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Pisa-Like Mathematics Task Using Weight-Lifting Context

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Abstract. The use of PISA item can improve the quality of learning because in solving the PISA problem students must be able to use some fundamental mathematical capabilities. The fundamental mathematical capabilities can be applied in everyday life. This paper aims to produce a PISA-like mathematics task using weight-lifting context which is valid and practical. The research method used in this research was Design research. Data were collected using tests, interviews, and observation. The subject in this research were 15-years-old students in SMAN 1 Palembang. The items validation process involves three experts and three students. The validity of this developed problem was seen from its compatibility with the PISA framework, both regarding content, context, literacy process and level of questions accordance validator stated. Practicality was seen from small group test results involving six students. Items developed were said to be practical because the items can be understood by students and easy to use. The developed PISA task capable of generating fundamental mathematical competences, i.e., communication; representation; mathematization; reasoning and arguments; choosing strategies to solve problems; using language and symbolic, formal and technical operations.

Keyword: Design Research, PISA, Weightlifting, Context

INTRODUCTION

The achievement of Indonesian students' mathematical literacy skills in the international study results of the International Student Assessment Program (PISA) is below the average achievement of the Organization for Economic Cooperation and Development (OECD). The ability of mathematical literacy is the ability of individuals to formulate, use, and interpret mathematics in various contexts [1]. From the definition is illustrated that the ability of mathematical literacy is one of the abilities that must be owned by students in everyday life. The ability of this mathematical literacy consists of seven fundamental mathematical capability.

Several studies have been conducted to investigate the underlying causes of Indonesian students' mathematical literacy skills in the PISA study, the results of which show that some of the causes are difficulties in formulating daily problems into formal forms of mathematics, understanding mathematical structures and evaluating mathematical results to real-world contexts, difficulty in interpreting mathematical solutions recovered to the given context [2,3,4,5,6]. Related to the problem, Stacey [7] recommends conducting a study using PISA in learning to improve the quality of mathematics learning and to analyze how students make mistakes in solving PISA problems.

Asian Games XVIII 2018, the biggest sporting event in Asia will be held in Indonesia. About this matter, the President of the Republic of Indonesia instructed the Minister of Education and Culture of the Republic of Indonesia to facilitate the socialization support of the Asian Games XVIII in 2018 at primary and secondary institutions [8].

One characteristic of the PISA problem is to use the context in each case. Context is a natural phenomenon associated with mathematical concepts studied or experienced by the students themselves [9]. The context used

will make the mathematical concepts used in solving the given problem more meaningful [10,11,12,13]. Using mathematical problems that exist in the real world is also one way for students to enjoy mathematics [14,15,16]. It is also by the government's vision as outlined in the 2013 curriculum that improves the mindset of strengthening the interactive learning pattern and strengthening the learning patterns of the network [17]. Strengthening of interactive learning pattern covers the happening of interaction between learners and society as well as the natural environment, strengthening of learning pattern in a network means learners are expected to gain knowledge from anyone and anywhere. For that in this research the researcher will design the learning instrument in the form of math problem of PISA type using the context of sports branch that exists in Asian Games event is weight-lifting sports.

RESEARCH METHODS

The research method used in this research is Design Research which had two stages: the preliminary and prototyping (formative evaluation) consisting of self-evaluation, expert review and one-to-one, small group, and field test [18].

This research aims at generating a PISA task using the context of weight-lifting that is valid and practical. The validity was determined by looking at the result of the expert validation (expert review stage) and students' comment (one-to-one stage). The practicality of the task was determined by the opinion of students (small group). Practicality means ease of use, the possibility of proper administration and interpretation and improbability of multiple interpretations. The answer sheets and interview results were analyzed qualitatively to see the fundamental mathematical capabilities.

The research subjects were grade X students at SMAN 1 Palembang. The research was conducted in October 2017 - November 2017. The data were collected by (1) walkthrough, it was performed on expert review stage to get validation in aspects of content, construct, and language of PISA task. It was done through e-mail; (2) interview, it was conducted on the one-to-one, and small group to explore the practicality of the PISA task.

RESULTS AND DISCUSSION

This study has produced Nine (9) similar problems of PISA using various contexts, but in this article, the researcher will focus on one particular item. That is PISA-like mathematics task using the weight-lifting context. The process of developing the PISA problem in this study consists of two stages, preliminary stages and prototyping stages (formative evaluations) that are comprised of self-evaluation, expert review and one-to-one, small group, and field test [18].

Preliminary Stage

At this stage, the researchers analyzed the 2013 curriculum, PISA framework and studied the published PISA issues as well as some previous research relevant to the research that is about developing the PISA problem. Also, researchers also determined the place and subject of the study. This research was held at SMAN 1 Palembang, and the subject of this research is the 15-year-old student. After that, researchers began to design the instrument questions such as lattice matter, problem cards, scoring rubrics, determine the validator of the instrument in the design.

Prototyping Phase Using Formative Evaluation Flow

Self-Evaluation

The self-evaluation stage is the stage in which the researcher evaluates the instrument himself [18]. The instruments that are evaluated are lattice matter, question cards, scoring rubric. The evaluation process of all instruments is viewed regarding content, constructs, and language used. In practice, the researchers asked for help to colleagues, ie, teachers mathematics subjects SMAN 1 Palembang Eriga to evaluate the instruments that have been designed. The result of the improvement in the self-evaluation stage is called prototype 1.

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 [18]. In the expert review stage of this study, the experts validate the instrument made regarding the content, constructs, and language used.

In this research, the validation process was done through electronic mail (e-mail). Prototype 1 was sent to experts who have experiences in developing PISA problem. The experts were Kaye Stacey, the chairman of the PISA world, Ahmad Fauzan, a professor of Mathematics Education at the State University of Padang, and Hasratuddin, a professor of Mathematics Education at Medan State University. All three experts have reviewed and provided suggestions and feedback on the content, constructs, and language used.

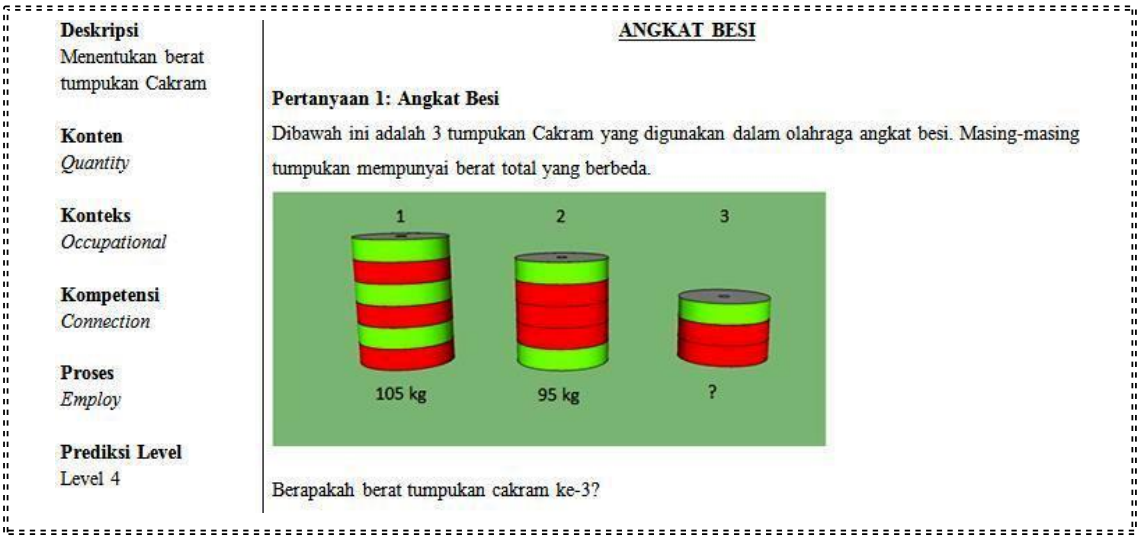
Aspects reviewed the content was conformity to PISA content, context, competency, literacy process, and level of PISA. While aspects reviewed from construct domain were whether or not it can develop students' fundamental mathematical competencies and advanced concepts; whether or not it used visible tables, graphics and images, and whether or not it was readable and functional. Furthermore, Aspects reviewed on language domain were whether or not it complied with Ejaan Yang Disempurnakan (EYD), whether or not sentence formulations give rise to multiple interpretations, and whether or not they have clear question and answer limitation.

At the stage of the expert review, Kaye Stacey commented on the content used, according to her more precise content for the matter developed is Quantity content. Furthermore, Kaye Stacey also explains and gives input that in PISA, all the right logical answers are acceptable and earn full points. Furthermore, he also explained that there is no added value for students who use certain methods. For that, researchers use suggestions and input provided by Kaye Stacey in revising the prototype of the problem to get better.

Ahmad Fauzan commented on a similar matter of PISA using this weightlifting context; he argued that the words "Disc" in the question should be supplemented by "discs used for weightlifting." The comment was taken as an input in revising the prototype 1 of question two.

In line with the expert review, the researchers also tested prototype 1 to individual students (One-to-one). In this study, researchers involved three students with different mathematical abilities of high, moderate and low mathematics students. Students who are involved are 15-year-old students outside the subject of research used during field tests. At this stage, researchers observe the students as they complete the given questions, write down their comments on the questions, explore the students' comments, and ask students whether they are working or when they have done the questions. The focus of this one-to-one step is to clarify the clarity of question intent, to seek suggestions for improvement, and to investigate the reasons for students' difficulties in solving the problems they have made.

Based on the suggestions and comments obtained at the expert review and one-to-one stage, the researcher revised the questioning instrument on prototype 1 to obtain a new instrument called prototype 2. This prototype is a prototype that has been declared valid because the prototype has been revised following the suggestion and comments from experts. Figure 1 below is prototype 2 of a PISA-like problem using a weight-lifting context.



Deskripsi
Menentukan berat tumpukan Cakram

Konten
Quantity

Konteks
Occupational

Kompetensi
Connection

Proses
Employ

Prediksi Level
Level 4

ANGKAT BESI

Pertanyaan 1: Angkat Besi

Dibawah ini adalah 3 tumpukan Cakram yang digunakan dalam olahraga angkat besi. Masing-masing tumpukan mempunyai berat total yang berbeda.

Berapakah berat tumpukan cakram ke-3?

FIGURE 1. Prototype 2

Prototype 2 is tested in this small group stage. In this study, researchers involved six students aged 15 years with different mathematical abilities. Each of them consists of two students with high, medium, and low math skills. Students involved in this stage are different students, either with the students involved in the previous one-to-one stage or the students involved in the field test stage at a later stage. The focus of this small group stage is to look at the weaknesses, advantages, and practicalities of prototype two that have been made.

At this small group stage, all students can solve the problem given without difficulty, both in the clarity of the image used and clarity of the latter intention. For that, the prototype two is stated to be practical.

The following figure is the answer sheet of one of the students that the researcher discovered during small group.

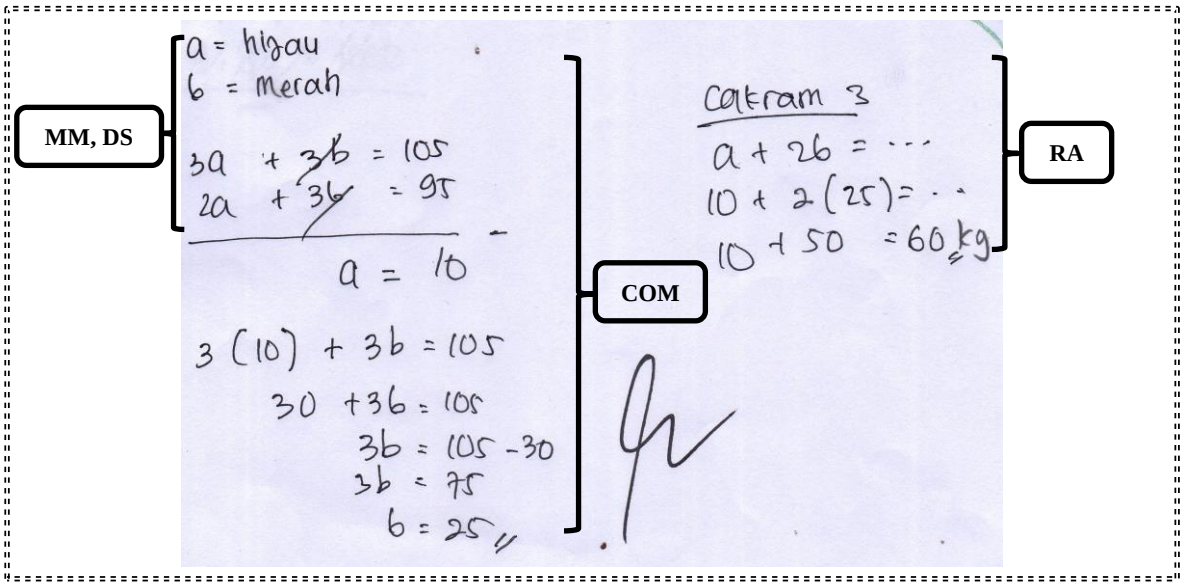


FIGURE 2. AZ worksheet

High-ability students solve the problem given using a strategy that matches what the researcher predicts, the system of two-variable linear equations. The first step that AZ students do in solving the given problem is to symbolize known discs based on their color. The green disc is symbolized by a and the red disc symbolized by b. The next step is to change the stack of discs that are given in the form of mathematical equations that form the system of two linear equations. This ability in PISA is called the Mathematizing (MM) ability. Also, at this stage is also a stage of students in determining the strategy in solving problems that in PISA ability is called Devising strategies for solving problems (DS). Then the student performs a mathematical operation, in this case, doing the elimination of both equations made. [17] states that the ability of mathematical reasoning indicates that students can provide simple inductive and deductive reasoning. After obtaining one of the values of the variable, the value is substituted again to the initial equation to obtain the value of the other variable. This ability in PISA is called the reasoning and argument (RA) ability that is the ability of students to connect information that has been in the previous to determine the solution. Having obtained the weight of the two discs in question, the final step is to sum the disk according to the question, i.e., two red discs, and one green disc. After summing the results obtained the total weight of the third pile of discs is 60 kg. The process of students writing the process of achieving their solutions in PISA is called communication skills (COM). It complies with the statement of [17] that the ability of mathematical communication indicates that students can declare and interpret mathematical ideas orally, written, or in a demonstration.

In addition to the above answers, the researchers also found alternative answers used by students; the answers used are as follows.

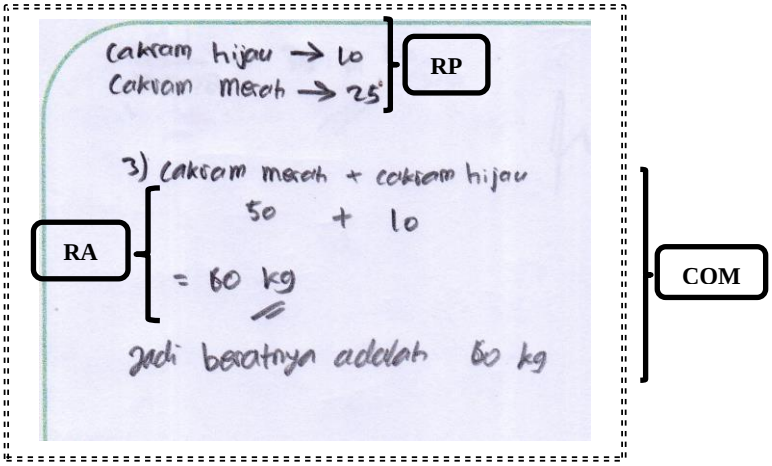


Figure 3. FMF worksheet

The strategy used by the students in solving the given problem as shown in figure 3 above is to try to determine the corresponding value of each disc color corresponding to the total weight value assigned to the discs 1 and 2. The fulfilling value is used by students in determining the total weight of the third disc heap. This method is commonly referred to as trial and error. At the stage of expert review Kaye Stacey states that in PISA, all logical methods can be used in solving the given problem. The method is also given full value. To that end, students who respond with this method correctly also get the maximum value. When looking at the student's answer, the researcher feels like to know more about the strategy that the student used in solving the given problem. It is because the process of completion used by students was different from the preview of answers that the researchers had made before. For that researcher do interviews with these students as can be seen in the transcript below.

Q: How many results?
S: 60 sir
Q: Can be from 60?
S: Green 10, red 25
Q: 10 and 25 can be from where?
S: Just think about it sir
3x25 = 75, 3x10 = 30,
75 + 35 = 105 pack
Q: Here (the second pile) is not true?
S: The red is 75, right sir.

CONVERSATION TRANSCRIPTS 1. About Student's Worksheet

The first process undertaken by students is by determining the weight of each disc, ie, the weight of red and green discs. At this stage, students use the representational ability (RP) that connects various representations when solving the problem by determining the weight of the disc based on the color of the disc that is matched to the total weight of the disk heap. After obtaining the weight of each disc, students use the information to determine the weight of the third disc heap. The ability to use such information is called reasoning and argument (RA). Writing all the student processes solving the problem given in the answer sheet is a communication skill (COM). It complies with the statement of [17] that the ability of mathematical communication indicates that students can declare and interpret mathematical ideas orally, written, or in a demonstration.

Pisa-Like mathematics task using weight-lifting context developed capable of generating basic mathematical skills or within the PISA framework are called *mathematical literacy*. Some of the capabilities that appear in the student's strategy when working the problem are communication skills, representation, mathematization, reasoning, and arguments, choosing strategies to solve problems, as well as using language and symbolic, formal and technical operations.

CONCLUSION

Based on the results presented earlier, it can be concluded that the problems developed have been valid. The validity of this research is based on the validation results to the expert on the expert review stage which sees prototype questions regarding content, constructs, and language. Regarding content, experts perceive the

suitability of the PISA math problem using the weightlifting context of the PISA content category, the PISA context, the PISA literacy process and the level of questions on PISA. Regarding constructs, experts perceive that the problem has the potential of generating mathematical literacy skills, inviting the further development of concepts, tables, drawings, graphics, presented clearly, legibly and functionally. In parallel, the developed question was also involved to three students at the one-to-one stage. Practical problems are based on the results of trials to six students with different abilities at the small group stage. Also, the developed problem has also been practically based on the results of one-to-one and small group stages tested to nine students who have different math skills. So the matter developed can be declared valid and practical.

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