher still revise the first prototype based on comment and suggestion for this item, so that produce the second prototype which will tested in the small group experiment. The following is the problem after revision.

**AFTER REVISION**

**Unit 1: CIRCUMFERENCE OF A CIRCLE**



“Selamat Datang” Monument is a monument located in the middle of the Hotel Indonesia, Jakarta, Indonesia.

**Question 1:**

Estimate the circumference of the circle and explain your strategy.

**Figure 3.** The problem after revision

d. Small Group

At this stage, researcher carries out the test for six students. After working with the problems, students fill out the questionnaire and researcher asks something about the test. The following one of the student’s answer.

**Penyelesaian:**  
 Kelilingnya dicari dengan cara mencari diameter  
 $(2 \times \pi)$  Soal kurang lengkap.

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The circumference is determined by finding the diameter ( $2 \times \pi$ ). The problem is incomplete.

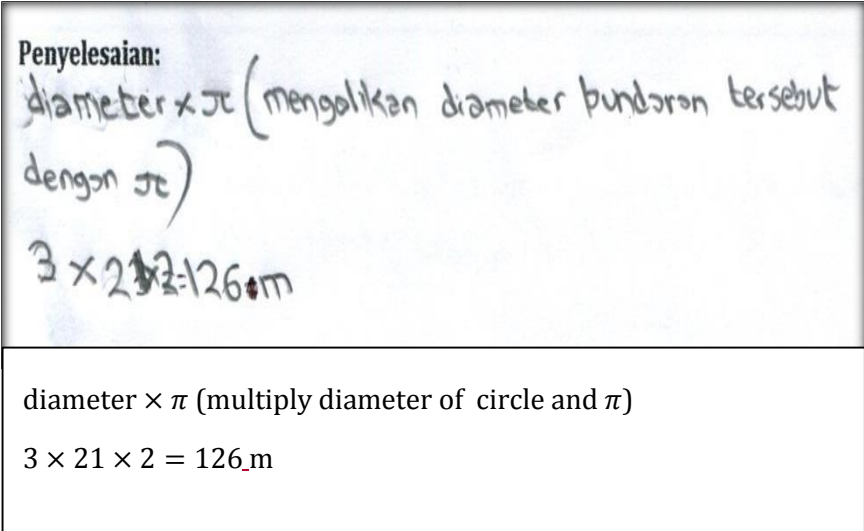
**Figure 4.** One of the student’s answer in small group

Based on the student’s answer, the student said that the question is not complete. After interviewed, the student said that he could not do the problem because there is no number in that problem. Whereas, researchers did not provide a number on the problem because the researcher wants the students estimate the circumference by utilizing

objects that are all around the circle. In this case, there is no something which revised in this problem so that this problem used to the third prototype.

e. Field Test

At this stage, the test given to students who are the subject of research. The results of the students' answers analyzed to know potential effects of problems that developed. The following one of student's answer in the field test.



Penyelesaian:  
 $diameter \times \pi$  (mengalikan diameter bundaran tersebut dengan  $\pi$ )  
 $3 \times 21 \times 2 = 126.m$

diameter  $\times \pi$  (multiply diameter of circle and  $\pi$ )  
 $3 \times 21 \times 2 = 126.m$

**Figure 5.** one of the student's answer in field test

Based on the figure 5, the student writes a formula of circle circumference, after that he writes " $3 \times 21 \times 2 = 126$ ". Then, the researcher asks the student about what he wrote. The student assuming the length of one car is 3 meters, then the students count the number of cars for a half circle. In a half circle there are 21 cars, then to get the number of cars in one circle, he multiply  $21 \times 2$ , so that he writes circumference of a circle is " $3 \times 21 \times 2 = 126$ ". Based on the answers, the students understand the concepts well and use the information to solve problems, students are also able to reason, but the students have not been able to communicate the answer in detail. Based on the indicators of level in PISA, this problem according to the indicator level 6.

## CONCLUSION

The result in this study is sixth level pisa problems in lower secondary school with content space and shape are valid and practical. The prototype is valid qualitatively by experts, one to one experiment, and small group experiment. That prototype is valid quantitatively by tested to student and accounted for validity and reliability of each item. In field test, researcher give test to 28 student to knowing that the problems which developed can be used on the actual situation.

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