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Developing Teaching Materials PISA-based for Mathematics and Science of Junior High School

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Abstract
This research aims to develop valid and practical teaching materials for mathematics and science lesson PISA-based for junior high school students and to determine potential effects on students in scientific activity. Subjects of this study were students of Junior High School 9 Palembang (SMP Negeri 9 Palembang). The method used in this study is the Development Research consists of three stages: preliminary, prototyping, and assessment. Data collection techniques used in this study is walk through (expert review stage) to determine the validity of teaching materials in terms of content, construct, and language; interview (one-to-one and small group stage) to determine the practicality of teaching materials, and field tests stage to determine the potential effects of instructional materials. From the analysis of the research data, it can be concluded that: this study produced two instructional materials namely mathematics instructional materials with topic similarity and science instructional materials with topic temperature and its amendment. The teaching materials have the potential effects on the students in scientific activities.
Keywords: Mathematics and Science, Curriculum 2013, PISA

1. Introduction

The Curriculum 2013 required that the learning activities for all levels and all subjects achieve attitude competency, knowledge, and skills, in all learning process. In order to implement the Curriculum 2013, it would require an innovation in the planning learning process and learning approaches. Mathematics and Natural Sciences are very basic subjects to be well understood by students. This is because Mathematics and Science are directed to develop critical students' thinking process, creativity, and reasoning. One of the instrument or learning approaches that can be developed for mathematics and science is teaching learning PISA-based.

Programme for International Student Assessment (PISA) is an international assessment of the skills and abilities of students at age 15 (Shiel, et al., 2007; OECD, 2009). Skills and abilities assessed in PISA are mathematics, reading, and science (OECD, 2003; OECD, 2009; Stacey, 2011). PISA was first implemented in 2000 which was organized by the OECD (Organisation for Economic Co-operation and Development) (Shiel, et al., 2007; OECD, 2009; OECD, 2010; OECD, 2013).

Although Indonesia has not become a member of the OECD, Indonesia has participated in PISA since the first PISA assessment carried out in the international scale (OECD, 2003; OECD, 2009; Kemdikbud, 2011). However, the results of the assessment carried out from 2000 through 2012 showed that Indonesian students always occupy the lowest position, around rank 65th (Kemdikbud, 2011; OECD, 2013). For example, in mathematics literacy, consecutively in 2000, 2003, 2006, 2009, and 2012 Indonesia has been always in rank 10 lowest of the PISA participating countries (Kemdikbud, 2011; OECD, 2013). This low Indonesian students PISA results is caused by weak problem-solving abilities of non-routine problems or high level problems. In addition, the assessment system in Indonesia still uses low-level questions. Also, students are accustomed to acquire and use knowledge of formal mathematics in class (Stacey, 2010; Wu, 2011; Novita, Zulkardi, and Hartono, 2012).

Responding to the poor performance of Indonesian students in PISA, various efforts have been made both from Indonesia government and from the education researchers. Indonesia government has conducted an evaluation of the poor performance of Indonesian students in PISA in the public test material of the Curriculum 2013. This case is one of the rationale for the Curriculum 2013 development as a replacement for KTSP (Kemdikbud, 2012; Kemdikbud, 2013). While researchers of education, Institute of Indonesian Realistic Mathematics Education Development (IP-PMRI) in collaboration with PPPPTK (Center for Development and Empowerment of Teachers and Education Personnel) held Literacy Mathematics Contest for national level in 2012 (P4TK, 2012). In addition, various studies about PISA models have also been carried out (Novita, Zulkardi, and Hartono, 2012; Kamaliyah, Zulkardi, & Darmawijoyo, 2013; Edo, Hartono, and Daughter, 2013; Lutfianto, Zulkardi, & Hartono, 2013). All the research on the PISA mentioned is done at the level of junior high school (SMP) or equivalent.

Therefore, it is very necessary to prepare Indonesian students for PISA, both in mathematics and in science. So, there is a need to develop mathematics and science learning based on PISA. Through the PISA-based learning, it is expected that junior high school students are able to practice questions of PISA.

PISA is a collaborative effort to measure how well students aged 15 years may face the challenges in life and solve real problems in this life (OECD, 2003; OECD, 2011). There are three types of literacy measured

in PISA: Reading literacy, Mathematical literacy, and Scientific literacy (OECD, 2003; Stacey, 2011). In PISA 2012, there is additional assessment, Problem Solving literacy and Financial literacy (OECD, 2013). PISA is held every 3 years (Prenzel, Kobarg, Schöps, & Rönnebeck, 2013).

In the implementation of PISA since 2000 until 2009, only one of the three domains (Reading literacy, Mathematical literacy, and Scientific literacy) are considered the major focus (Wetzel & Carstense, 2013), while the others become companion domains. The cycle begins by Reading Literacy was the focus in PISA 2000, Mathematical literacy was the focus in PISA 2003, and Science literacy in 2006. Then in 2009, PISA started with a new cycle, in which Reading Literacy is back as the main focus.

The definition of mathematical literacy is described in PISA 2012 Mathematics Framework Assessment and Analytical Framework (OECD, 2009; OECD, 2010; OECD, 2013), namely: mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in variety of contexts, including the ability to perform mathematical reasoning and use concepts, procedures, and facts to describe, explain, or predict phenomena. Mathematical literacy can help individuals to understand the role or mathematics in everyday life and to make well-founded judgments and right decisions needed by constructive, engaged, and reflective citizens. So from the definition, it can be said that a person is said to have a good level of mathematical literacy if s/he is able to analyze, to do reasoning and to communicate mathematical knowledge and skills effectively, and be able to solve and interpret mathematical problems.

The use of mathematical literacy in PISA begins with everyday problems (contextual problems). Context of the PISA mathematics can be categorized into four contexts (OECD, 2010; OECD, 2013), namely: Personal context, Occupational context, Societal, Scientific context. In mathematics, all the contexts are related to the content of number (quantity), probability / uncertainty and data, change and relationships, and space and shape (OECD, 2010; OECD, 2013).

Learning science (IPA) essence is the way to get the truth of what we have known. The values in learning science proposed by Lakshmi (quoted in Prasetyo, 2011: 15) are as follows:

a. Proficiency in work and thinking skills in regular, systematical, and in scientific method.
b. Skills and proficiency in conducting observations, using tools for experiments using to solve problems.
c. Scientific attitude in solving problems both in science lessons as well as in life.

Science learning activities include the development of the ability to ask questions, seek answers, understand the answer, complete answers about the "what", "why" and "how" of natural phenomena and the characteristics of the surrounding nature through systematic ways that will be applied in the environment and technology. These activities are known by the scientific activities that are based on the scientific method. Process skills develop the attitudes and values which include curiosity, honest, patient, open, critical, determined, tenacious, thorough, disciplined, caring for the environment, pay attention to safety, and to cooperate with others (Prasetyo, 2011: 3). There are three types of capabilities that can be developed in science learning, namely:

a. The ability to know what is observed,
b. The ability to predict what has not happened, and the ability to test the follow-up results of an experiment,
c. The development of scientific attitude.

Carin (quoted in Prasetyo, 2011: 3) defines science as "a systematic and structured knowledge on a regular basis, universal, and is a collection of data from observation and experiment". Referring to the definition, it can be concluded that the nature of science includes four main elements, namely: attitudes, processes, products, and applications. The four elements are expected to build the learners who have problem solving skills with the scientific method, and imitate the way scientists work in finding new science facts. Integrated learning in science can be packaged with a theme of a discourse discussing various aspects of the field of science studies that is easy to understand by the learners.

Science learning for students can be obtained if the student has a good scientific literacy ability. Scientific literacy is made up of two words, namely literacy and science. According to Paul de Hart Hurt (in Joseph Hilmi Adisendjaja, 2007: 6), scientific literacy is defined as understanding of science and its application to people's lives. PISA suggests that Scientific literacy is defined as the ability to use science to identify questions and draw conclusions based on the evidence in order to understand and make decisions regarding the nature. In the aspect of scientific literacy measurement is divided in three dimensions, namely the content of science, scientific process, and application context (Emiliannur, 2010:1)

2. Research Methodology

2.1 Research Design and Sample

The research method used in this study is Design Research which is the development research (Akker, Gravemeijer, McKenney, & Nieveen, 2006; Nieveen & Plomp, 2007). This development research aims to develop valid and practical teaching materials for mathematics and science lesson PISA-based for junior high school students and to determine potential effects on students in scientific activity. The study was conducted in three stages, namely the preliminary or preparation stage, prototyping stage, and assessment stage (Nieveen &

Plomp, 2007).

At the preparation stage, researchers determine and analyze the place and subject of study, the researchers also reviewed some of the literatures on research development related to this research. Researchers also analyzed the Curriculum 2013 for junior high school associated with the framework of PISA 2012, and made lattice teaching materials, interview guide, questionnaire sheets and walk through sheets. Researchers also contacted the teachers in the school and asked the procedure to do research in that school.

At the prototyping phase, the flow used is formative evaluation, including self evaluation, expert reviews and one-to-one and small group, and field tests. Figure 1 is a formative evaluation design flow.

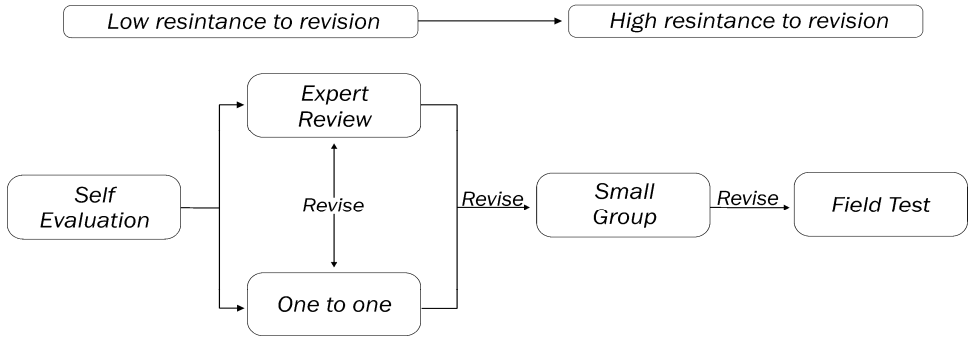

Figure 1. *Formative Evaluation Flow* (Tessmer, 1993; Zulkardi, 2006)

In the self evaluation stage researchers evaluated and examined the draft of prototype 1. The purpose of this stage is to look at the obvious errors in the preliminary stages. In the stage of the expert review, the prototype 1 was validated by experts to be observed, assessed and evaluated. Expert Validation used in this study is in terms of content, language, constructs.

The results of expert review are used to revise the product. Along with expert review, researchers conducted tests to students individually (one-to-one stage). Results of one-to-one are used to revise the first prototype. From the results of expert reviews and one-to-one produces the second prototype of teaching materials.

After conducting expert reviews and one-to-one to produce prototype 2, the researchers conducted a small-group test. The group used a total of 12 students with varied capabilities. The results of the small group became prototype 3. Small group of test is used to identify the weaknesses and strengths, effectiveness, efficiency, usability, and the interest of the prototype 2.

The prototype 3 was then used for field tests. The trial was conducted in Junior High School (SMP) 9 Palembang in class VIII and IX. Products produced at the field test must meet the quality criteria which consist of three criteria: validity, practicality and have a potential effect (effectiveness).

Based on the research method used in this study, the data collection techniques used in this study are: documentation like videos and photos, walk through conducted by the experts. Documentation is to record the teaching learning process. Experts provide feedback / comments or suggestions related to the content, language, and constructs. The result of walk-through was used for the revision of the first prototype combined with one-to-one to get the second prototype; interviews were conducted to students after the students finished the lesson.

At the stage of self-evaluation, researchers analyzed the data and the prototype of teaching materials adjusted with the standard of the Curriculum 2013 and PISA assessment. The criteria for the success of this research is to obtain the teaching materials for mathematics and science PISA-based. The teaching materials must be valid, practical and has a potential effect.

Validity of the instructional materials can be determined by looking at the results of the validation expert (expert review), the interview stage during one-to-one, and the results of the quantitative analysis of items on the stage of a small group. While practicality of teaching materials can be known from observations and interviews in small groups and interviews on the field test with reference to the practical sense. Potential effects of teaching materials can be seen from the results of the field test and interview after the implementation of learning at this stage of the test field.

3. Finding and Discussion

This research has developed two teaching materials in the form of Student Activity Sheet (LAS), namely mathematics instructional materials with topic similarity and science instructional materials with topic temperature and its amendment.

LAS begins with understanding the concepts and principles of similarity in mathematics and temperature / changes in science (IPA). At the end of LAS, there are questions to practice understanding

concepts.

In accordance with the research objectives, the teaching materials developed have potential effects on the scientific activities of students in the learning process. Highly visible activity is the activity of observation, reasoning, ask questions, and try to do the working group in Student Activity Sheet (LAS). The following photos show the activities of students in LAS work in groups.

Figure 2. Students were observing the Pragoda in the picture

From figure 2, it is seen that the students work in group solving problems in LAS. In these activities, based on the observation, the students made observations, experimets, asked among friends and teacher. In addition, the students conducted reasoning when s/he wrote a report on the student worksheet.

Figure 3. Students present their discussion

Figure 3 shows a agroup of students conducted group presentation. This activity shows that the students do communication.

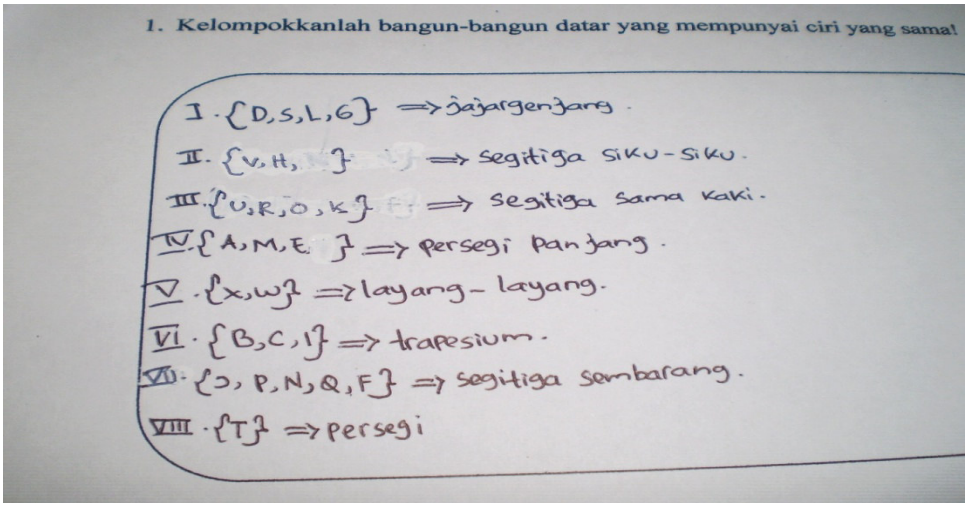

Figure 4. Students' work in mathematics worksheet

This research has developed two teaching materials in the form of Student Activity Sheet (LAS), namely mathematics instructional materials with topic similarity and science instructional materials with topic temperature and its amendment.

Figure 4 is an example of student work. The student's work shows the activities of the reasoning process. This study is limited to the product development process of teaching material similarity for mathematics, and temperature and its amendment for science. The product of this research is the teaching materials in the form of student activity sheet (LAS) which has been though the process of developing appropriate with research methods.

The development of teaching materials is adapted to the demands of the learning in the Curriculum in 2013based on scientific approach: in the learning process the students must do observation, reasoning, trying,

asking, and communicating. This approach is in accordance with the process of learning-oriented demands on the ability of working on the PISA problems.

In conclusion, based on experiment in student class IX, it is shown that the scientific process was appeared along the teaching process both in mathematics and in science. Students were very active and fun to learn. It shows students are actively involved in the learning process and develop or construct the concept of learning through observing, trying, asking, reasoning, and communicating.

4. Conclusions

Based on the results of research and discussion, it can be concluded that the teaching materials developed, topic of similarity for mathematics and temperature and its amendment for science, is in accordance with the characteristics of the curriculum in 2013 and PISA. Also, based on the research results, it is recommended to teachers can use this teaching learning materials, because it is in accordande with the characteristics of the Curriculum 2013 and PISA. Because this study is limited to the implementation, it is suggested for other researchers to conduct research on the student learning outcomes.

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