# INVESTIGATING POTENTIAL EFFECTS OF PISA-*like* MATHEMATICS TASKS FOR THE SEVENTH GRADERS

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***Abstract***

*Programme for International Student Assesment (PISA) result in all five-surveys2000-2012 indicates the low of Indonesian students' mathematical literacy performance. Even, in PISA 2012, Indonesia merely ranked 64 out of 65 countries in which most of students were only able to solve the low-level tasks. Considering those reasons, it is realized that mathematics problem which could support students' mathematical literacy promoting, such as PISA-like tasks, is important to develop. Therefore, this design research type development study aims at producing a set of PISA-like mathematics problems which are valid and practical as well as have the potential effect. Investigating the potential effect then becomes the focus on this article. It is needed to address how PISA-like tasks developed in this study could propose the potential benefit especially for students. There were 28 seven graders of SMP Negeri 1 Palembang involved in field test became the subject of this study. Data collecting techniques used were students' test result, questionnaire, and interviews. Overall findings indicate that 15 items of PISA-like mathematics task developed in this study has thepotentialeffects indicated by students' interest and motivation in solving problems, students' positive response toward integrating of PISA-like problems into the mathematics textbook or daily mathematics exercise in the classroom, as well as students' fundamental mathematical capabilities (FMC) activation underlying three process of mathematical literacy; formulate, employ, and interpret.*

**Keywords:** PISA-like problems, mathematical literacy, potential effests

## INTRODUCTION

PISA is a large-scale survey conducted every three years to evaluate students' literacy, including mathematical literacy (OECD, 2013). This survey focuses to determine whether the students could apply the mathematics knowledge they obtained in the classroom in a variety of real-life situations. Such focus is also basically regarded as the core goal of mathematics education (Wijaya, 2015; Biembengut, 2007; Greer, Verschaffel, & Mukhopadhyyay, 2007). Indonesian students, however, consistently showed their low performance in all five-PISA surveys. Even, in the latest PISA survey Indonesia only ranked 64 out of 65 countries with most of Indonesian students were merely able to answer mathematics tasks embedded in familiar context and low-level (OECD, 2013).

As a respond to this problem, Indonesia decided to develop and implement the new curriculum what so called as curriculum 2013 of which one of its implementation background implied by the PISA results (Kemdikbud, 2013). In this curriculum implementation, the textbook plays a vital and essential role as the main instructional for the teacher since the single provider of textbook is government (Kemdikbud, 2013). Therefore, it is also highly needed to ensure that the quality of tasks provided in the textbook meet the good criteria; such as potentially promote students' mathematical literacy as evaluated internationally. Some studies revealed, however, the intended characteristics of problems which stimulate the promoting of students' mathematical literacy have not integrated maximal yet in most of textbook used in the classroom (Gatabi, Stacey, & Gooya, 2012; Wijaya, 2015).

Regarding this case, developing mathematics items which could promote students' mathematical literacy, such as PISA-like tasks, is considered to be important to develop. It is in line with Kohar's (2013) argument that it is needed to support mathematics learning resources by developing tasks enhancing students' mathematical literacy. Zulkardi (2002) also suggested to develop PISA-like mathematics problems and then employing them wisely in instructional practices.

To obtain a PISA-like problem set in a good criteria, van den Akker (1999) proposed three main principles; valid, practical, and effective. The effective aspect is considered to be important to do for addressing how a developed product, PISA-like tasks, appropriately work on as the intended aims proposed, i.e. supporting the learning material used in mathematics learning process as a contribution to the implementation of curriculum 2013, especially in the term of promoting students' mathematical literacy.

Therefore, in this present study the researcher pose a research question: how do the potential effect of the developed PISA-like tasks toward seven graders as the research subject.

## THEORETICAL FRAMEWORK

### Mathematical Literacy

In OECD (2013), mathematical literacy is explicitly defined as follows;

> An individual's capacity to formulate, employ, and interpret mathematics in a variety of context. The capacity also includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that mathematics plays in the real world.

This defenition explicitly refers to an individual's ability to actively engage in mathematics world involving three mathematical processes; formulate, employ, and interpret (OECD, 2013) as described below;

a. Formulating indicates how well individuals are able to recognise and identifiy the mathematical aspects of a real-world problem and then formulate it into a mathematical structure.

b. Employing refers to individuals being able to perform computations and to apply mathematical reasoning as well as mathematical concepts, procedures, facts and tools to find mathematical solution.
c. Interpreting involves reflecting upon the acquired mathematical solutions or results and evaluating them back into the context of a problem whether the conclusions are reasonable or not.

**Potential Effect**

Van den Akker (1999) claimed that a learning package developed is categorized to be good if it meets three criterias; valid, practical, and effective. Yet, in this study, the main focus was only to investigate the effective aspect of the development product, in this term PISA-like tasks. Then, Plomp & Nieveen (2007) categorized effective aspects into two kinds; the expected effectiveness (having the potential effects) and the actual effects. While Guskey (in Zulkardi, 2002) used five levels of effective aspects, those are the satisfaction of participants, changes in the knowledge and abilities of participants, changes in the organization/group, the use of new knowledge or the ability of the participants, as well as the responses of students and learning outcomes.

**METHOD**

This is a design research type development study with formative evaluation (Plomp & Nieveen, 2007). The research was conducted in two phases; preliminary stage and prototyping phase including self-evaluation, expert reviews and one-to-one, small group, and field test (Tessmer, 1993; Zulkardi 2002).

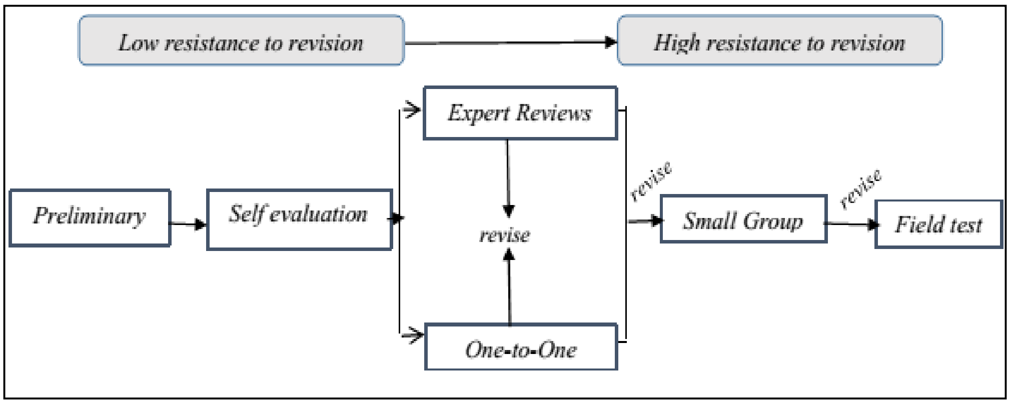



**Figure1:** Formative evaluation (adapted from Tessmer, 1993; Zulkardi, 2002)

The development process was started by analysing curricula, subject, appropriate literatures, as well as analyzed textbook content in the preliminary pahase. In this case, researcher analyzed problems' characteristic in a single chapter (proportion chapter) of curriculum 2013 textbookfor seven grade to see if those problems have been able to explore the students' mathematical literacy skills or not. In preliminary stage, the researcher also developed instrument such as PISA questions, rubric, questionnaire, interviews guidance, and sheet of walk through. PISA questions which were developed in the prliminary stage was simply called as initial prototype. This prototype was then selfevaluated producing prototype 1. This prototype then validated paralelly in both expert review and one-to-one phases. Some comments and suggestions from experts and students were then used to revise the existing prototype resulting prototype 2 which was re-evaluated in small group. Ten students with various academic abilities involved in this phase. The collected data were used to revise prototype to producing prototype 3. This prototypewas then used to assess student's real performance in larger test, i.e. field test. However, this article merely focuses on the result of this stage, field test, involving 28 seven graders of SMPN 1 Palembang, Indonesia. At the end of the field test, students gave their written comment through questionnaire and some of them were interviewed by researcher to investigate the effect potential emerging when they solved the tasks.

**RESULT AND DISCUSSION**

Prototype 3 including 15 PISA-like problems was tested in field test. Such step aimed at investigating the potential effects of PISA-like problems which had been developed. The researcher analyzed questionnaire and students' test result to find out the emerging potential effects by analysing students' responses on the questionnaire regarding question 1 and 2 (students' interest and seriousness in solving the tasks), question 3 (fundamental mathematical capabilites/ FMC), and question 4and 5 (students' response toward inntegrating of PISA-like problem into the mathematics textbook or daily mathematics exercise in classroom).

Based on the analysis of questionnaires, the data distribution obtained as follows:

**Table 1.**Students' interest and seriousness in solving the tasks for item 1

**Question:** How interesting are the problems?

| Students' Response | Percentage (%) |
|---|---|
| Very interesting | 7.14 |
| Interesting | 60.72 |
| Nothing special | 25.00 |
| Not interesting | 7.14 |

**Table 2.** Students' interest and seriousness in solving the tasks for item 1

**Question:** How was your response when solving the problems?

| Students' Response | Percentage (%) |
|---|---|
| I am interested and serious in finishing all the problems | 21.43 |
| I am only interested and serious in finishing certain problems | 60.71 |
| I am interested, but not serious in working the problems | 17.86 |
| I am totally not interested in the problems | 0.00 |

**Table 3.** Student's Response in Activating FMC

**Question:** What kinds of FMC are you activating when solving PISA-like problems?

| Types of FMC | Percentage (%) |
|---|---|
| Using and manipulating formulas of specific mathematical procedure to obtain solutions (Using formal, symbolic) | 42.86 |
| Making reasoning by associating the provided information and the existing experience (Reasoning and argumentation) | 82.14 |

| Types of FMC | Percentage (%) |
|---|---|
| Making writing mathematical argumentation correctly (Communication) | 28.57 |
| Creating mathematical models (Methematizing) | 42.86 |
| Creating model of representation and/or utilizing images, tables, and graphs to help find the solutions (Representation) | 71.43 |
| Choosing and comparing strategies for finding solutions (Devising problem solving strategies) | 25.00 |

**Table 4.** Students' Response Related to PISA-like tasks and Textbook item 1

**Question:** How if some mathematics problems in textbook use PISA-like problems?

| Students' Response | Percentage (%) |
|---|---|
| I want all of the tasks used in textbook are PISA-like problems. | 7.14 |
| I want sometimes we get PISA-like problems for exercising. | 71.43 |
| I want there are some PISA-like problems at the end of every chapter in my mathematics textbook. | 21.43 |

**Table 5.** Students' Response Related to PISA-like tasks and Textbook item 2

**Question:** How if the PISA-like problems are integrated in the mathematics textbook?

| Students' Response | Percentage (%) |
|---|---|
| Agree | 92.86 |
| Disagree | 7.14 |

Potential effects in this article implies how benefit the PISA-like problems could potentially give for the students. As Zulkardi (2002) claimed, effectiveness of a learning product could be assessed, e.g from the participants' learning, participants' reaction, and participants' use of new knowledge and skills. In this term, students of field test subject had shown the positive respon on these cases.

Potential effect of PISA-like mathematics model in this study could be implied from the extent to which participants are interested and seious in solving the proposed problems. Regarding the participants' reaction or attitude, based on table 1 and 2 it is notable that all of students(100%) were interested to work on the tasks. This findings is in line with several written comments and data of interviews with students as follows.

**Table 6.** Students' Comments Related to Their Seriousness when Solving Problems

| Student | Comment |
|---|---|
| A-27 | " I was serious and very interesting to finish the tasks. They were so challenging." |
| A-15 | "The tasks were so interesting, challenging, exciting, although some of them were so confusing and complicated." |

However, there are some people (17.86%) were admitted to merely interested and serious in finishing certain problems. The interview with those studentsshowed they declared such response since they thoughtthere are some questions which were very difficult to solve. Five out of 28 students in this group admitted only seriously solve the items that are considered to be resolved and prefer to let it blank or guess the answers for questions that are considered too difficult.

In general, students also showed positive response toward inntegrating of PISA-like problem into the mathematics textbook or daily mathematics exercise in the classroom.They generally agree that PISA-like problems could be integrated to the textbook used in the classroom. This response is also reinforced by most of students (71.43%) want mathematics task for practicing in classroom occasionally use problems demanding reasoning ability, as PISA-like problems propose. Even, 21.43% of the students want there are some PISA-like problems at the end of every chapter in textbook. There are several reasons underlying it. The following written comments and interview record showed that PISA-like problem is something new so it could increase the variety of problems in the text book, challenging due to it involves reasoning abilty to solve it so it can train the ability to think, as well as it could recognize the application of mathematics in real world.

**Table 7.** Students' Comments Related to PISA-like Items

| Student | Comment |
|---|---|
| A-02 & A-07 | "The tasks definitely could promote the reasoning ability." |
| A-15 | "It would be more interesting if we occasionally use PISA-problems as exercise in the classroom." |
| A-22 | "To finish all of these tasks, we need more logic. It is so different from the daily problems we encountered in the classroom" |
| A-01, A-05, A-11 | "A very challenging task. Finishing it was also a new knowledge and experience." |

Furthermore, table 3 shows 6 of 7 FMC had been activated by students when they solving PISA-like problems. Most of students (82.14%) tend to invove reasoning by linking information with the existing experience or simply called as reasoning and argumentation of FMC. Creating model of representation and/or utilizing variety of representation forms, e.g images, tables, geraphs are also recognized by most students (71.43%) in solving the tasks. This is supported by some of the written comments and interviews of students as follows.

**Table 8.** Students' Comments Related to FMC Activated when Solving the Problems

| Student | Comment |
|---|---|
| A-04 & A-26 | "Although quite confusing, I like this type of task. It demands more reasoning skill. (Reasoning and Argumentation) |
| A-01 | "Complicated task, but it used many figures which was helpful making me more interesting to finish it". (Representation) |
| A-27 | "I used pictorial aid to find some solutions of the task That much more helpful. (Representation) |

Furthermore, the potential effect of the tasks could also be inferred from the activation of students' fundamental mathematical capabilities (FMC) underlying three process of mathematical literacy. Activation of FMC in the process of problem solving could be identified from the students' answer documents in field test. The following is one of the item examples followed by involvement of students' mathematical literacy within three main processes of mathematical literacy (formulate, employ, and interpret) when they solving the problem.

**Context Unit 1: Egrang Competition**

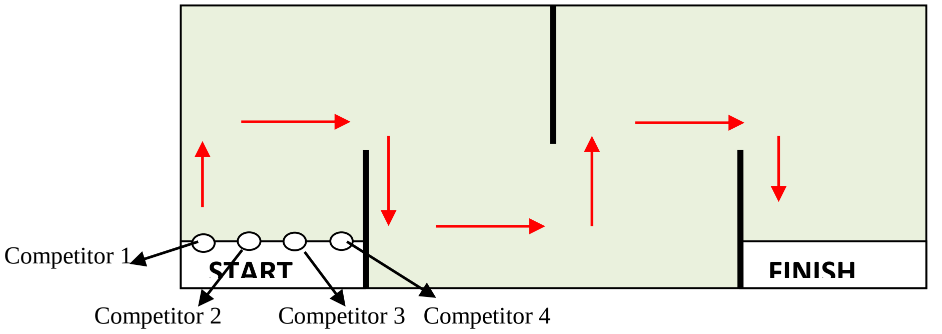



Illustration above shows a race track for an egrang competition made by committees. They claimed that all-four competitors would have the same length-distance in this track. However, Rahmat, one of the competitors, argued that the egrang track made by committee is unfair since all of competitors might reach the different distance from start to finish line.

Whose statement was correct, committees or Rahmat? Explain your reasoning.

**Figure2.** Question for Unit Egrang Competition

In term of demanded FMC, *reasoning and argument* competency would be activated when students associate between the committee's statement and visual information of race track figure. In other words, students are required to use their *visual reasoning* to be able to *interpret* the correctness of the statement of committees as well as Rahmat as stated in the problem sentence. Therefore, to understand the main focus of the problem -about the unfair track distance of each competitors- a *receptive communication* competency is highly demanded. The *using symbols, operations and formal language* was less or even not involved in this task. Instead, the *strategy* needed to solve the problem merely involves the student's creativity to prove that all competitors have the same or different track distance. All these ideas could simply be represented into a pictorial *representation*. The images as a form of external *representation* of each student's idea are then predicted diverse, which are very dependent on the level of stheir creativity and *reasoning* abilities.

Field test result shows a good students' achievement on this item. 18 out of 28 students could answer the task correctly by including the logical supporting arguments. For this group, two solution models were generally employed; (1) representing the idea through pictorial representation of the race track involving distinct and clear track for each competitors, (2) using a pictorial *representation* containing the shortest track for each competitors to reach the finish line.

The figure 3 is the first students' solution model

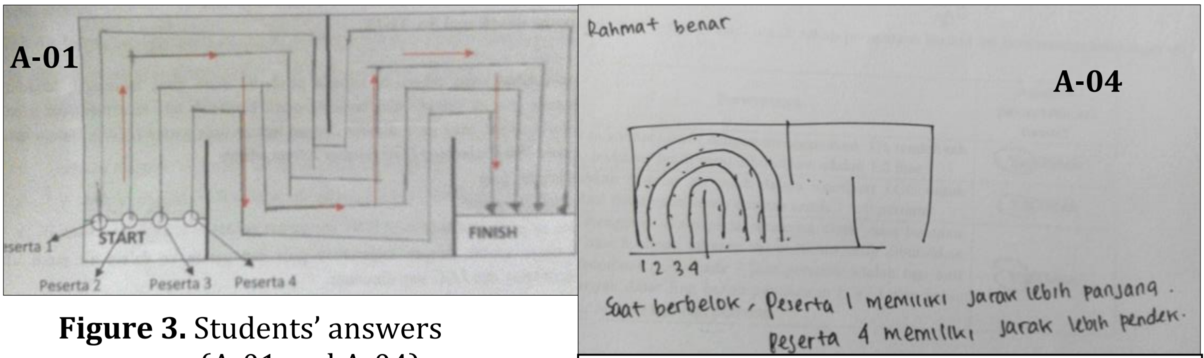


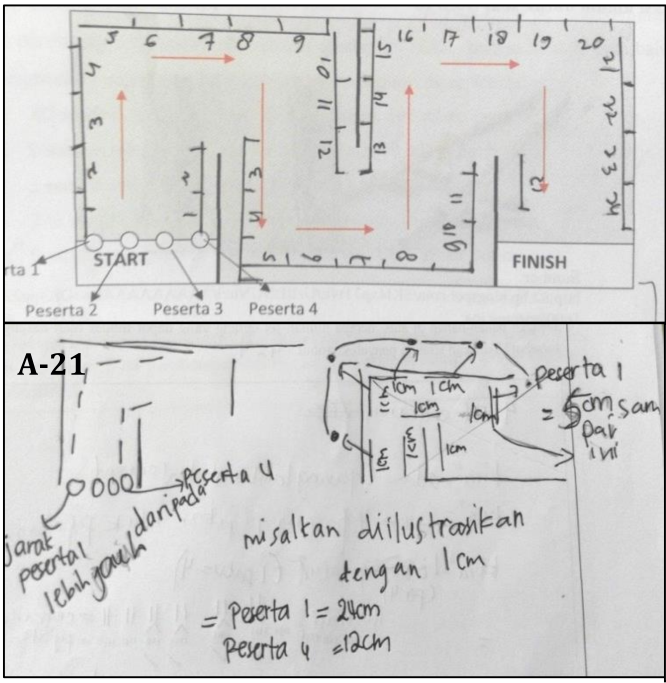

**Figure 3.** Students' answers (A-01 and A-04)

Rahmat's argument was correct.

When they turned right, the competitor 1 reached the longest distance. While the competitor 4 would have the shortest track.

Based on the figure 3, it is notable that A-01 made different paths for each competitor in the whole track from the start to the finish line. While another student, A-04, only *represented* a part of the track that all-four competitors will take in the match. When such idea was confirmed through a brief interview, A-04 argued that some track could be safely ignored to draw. The idea he expessed in the pictorial representation is obviously adequate to show that the track made by the committee is not fair. Although they both used the different *constructive communication* to *represent* the idea, in general A-01 and A-04 had activated the *visual reasoning* competency to refute the committee's statement. For *receptive communication* ability, both of them had grasped the main focus of the task by understanding the text (e.g. the unfair track for each participant).

If A-01 and A-04 estimated the ratio of track length for each participant, then it is slightly different from idea of the other student, A-21, as follows.



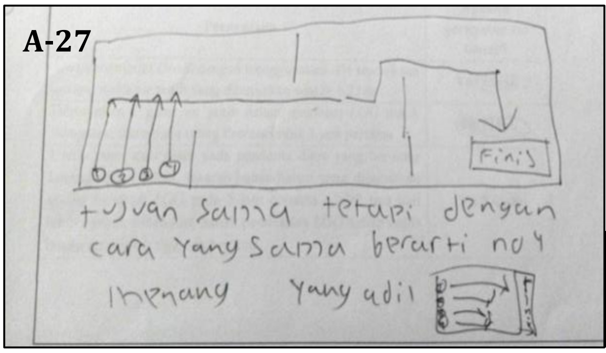

dtance taken by competitor 1 farther than that of competitor 4

assumed it is illustrated with 1 cm, then
Competitor 1= 24 cm
Competitor 4= 12 cm

**Figure 4.** Student' answer (A-21)

In the figure 4, A-21 tried to *represent* a supporting argument that is more precise by involving the *use of simple symbolic/formal*. In the *formulation* process, A-21 used the pictorial *representation* with standard measurement to compare the distance taken by competitor 1 and 4 to precisely. Although the *constructive communicative* in using standard measurement he performed is not completely correct because of the inappropriate unit he used, in general A-21 has been able to well activate the ability of *mathematising* and *representation.* These cases led him to the correct conclusion that each competitor has the difference distance to reach the finish line.

The second solving model made by student was making the shortest track for each participant to reach the finish line. The following answer shows such idea.




The same goal (finish line) and the same track. So, competitor 4 would be the winner.

**Figure 5.** Students' answer (A-27)

To confirm answer on figure 5, A-27 then was interviewed by researcher (R) as in the fragment 1.

**Fragment 1.** Interview with A-27

1. R : "Would you mind explaining your solving strategy for this item?"
2. A-27 : "As you notice in my figure" (pointing the figure he made)
3. R : "Why did you make all of the competitors do not reach the edge of the field, yet they directly turn right? (*1)"
4. A- 27 : "To reach finish line as soon as possible. Every competitors might think this way, taking the shortest track."
5. R : "If you did this way (*1) don't you think that there would be a crash when they turned right?"
6. A-27 : (think for a moment).. "No. Assumed they have a relatively same acceleration, then competitor 4 might be the fastest to turned right."
7. R : "Ok. Good. Then, if you want to make the shortest track to the finish line, then why did not you make the same way on the third turn? (pointing *2). I mean they should directly turn right."
8. A-27 : "O..yes. You're right. I did a mistake."
9. R : "So, what is the conclusion?"
10. A-27 : "Each competitor has the different distance to reach the finish line. So, the egrang track made by committees is unfair."

Based on the fragment 1 (e.g. line 4 and 6), it is notable that A-27 has activated well his *reasoning* ability before coming to the *mathematization* and *representation* process. Through *reasoning* process, A-27 could easily understand that there is no any specific rules mentioned in the match track. Therefore, the most reasonable path he though was the shortest path to the finish line, although the shortest path that he *represented* as a form of *constructive communication* is not completely correct. Mistakes that A-27 wrote (*2) does not totally make him failed to *interpret* the correctness of Rahmat's argument proposed in the problem, since A-27 could *interpret* the pictorial *representation* he made into a correct conclusion.

## CONCLUSION

A set of PISA-like mathematics problems produced in this study have the potential effects, indicated by students' interest and motivation in solving problems, students' positive response toward integrating of PISA-like problems into the mathematics textbook or daily mathematics exercise in the classroom, as well as students' FMC activation into three mathematical processes; formulate, employ, and interpret as the components of mathematical literacy.

## ACKNOWLEDGEMENT

This study was supported by Directorate General of Higher Education (DIKTI), through International Master Program on Mathematics Education (IMPoME) scholarship.

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