

## DEVELOPING PISA-LIKE MATHEMATICS TASK WITH INDONESIA NATURAL AND CULTURAL HERITAGE AS CONTEXT TO PROMOTE REASONING SKILLS of STUDENTS

Wuli Oktiningrum<sup>1</sup>, Zulkardi<sup>2</sup>, Yusuf Hartono<sup>3</sup>

Sriwijaya University<sup>1,2,3</sup>

1) wulie.okti@gmail.com, 2) zulkardi@yahoo.com, 3) y\_hartono@yahoo.com

### **Abstract**

*One of the goals of learning mathematics for students is that students have skill to solve the mathematical problems as a mean to promote the careful reasoning, logical, critical, analytical, and creative (Widjajanti,2009). But in fact, the Indonesian students have the low skill in reasoning mathematics. It has been proved by the low performance of Indonesian Students in PISA (Programme for International Student Assessment) survey in the period 2000 – 2012. Based on the result, this study aims to produce a set of PISA – like mathematics task with natural and cultural heritage of Indonesian as context which are valid and practical. This is a design research using type of development study with formative evaluation. Technique of the data collection is walkthrough, documentation, and test. The subjects were 34 ninth graders from SMP Negeri 1 Palembang. From the analysis of the documentation it can be concluded that (1) the set of PISA – like mathematics task with natural and cultural heritage of Indonesian as context which are valid and practical; (2) based on the development process showed that the set of PISA – like mathematics task with natural and cultural heritage of Indonesian as context have the potential effect on reasoning skill of students.*

**Keywords:** Development research, PISA-like mathematics task, reasoning skill

### **INTRODUCTION**

Every student should have good reasoning ability, because this is consistent with the goal of learning mathematics. According to National Council of Teacher (NCTM, 2000), the goals of learning mathematics are: (1) mathematical communication; (2) mathematical reasoning; (3) mathematical problem solving; (4) mathematical connections; and (5) mathematical representation. Widjajanti (2009) adds that one of the aims of learning mathematics for students is that students are able to have the ability or skill to solve the mathematical problems or mathematics task to promote the rigorous reasoning, logical, critical, analytical, and creative. All students should be able to reason and communicate proficiently in mathematics and should have knowledge include the ability to define and solve the mathematics problems. It uses of the vocabulary forms of representations, materials, tools, techniques, and intellectual methods of the discipline of mathematics (Lappan et al., 2002).

But in reality, Indonesian students have low reasoning skills. It because students didn't have the ability to design mathematics models, solved the models and interpret the



obtained solution (Prihastuti et al., 2013). Sadiq (2007) also explained that the low level of mathematical problems solving skills of students due to the learning process of mathematics classroom less increase high-level thinking skills (higher order thinking) and less directly related to the real life of students.

Because of that, the latest PISA mathematics survey results in 2012 shows that Indonesian students, as in several previous results, only reached below level of items assigned and bottom rank compared to the other country participants, that is, 64 from 65 countries. Considering that fact, government made changes the Indonesia education system, one of it is the change curriculum. It calls the Curriculum 2013 whose framework of its development is encouraged by the PISA result (Kemdikbud, 2013). PISA task recommended conducting study in designing teaching program, because it can improve the quality of mathematics teaching and analyzing how students make errors in solving mathematics problems (Stacey, 2013). Hence, Zulkardi (2010) suggest developing PISA-like mathematics task ask well as use them in instructional practices. And to produce PISA tasks which valid, practical, and has a potential effect, research on developing PISA-like tasks also were conducted by several researches with a focus on examining the context (Lutfianto, 2012).

Thus, this research aims to produce a set of PISA-like mathematics tasks with Indonesia natural and cultural heritage as context which are valid, practical, and has potential effect to development the reasoning skill students.

## **THEORETICAL FRAMEWORK**

### **Reasoning Skills**

The process or a thought activities to make a conclusion or thought processes in order to make a new statement is true based on some statements whose truth has been proved or assumed before, it call reasoning (Shadiq in Wardhani, 2004). Mathematical reasoning that include the ability to think logically and the highest systematics mathematical cognitive. Sumarmo (2000) provides that reasoning skills has several indicators, the first, students should making analogy and generalization for the mathematics problems. Second, students should giving the reason and using the mathematics models to solve the problems. Third, when students find the complicated problems, they should using the pattern or connection to analyze the mathematics situation. Fourth, they should test and develop the conjecture. Fifth, after tested conjecture, they should check the validity of the argument. After that, students should prepare the direct and indirect evidence to make sure if that's true. Even better, if they make the denialists example. And, to make it better if the students always follow the rules to solve the mathematics problems.

Mathematical reasoning more than teaching mathematical reasoning using formal mathematical procedural route but rather encourage students to discover the connection of learning mathematics. National Council of Teachers of Mathematics (NCTM, 2000) explained that using the various types of reasoning and the method of proof and selected it is one of the standard processes of learning mathematics. Furthermore, the standard



process of learning mathematics is identified, make and investigate mathematical conjecture, developed and evaluated mathematical arguments and proof.

## **METHOD**

This research is design research using type of development study. This research concerns about iterative development using the formative evaluation in various consumers (Plomp & Nieveen, 2007). The formative evaluation contained in this research consisted of preliminary stage and prototyping phase which includes self-evaluation, expert reviews and one-to-one, small group, and a field test (Zulkardi, 2002; Tessmer, 1993).

The development process started form preliminary steps by grasping with the concept related to developing mathematical literacy task then used it to design an initial prototype. This prototype was then self-evaluated before entering the next steps. In expert review, ten experts were involved to validate the task in term of content, construct, and language. For one-to-one phase, 4 students evaluated particularly on how they understand the information, for example, picture, phrase, etc. in the task and not focus on how they answer the task. This result gave important suggestion to revise the task so that those could be re-evaluated in small group. The small group phase involved 10 students with various academic abilities to solve the task in 75 minutes. Here, we firstly obtained students' performance in solving the task because the scored analyzed a variety of students answer. We used the data as a view to assess students' real performance in field test. The field test was conducted on 20 students grade IX form SMP Negeri 1 Palembang.

## **RESULT AND DISCUSSION**

### **Developing task**

In the preliminary stage, we conducted several steps; (1) examined the literature on developing mathematical task, framework of the PISA 2015, the relationship between the current curriculum and the PISA survey, (2) designed an initial prototype comprising a set of PISA-like task and its scoring, (3) determined the validators, (4) determined the research subject. At the stage of self-evaluation, we examined the initial prototype resulting prototype 1.

The prototype 1 evaluated by validators or expert review and students (one-to-one phase). In the expert review, prototype 1 was assessed and evaluated by experts consisting of 10 experts, namely 2 experts from Mathematics Expert Group of PISA is Prof. Kaye Stacey and Dr. Ross Turner, the PMRI lecturers are Prof. Dr. Ahmad Fauzan, Prof Dr. Ipung Yuwono, Dr. Yenita Roza, mathematics teachers are Nurjannah, M.Pd and Nadya Husenti, M.Pd, and Dr. Ariyadi Wijaya, Kamaliyah, M.Pd, Ni Luh Sakinah M.Pd, Ahmad Wahidul Kohar, M.Pd as PISA researchers. The expert reviewed the prototype 1 in terms of content, construct and language. The researcher conducted a test to 4 students SMP Negeri 1 Palembang grade IX with individually (one-to-one). The following is one of tasks example on this situation.



### Before revision

## PISA Models with the Context Natural Heritage and Indonesian Culture

### UNIT 1: The National Parks 'Bromo, Tengger, Semeru'

**Basic competence:** Understanding graded and percentage comparison, and describing problems by using tables, graphs, and equations.

- Semeru Mountain is the highest mountain in Java island. There are several mountains surrounding Semeru Mountain namely Batok Mountain, Bromo Mountain, and Widodaren Mountain. If the ratio of the height of Bromo Mountain and Batok Mountain is 2:3, and the ratio of the height of Batok Mountain and Semeru Mountain is 4:5. Then specify the ratio of the height of Bromo Mountain and Semeru Mountain is..

Discussion:

If the ratio of the height of Bromo Mountain : Batok Mountain = 2:3

Batok Mountain : Semeru Mountain = 4:5

Then, the ratio of the height of Bromo Mountain : Semeru Mountain = 8:15



**Figure 1: Task 1 before revision**

**Table 1:** Comments from Expert and Students on task 1

| Validation    | Comments/Responds   | Revision   |
|---------------|---|--|
| Expert review | <p>"Can you think of a reason anyone would actually want to know this? If you can, perhaps that can be worked into the question in some way."</p> <p>"I suspect that these are very rough approximations, rather than precise ratios."</p> <p>Make the realistic problems</p> <p>The question is not "open ended", you should make the question with the various answer</p> | <ul style="list-style-type: none"> <li>• Changing the question with the realistic question</li> <li>• Using different context</li> </ul> |
| Student       | <p>I don't know how to solve the problem, because this question have different proportion</p> <p>The picture less clear, and I think not help me to solve the problem</p>   |  |

After obtaining some suggestion from experts and students, the prototype 1 was revised become prototype 2. The following is the revised task based on the table 1.



### After revision

**NATURAL HERITAGE AND CULTURE OF INDONESIA AS THE  
CONTEXT IN PISA MODEL QUESTIONS**

**UNIT 1: Tourism Spot 'Mt. Bromo Crater'**

1. Andi, who comes from Surabaya, is planning to spend holiday to the National Park 'Bromo Tengger Semeru' with 9 of his friends by renting cars. The distance from Surabaya to Mt. Bromo is 150 KM. The following is the list of rental cars.

| No | Type of vehicle | Capacity | Rental cost per-24 hour | Fuel consumption | Fuel tank capacity |
|----|-----------------|----------|-------------------------|------------------|--------------------|
| 1  | Car A           | 4 people | Rp 200.000              | 10 km/ liter     | 35 liter           |
| 2  | Car B           | 7 people | Rp 300.000              | 14 km/ liter     | 45 liter           |
| 3  | Car C           | 6 people | Rp 250.000              | 12 km/ liter     | 43 liter           |

The price of fuel is Rp 6.600 per liter. Try to help Andi to decide which car he should choose, so that he has comfortable and low-cost trip. Give your reason!

**Figure 2: Task 1 after revision**

The results of expert review and one-to-one were used to revise the prototype 1 become prototype 2. Prototype 2 was then tested on small group consisting 10 students. The results of the small group show that the task has coefficient of high reliability of 0.70 but some task were empirically invalid. Therefore, the researcher reviewed each item developed primarily on the invalid task for discarded, maintained with revisions, or retained without revision. This decision was based on the result of activities : (1) giving a questionnaire asking students opinions on the task; (2) examining the distribution of student's answers, and (3) interviewing subjects of small group to investigate whether the student were not able to solve the task in the absence of the aid scheme or as a matter of readability issues. The result of this evaluation resulted in prototype 3 which was then used in a field trial test as many as 20 students in order to know the potential effect to the task as well as to measure the problem solving skills of students when they solve the mathematics PISA problems with Indonesia natural and cultural heritage as context.

### Potential effects of the task

The aims of the field test was to find the potential effects of the task on students reasoning skills. After the students completed work on the task, we gave questionnaires to all students, and interviewed 4 students to obtained data about the potential effect. The students' response on the questionnaire is shown below.



**Table 2:** Students Response

| No | Activity  | Students Response |
|----|---|-------------------|
| 1  | Create mathematical models, such as creating mathematical equations, making the pattern sequence number (mathematizing) | 18 %              |
| 2  | Make written mathematical argumentation/ calculation correctly (communication)  | 31%               |
| 3  | Create model representation and utilizing images, table, graphs, and the like to help find the answer (representation)  | 50%               |
| 4  | Comparing the strategies to solve the problem   | 45%               |
| 5  | Make reasoning by linking the information with the existing experience (reasoning and argumentation).                   | 91%               |
| 6  | Use manipulate formulas or specific mathematical procedure to obtained solution (use of formal/ symbolic language)      | 45%               |

The Table 2 shows that reasoning and argumentation activity were recognized by most students in solving the problems. The recognition is in line with some of the written comments in general impression, like as shown below.

#### Response of Students

Student 1 : *I used logical thinking to solve this problem, and I like it*

Student 2 : *the task requires more reasoning, it different with what I used to solve, where the only ask me to use an available formula.*

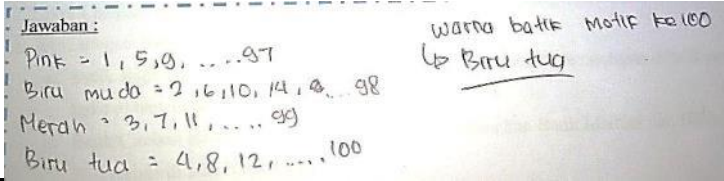
Furthermore, the potential effect of the task is also seen from the extent to which students are interested and serious in solving the task. The data supporting students responses on the task are given in the following table.

**Table 3.** Student's responses

| Question Number | Easy | Hard | So Hard |
|-----------------|------|------|---------|
| 1               | 25%  | 35%  | 5%      |
| 2               | 30%  | 30%  | -       |
| 3               | 35%  | 30%  | -       |
| 4               | 50%  | 30%  | -       |
| 5               | 40%  | 10%  | -       |
| 6               | 25%  | 35%  | -       |
| 7               | 25%  | 35%  | -       |
| 8               | 5%   | 60%  | -       |
| 9               | 30%  | 30%  | -       |
| 10              | 10%  | 50%  | -       |
| 11              | 0%   | 55%  | -       |
| 12              | 10%  | 45%  | -       |



As a proof how students activate their reasoning skill into mathematical process, the following are example of students work on task 7. The aim of the task is to know the students ability in observing empirically the pattern of the color of batik.



**Jawaban :**

Pink = 1, 5, 9, ..., 97

Biru muda = 2, 6, 10, 14, ..., 98

Merah = 3, 7, 11, ..., 99

Biru tua = 4, 8, 12, ..., 100

Warna batik motif ke 100  
↳ Biru tua

**Answer :**

Pink : 1, 5, 9, .... 97

Blue : 2, 6, 10, 14, ... 98

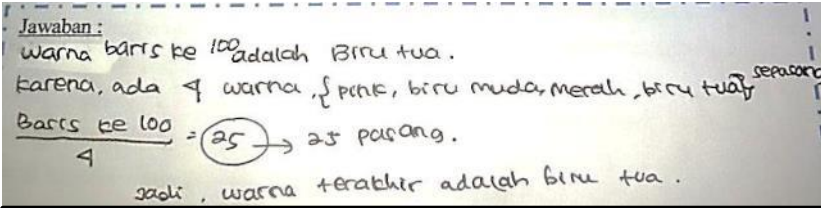
Red : 3, 7, 11, .... 99

Dark Blue : 4, 8, 12, ... 100

the color of batik in the 100<sup>th</sup> line is Dark Blue

**Figure 3:** Student Answer for task 7

From figure 3 show that students have different ways to answer the task 7. Figure 3 showed that students using the manual ways to know the color of the batik. He give the number for each color, and after this write the number 1 until 100 until he find the batik color in the 100<sup>th</sup> line.



**Jawaban :**

Warna batik ke 100 adalah Biru tua.

Karena, ada 4 warna, {pink, biru muda, merah, biru tua} <sup>separang</sup>

$\frac{\text{Baris ke 100}}{4} = 25 \rightarrow 25 \text{ pasang.}$

Jadi, warna terakhir adalah biru tua.

**Answer :**

the color of batik in the 100<sup>th</sup> line is Dark Blue

because, there are 4 color (pink, blue, red, dark blue)  $\rightarrow$  pair

$\frac{\text{the 100<sup>th</sup> line}}{4} = 25 \rightarrow$

4

So, the last color is Dark Blue

**Figure 4:** Student Answer for task 7

Figure 4 show that he used logical thinking. He knows the pattern of the color, after this he dividing the pattern with 100. And he found that the batik color in the line 100<sup>th</sup> is blue.

## CONCLUSION

This study produced set of PISA-like mathematics task with Indonesia natural and cultural heritage which valid and practical. Based on the result, prototype 3 has potential effect to develop reasoning skills students, it shown by the students' answers. Others indication of this effect are also seen from their seriousness and interesting when solving the task. Lastly, suggest teachers and other practitioners to use the task from study as tools in designing PISA problem based learning.



## ACKNOWLEDGEMENT

This paper is part of the thesis that is compiled by one of IMPoME students. International Master Program on Mathematics Educations (IMPoME) is a special scholarship program that is funded by DIKTI and NESO and initiated by P4MRI. Also, this program is a collaboration between UNSRI, UNESA, and Utrecht University

## REFERENCES

- Kemdikbud. (2013). *Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Atas/Madrasah Aliyah dalam Lampiran Permendikbud No 69 Tahun 2013*. Jakarta: Kemendikbud.
- Lappan, G., Fey, J.T., Fitzgerald, W.M., Philips, E.D. (2002). *Getting to Know: Connected Mathematics*: New Jersey : Michigan State University
- Lutfianto, M., Zulkardi, & Hartono, Y. (2012). Unfinished Student Answer In PISA Mathematics Contextual Problem, *Journal on Mathematics Education (IndoMS-JME)*, 4(2), 201-208.
- NCTM. 2000. *Principles and Strandarts for School Mathematics*. USA : The National Council of Teacher Mathematics inc.
- Plomp, T., & Nieveen, N. (2007). An Introduction to Educational Design Research. In *Proceedings of the Seminar Conducted at the East China Normal University [Z]. Shanghai: SLO-Netherlands Institute for Curriculum Development*.
- Prihastuti, W.S., Hudiono,B., Hartoyo, A. (2013). Pemecahan Masalah Matematis Siswa Ditinjau dari Tingkat Kemampuan Dasar Matematika. *Jurnal Pendidikan dan Pembelajaran Vol 2 no 12, 2013*
- Shadiq, F. (2007). *Laporan Hasil Seminar dan Lokakarya Pembelajaran Matematika dengan Tema “ Inovasi Pembelajaran Matematika dalam Rangka Menyongsong Sertifikasi Guru dan Persaingan Global”* yang dilaksanakan pada tanggal 15 – 16 Maret 2007 di P4TK Matematika Yogyakarta
- Stacey, K. (2013). PISA 2012: Philosophy, Item Development, Success and Possible Research. Makalah dipresentasikan di kuliah umum Pascasarjana Universitas Negeri Malang, Rabu, 26 Juni 2013
- Sumarmo, U. (2010). *Teori, Paradigma, Prinsip, dan Pendekatan Pembelajaran MIPA dalam Konteks Indonesia*. Bandung: FPMIPA UPI
- Sumarno, A. (2011). *Model Pembelajaran Konvensional*. <http://blog.elearning.unesa.ac.id/alim-sumarno/model-pembelajaran-konvensional> (accessed Mei 2015).
- Tessmer, M. (1993). *Planning and Conducting Formative Evaluations: Improving the Quality of Education and Training*. London: Kogan Page.
- Wardhani, S. (2004). *Permasalahan Kontekstual Mengenalkan Bentuk Aljabar di SMP.Paket Pembinaan Penataran*. Yogyakarta: Departement Pendidikan Nasional Direktorat Jendral Pendidikan Dasar Menengah Pusat Pengembangan Penataran Guru Matematika.



- Widjajanti, D. B. (2009). Kemampuan Pemecahan Masalah Matematis Mahasiswa Calon Guru Matematika: Apa dan Bagaimana Mengembangkannya. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika, Jurusan Pendidikan Matematika FMIPA UNY, Desember 2009*
- Zulkardi. (2002). *Developing a Learning Environment on Realistic Mathematics Education for Indonesian Student Teachers*. Dissertation. University of Twente, Enschede. The Netherlands. Published Dissertation.