

# The Development of Student Worksheet Based on PISA to Improve Problem Solving Ability

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**Abstract** Problem solving ability is an ability that student have to achieve after learning mathematics. This ability can be trained through using appropriate problems on student worksheets. The purpose of this study was to produce effective worksheet based on PISA and be able to improve students' problem solving abilities. The type of research is the research development that use Dick & Carey models. The trials in this study were carried out in the X IA 3 and X IA 5 classes of Brigjend Katamso I Medan. From the results of trial I and trial II obtained: (1) Worksheet based on PISA that was developed effectively, in terms of: a) classical learning completeness of students that is 89,74%; b) learning objectives for each item is more than 75%; c) 91,79% of students give positive responses; and d) learning time is the same as regular learning time; and (2) there is an increase in the average problem solving ability of students in the first tryout of 0,3 with a low category and in the second trial of 0,4 in the medium category.

**Keywords:** *mathematical problem solving skills, PISA, student worksheets*

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## 1. Introduction

Problem solving ability is the ability of a person to be able to solve a problem or situation that is new to him by linking the knowledge he has had to the problems he faces. Problem solving ability is important because it requires humans to be able to combine skills and concepts with certain mathematical situations [1].

Problem solving skills can be trained through mathematics learning. One of the appropriate learning models to help students improve their problem solving skills is the PBL (*Problem Based Learning*) [2]. In the PBL students are faced with unstructured problems to solve. For that reason, learning needs to be provided in a structure to solve the problem given [3]. In line with this, Hmelo-Silver, Duncan & Chin [4] states that in problem-based learning students need to be given scaffolding. One of them is by providing student worksheets [5].

To help students improve their problem solving skills, the teacher should provide problems that are able to challenge students. One of them is by using problem based on PISA (Programme for International Student Assessment) in learning. PISA is an ongoing programme that, over the longer term, will lead to the development of a body of information for monitoring trends in the knowledge and skills of students in various countries as well as in different demographic subgroups of each country. Test items were a mixture of multiple-choice questions and questions requiring students to construct their own responses. The items were organised in groups

based on a passage setting out a real-life situation [6]. PISA develops mathematical questions that can measure students' ability to use their knowledge and understanding of mathematical concepts to solve problems faced in everyday life. The questions given in PISA are presented mostly in the context of real world situations so that the benefits of mathematics can be felt to solve the problems of daily life [7].

Based on these problems, student worksheet based on PISA need to be developed in learning to improve students' problem solving abilities. Therefore, this study aims to produce student worksheets based on PISA on PBL models to improve students' problem solving abilities effectively.

## 2. Research Methods This Research

This research is development research using the Dick & Carey model [8]. The place and time of the research is the Brigjend Katamso I Medan Senior High School in the 2018/2019 school year. The stages of the development of worksheets in this study can be seen in Figure 1 below.

To see the effectiveness of worksheets developed, instruments are needed. In this study the instruments used were problem solving test instruments and response questionnaires.

The effectiveness of learning devices developed in terms of: 1) completeness of student learning outcomes in a classical minimum of 85%; 2) achievement of learning objectives of at least 75%; 3) positive student response of at least 80%; and 4) achievement of learning time does not exceed the usual learning time [9].

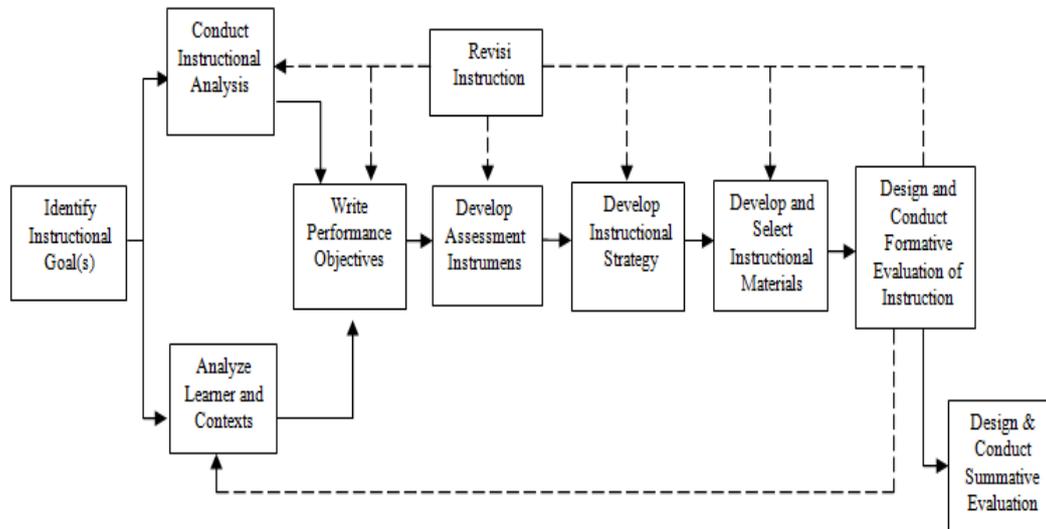


Figure 1. Dick & Carey Development Model

The improvement of students' problem solving skills was determined using the formula N-Gain from Hake [10] below.

$$N - gain = \frac{Posttest - Pretest}{Ideal Score - Pretest} \quad (1)$$

With the gain index criteria in the following table:

Table 1. Criteria for Gain Normalized

Gain Score	Interpretation
$g > 0.7$	Hight
$0.3 < g \leq 0.7$	Medium
$g \leq 0.3$	Low

### 3. Results Research

#### 3.1. Description of the Stage of Development of Learning Devices The

Stages of developing worksheet based on PISA with the Dick & Carey development model can be described as follows:

##### 3.1.1. Identify Instructional Goals

Based on the 2013 curriculum, mathematics learning aims to have students' skills or mathematical skills. Mathematical skills or skills are part of the life skills that students must possess, especially in developing reasoning, communication, and problem solving faced in the lives of everyday students.

##### 3.1.2. Conduct Instructional Analysis Instructional

Analysis aims to analyze the learning that has been done so far in Brigjend Katamso I senior high school. Based on observations it is known that the teacher has applied various learning models to improve students' problem solving abilities, one of which is the problem based learning model. But in practice, teachers have difficulty in giving scaffolding to help students solve problems given because there are too many students. To overcome this, in this study a worksheet was developed as a scaffolding in the PBL model.

##### 3.1.3. Analize Learner and Contexts

Based on the results of the test, it was found that students were not able to recognize real problems related to one mathematical concept. In addition, based on interviews with mathematics teachers in Brigjend Katamso I senior high school, it is known that so far the emphasis on learning objectives has only centered on mastering concepts and knowledge, and teachers rarely provide students with non-routine questions in learning. This causes students' ability to solve real problems related to mathematical concepts is low, even though students have mastered the concept well.

##### 3.1.4. Write Performance Obejctives

After analyzing the learning objectives contained in the curriculum and analyzing the students abilities, the researchers decided that the main objective in this study was to improve students' mathematical problem solving abilities. Mathematical problem solving abilities of students will be seen from the students' ability to solve real problems based on PISA related to the use of trigonometric concepts.

##### 3.1.5. Develop Assessment Instrument

The assessment instrument in this study is a problem-solving ability test that was developed based on the characteristics of the questions in PISA. The test given consisted of 4 questions based on PISA, with details of 2 pretest questions and 2 posttest questions.

##### 3.1.6. Develop Instructional Strategy

Based on the previous five stages, the next learning model will be identified which will be used to achieve the learning objectives. To improve students' problem solving skills, PBL model are used. This is because in the PBL model, students are encouraged to develop a possible solution to the main problem in the learning scenario.

The PBL model consists of 5 learning stages, namely student orientation to the problem, organizing students to study, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating problem solving processes.

**3.1.7. Develop and Select Instructional Materials**

At this stage a learning device will be developed. The learning tools to be developed in this study are student worksheets. The display of the developed worksheets is as follows.

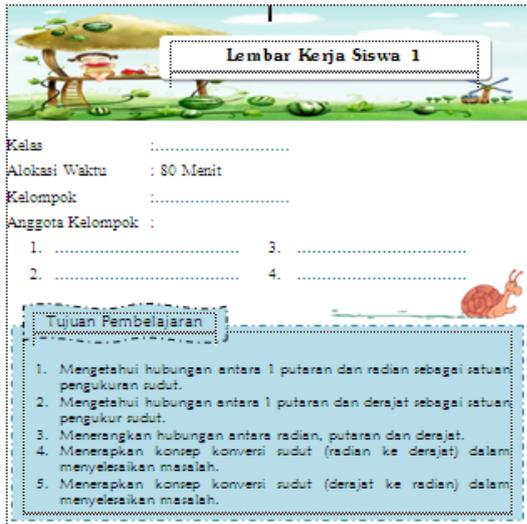


Figure 2. Worksheet Cover

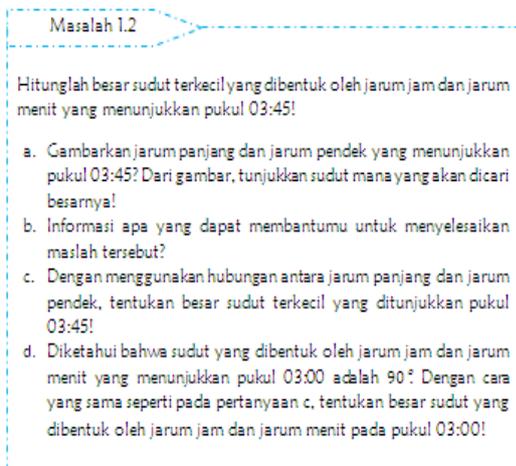


Figure 3. The Problem in Worksheet

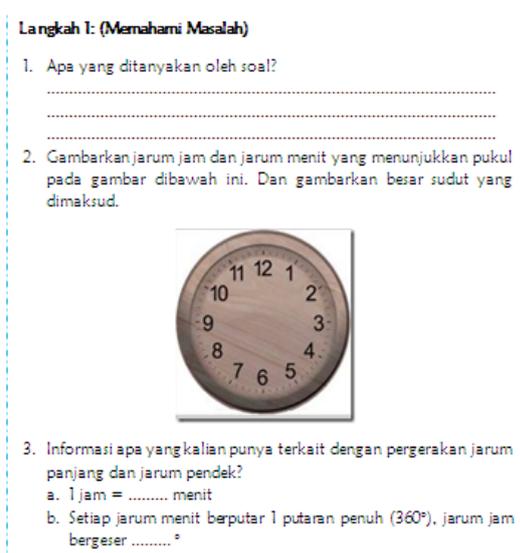


Figure 4. Completion Sheet in the Worksheet

**3.1.8. Develop and Conductive Evaluation of Instruction**

Formative evaluation in this study was conducted in 2 steps, namely: (1) one-on-one evaluation by experts, who followed by revision and trial of instruments, and (2) Trial with large groups. In the one-on-one evaluation by experts, it was found that the student worksheet developed were valid with an average validation value for worksheet of 4,07 and all the items in the pretest and posttest met valid criteria and were quite valid. Furthermore, based on the trial instrument, it was found that all items about problem solving ability were valid and had reliability values, namely  $r_{11} = 0,7748$  for the pretest question with a high category, and  $r_{11} = 0,8463$  for the posttest question with a very high category.

Student worksheet trials and test instruments were carried out at the research site, namely Brigjend Katamsno I Medan. The first trial was conducted in class X IA 3 which consisted of 37 students. Based on the results of the first trial data analysis, it is known that the learning device developed has not been effective. The effectiveness indicator that has not been achieved is the completeness of student learning outcomes. Student learning completeness is seen from the results of student problem solving ability tests. Student learning completeness in the posttest results is 72,97% and has not achieved the effectiveness criteria.

The achievement of learning objectives for questions number 1 is 71,81%, number 2 is 72,52%, number 3 is 73,27% and number 4 is 69,11%. So that it can be concluded that the achievement of the learning objectives did not achieved the effectiveness criteria. The indicator of effectiveness that has been fulfilled is the learning time does not exceed the usual learning time and students who respond positively more than 80%.

Increasing students' mathematical problem solving abilities in the first trial was seen through the calculation of *N-Gain*. Based on the calculation of the *N-Gain* from the results of the pretest and posttest, the average *gain* in the first trial was 0,3 in the low category.

**3.1.9. Revised Instruction**

Based on the results of analysis and trial I, it is necessary to revise the student worksheets and test instruments developed in the hope that student worksheets was developed have an impact on improving problem solving skills. Furthermore, field trials were carried out again in the formative evaluation phase, namely trial II. At this stage teaching materials are tested in different classes. This trial was conducted to see the quality of teaching materials developed in fulfilling indicators of effectiveness. The second trial was conducted in class X IA 5 which consisted of 39 students in the same school.

Based on the results of the analysis of the trial data II, it is known that the learning device developed has been effective. The effectiveness indicators that have been achieved, namely the results posttest of problem solving ability in the second trial amounted to 89.74%. This shows that classical student mastery learning has achieved the effectiveness criteria.

The learning objectives for question number 1 is 77,29%, number 2 is 76,64%, number 3 is 78,77% and number 4 is 75,09% that are more than 75% and have achieved the effectiveness criteria. Learning time used

during trial II is the same as ordinary learning and students respond positively to worksheet based on PISA in PBL models developed is 91,79%.

Increasing students' mathematical problem solving abilities in the second trial will be seen through N-Gain from the results of the pretest and posttest mathematical problem solving abilities in the trial II. Based on the calculation of N-Gain which was seen from the results of the pretest and posttest, the average gain in the second trial was 0,4 in the medium category.

### 3.1.10. Design and Conduct Summative Evaluation

In this study a summative evaluation phase was not carried out. This is because summative evaluation is not a part of the design or development process and this evaluation is not carried out by the learning designer.

## 4. Discussion

Based on the results of analysis of posttest I trials and II trials, it was found that student learning outcomes had achieved the classical completeness criteria. This is seen from the results of tests of students' mathematical problem solving abilities in which more than 80% of students get a value of  $\geq 68$  with a complete category. The use of worksheet in PBL learning is able to guide students to build their own knowledge. The use of worksheet based on PISA on PBL models provides clues that guide students towards correct completion. This is consistent with the research conducted by Barniol & Zafala [11] which states that the use of worksheets is able to facilitate students in learning and improve student learning outcomes. In addition, Askois & Jailani [12] with the title "*Effectiveness of Worksheet with Problem Solving Approach*" concluded that learning by using worksheets through problem solving approaches was able to facilitate the improvement of students' potential in learning.

In PBL models students are challenged to solve a problem that has never been encountered before. Therefore trained students can associate the knowledge they have with the new problems they face. This is in accordance with the results of research by Mawaddah & Yulianti [13] which states that the use of the PBL models is able to improve the ability to solve problems significantly. Another study conducted by Cahdriyana [14] showed that students' problem solving abilities taught using PBL models were better than students taught by conventional learning methods.

Although PBL is a learning model that directs students to learn actively and independently, but PBL is not a learning model without guidance at all. As revealed by Hmelo, Duncan & Chin [4] states that problem-based learning is not a learning approach with minimal guidance, but rather provides scaffolding and guidance to facilitate learning by students.

The availability of worksheets in learning with PBL models as scaffolding in this study helps students to solve problems that are given and are effective for classes with many students. This is in accordance with that expressed by Haruehansawasin & Kiattikomol [15] that the use of worksheets in PBL models with class characteristics with

a large number of students and low high-level thinking skills is very effective.

The use of PISA problems in a context close to the lives of students increases student motivation in solving problems given. This is in line with what was revealed by Charmila, Zulkardi, and Darmawijoyo [16] which states that learning to use context makes students find meaningful relationships between abstract ideas and practical applications in the real world context. In addition, the use of local contexts can help students understand mathematical phenomena from the perspective of their own life experiences. This makes mathematics far more interesting and useful for all students.

The criteria for mathematical questions in PISA are compiled to see a person's ability to formulate, apply, and interpret mathematics in various contexts that are very suitable for measuring problem solving abilities. Therefore, the use of questions based on PISA on problem-based learning is considered as something right to improve students' problem solving abilities. In line with the research conducted by Bidasari [17] which states that the development of questions based on PISA is appropriate for measuring students' problem solving abilities.

Positive responses given by students to the use of worksheet based on PISA in learning because students feel helped by the worksheet in learning. In addition, the problems displayed are problems with a context that is close to the student's life. So that students are interested and feel challenged in completing it. This is supported by previous research by Naimah [18] which states that students' responses to the use of worksheet in PBL are average good. Students assume that the use of worksheet in problem-based learning is new and interesting.

## 5. Conclusions

Based on the results of the analysis and discussion in this study, several conclusions were presented as follows:

- a) Student worksheet developed had met the effectiveness criteria in terms of: a) Classical student mastery learning had reached 89,74% in trial II and has met the criteria for achieving classical completeness; b) Achievement of learning objectives  $\geq 75\%$  seen from students' answers to each posttest item; c) 91,79% of students give positive responses to student worksheets used; and d) Learning time using student worksheet on PBL models is the same as regular learning time
- b) Students' mathematical problem solving abilities increase after learning using student worksheet based on PISA on PBL models seen from the results of the pretest-posttest trial I and trial II based on the calculation N-Gain the score was 0,4 with the medium category.

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