

Analysis and Design of PBL-Based Mathematics Students Worksheet to Improve Critical Thinking Skills

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Abstract Critical thinking needs to be integrated into the learning of mathematics in the 21st century and the industrial revolution 4.0. A learning model that supports the inculcation of critical thinking skills is problem-based. To implement the problem-based learning model, appropriate learning resources are needed. However, existing learning resources do not yet support the development of students' critical thinking skills. This study aims to analyze the needs of learning resources and then design student worksheets for problem-based learning models to improve critical thinking skills. This study used descriptive qualitative method. The subjects of the study were students of Muhammadiyah Middle School. The objects of research are essential skills of thinking, problem-based learning models, and student worksheets. Data collection instruments used interview guidelines, questionnaires, and validation sheets. The data obtained were analyzed using the Miles-Huberman model, which consisted of data reduction, data presentation, and concluding. This study produces an analysis of the needs of learning resources that are appropriate to the characteristics of students, curriculum, and subject matter. The study also provided a valid student worksheet design. This student worksheet design can be used by teachers who want to develop student worksheets that fit the problem-based learning model. This student worksheet design is also designed to improve students' critical thinking skills.

Keywords Critical Thinking, Students Worksheet, Problem-Based Learning

1. Introduction

Today, there are so many challenges to face in the 21st century or commonly referred to as the industrial revolution of 4.0 [1]. An individual needs to equip himself to be able to survive with the development of an

increasingly advanced era now. Critical thinking is required to solve complex problems in everyday life [2]. Critical thinking skill is an indispensable skill. This is due to the increasingly complex problems caused by rapid technological developments and social movements, so educators must teach these thinking skills to their students so that they can be equipped to become successful citizens in the future [3]. The progress of its education also measures the quality of a country. A nation is said to be advanced if it has a good quality education. This makes education compulsory for every individual. Individuals who have good quality critical thinking are needed to meet the challenges in life that continue to increase [4].

Critical thinking is a term associated with high-level reasoning that is usually characterized by good analysis and consideration [5]. Critical thinking skills are very important for students because they can influence the development of students' thinking [6]. Critical thinking skills are very important skills and function effectively both in life, work, and other aspects of life [7]. Most people can develop critical thinking skills in every aspect of life [7]. Most people can develop their critical thinking skills which can help them [8]. The Indonesian government made improvements to improve the quality of education. However, education in Indonesia remains stagnant and has not shown significant changes. This can be seen from the results of the PISA-OECD (Organization Program for Economic Cooperation and Development) in 2015, Indonesia ranked 63 out of a total of 72 countries participating in the event. Indonesia gets 386 out of 500, which becomes international standards [9]. Based on these results, it can be seen that education in Indonesia still needs to be improved.

Most students are not easy to solve mathematical problems [10]. One factor of the low value of Indonesian mathematics is the low ability to think critically. Critical thinking has six indicators, namely: interpretation, analysis, inference, evaluation, explanation, self-regulation [11]. Critical thinking is the realization of

high-level thinking. Critical thinking is seen as the ability to think in comparing two or more information [12]. Critical thinking can be the basis for teachers and students to participate and making decisions [13]. The ability to think critically is needed to work on HOTS problems.

Critical thinking is difficult and not easy to develop automatically. To develop, it requires practice and effort [14]. This is due to the absence of models and teaching materials that can be used as tools that can support teachers in realizing appropriate teaching. This resulted in the need for a learning model that not only could improve students' thinking skills, but also had to be able to attract motivation so they wanted to follow the teaching and learning process that was held. Problem-based learning can be a solution. The problem-Based Learning model is one of the learning models that can be used [15]. Problem-based learning is special learning because the focus of learning is the problem, not the subject [16]. Problem-based learning focuses on learning experiences in real life [17]. Problem-Based Learning is effective in achieving a general approach. The general approach is the first stage of critical thinking [18]. Problem-based learning is student-centered learning. The student can learn about the subject by trying to find solutions to open problems [18]. The pedagogic approach in Problem-Based Learning involves students building knowledge and collaborates with groups to solve questions [19]. Thomas said problem-based learning as a type of learning that involves problems and provides an opportunity to design investigative activities, using problem-solving to arrive at conclusions [20]. Problem-Based Learning models can be one way to improve critical thinking skills [21].

Problem-Based Learning authenticity involves students learning information using the same methods used to remember and used in future situations and assesses learning by showing understanding, not just acquisition. Problem-Based Learning models, students use a "trigger" to determine their own learning goals [22]. The thing that needs to be considered by educators when using Problem-Based Learning is the process of discussion and the use of various triggers for various problems [17]. The sequence in Problem-Based Learning is very important for student learning processes [23]. Problem-Based Learning

phases are important to influence student learning outcomes [24]. The student considers Problem-Based Learning as interesting learning and it motivates them to learn [25]. Problem-Based Learning was built to promote the various learning outcomes and objectives needed, including (1) helping students build a flexible knowledge base, (2) helping students become effective collaborators, (3) enhancing the ability to solve effective problems, (4) motivating students to learn intrinsically, and (5) developing independent learning skills [25]. Arends said the steps of the Problem-Based Learning model were (1) students' orientation towards problems, (2) Arranging students to study, (3) Assisting independent and group investigations, (4) Developing and presenting artifacts and exhibitions, (5) Analyzing and evaluating the problem-solving process, also Tan said the Problem-Based Learning Characteristics are as follows: 1) Asking questions or problems, making questions related to problems and allowing various solutions to solve problems. 2) Focus on interdisciplinary relationships, student reviews about problems from various subjects. 3) Authentic requests, students must analyze, build problems, develop hypotheses, and make predictions, collect, and analyze information, conduct experiments, and draw conclusions. 4) Produce products and publish, demanding students to produce certain products in the form of real work or demonstrations that represent solutions to the problems they find. 5) Collaboration, joint student work, most often form pairs in small groups [26]. Problem-Based Learning can be applied to learning in junior high school [27]. Therefore the objectives of this research are to develop Problem-Based Learning based student worksheet to improve student critical thinking ability.

2. Method

As in [28-32], this research and development use the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. ADDIE is a design guideline that is often used to create effective designs [33]. The ADDIE stages are presented in Figure 1.

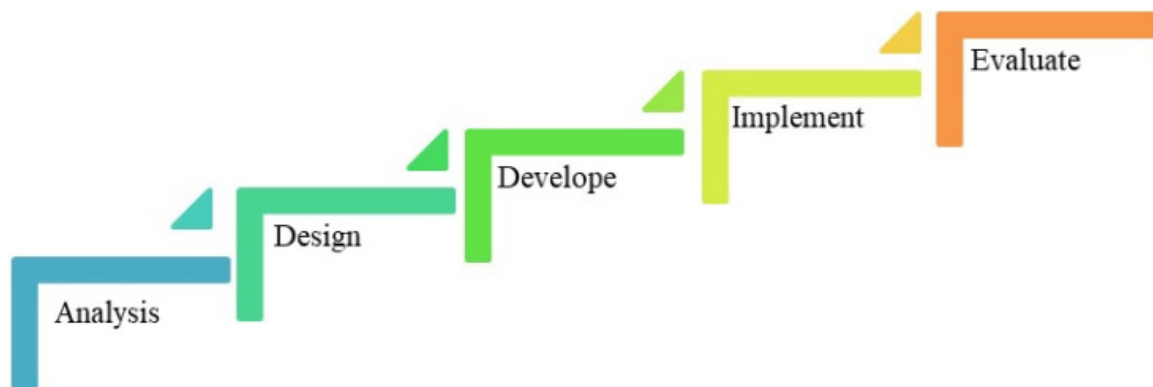


Figure 1. ADDIE [34]

This research is limited to the analysis and design stages. Interviews with teachers were conducted to find out data about student needs, the problem-based learning model, learning models, and teaching materials used by teachers and students in learning. The data obtained is used as a reference in the development of students worksheet based on the problem-based learning model.

Student worksheet which was developed in this research is used as a teaching language that can improve students' critical thinking skills. The subjects in this study were 8th-grade junior high school teachers in Muhammadiyah Bantul Yogyakarta 2019/2020 academic year. Data collection instruments include interviews.

3. Results and Discussion

3.1. Analysis

This stage is part of the background why so this teaching material is developed. At this stage, there are 2 stages, namely performance analysis and needs analysis. Based on observations and interviews there is some information. The results of this study received that information:

- 1) Teaching materials used are still conventional
- 2) The learning model used is still the same; the teacher has not used a learning model that can improve students' critical thinking skills.
- 3) In terms of curriculum, according to what is determined, that is, each material is displayed following KI and KD along with its indicators.
- 4) Unavailability of integrated student worksheet to help teachers improve students' critical thinking abilities.

- 5) Lack of students' interest to participate in the teaching and learning process so that teachers find it difficult to use certain models or methods because they must be adapted to the conditions of students when teaching.
- 6) Teachers need teaching materials such as student worksheet and immigration learning models that can improve students' critical thinking skills.

Based on the results of the study, the researcher concludes that students and teachers need teaching materials such as student worksheet that can attract students' interests and can be used by teachers so students can be motivated in following the teaching and learning process. Teachers and students need students worksheet based on Problem-based learning.

3.2. Design

Teaching material design is based on the results of needs analysis. The teaching material used is student worksheet based on Problem-based learning [35]. Student worksheet design consists of several components, namely cover, foreword, core competencies, basic competencies, instructions for using students worksheet, the design of the students worksheet can be seen in the following image.

3.2.1. Cover Design

A cover design includes the title of student worksheet and also includes Subjects, Circle Material and Problem-based learning models. Cover design can be seen in Figure 2.



Figure 2. Cover Design

3.2.2. Foreword

Preface containing the author's thanks to the parties involved can be seen in Figure 3.

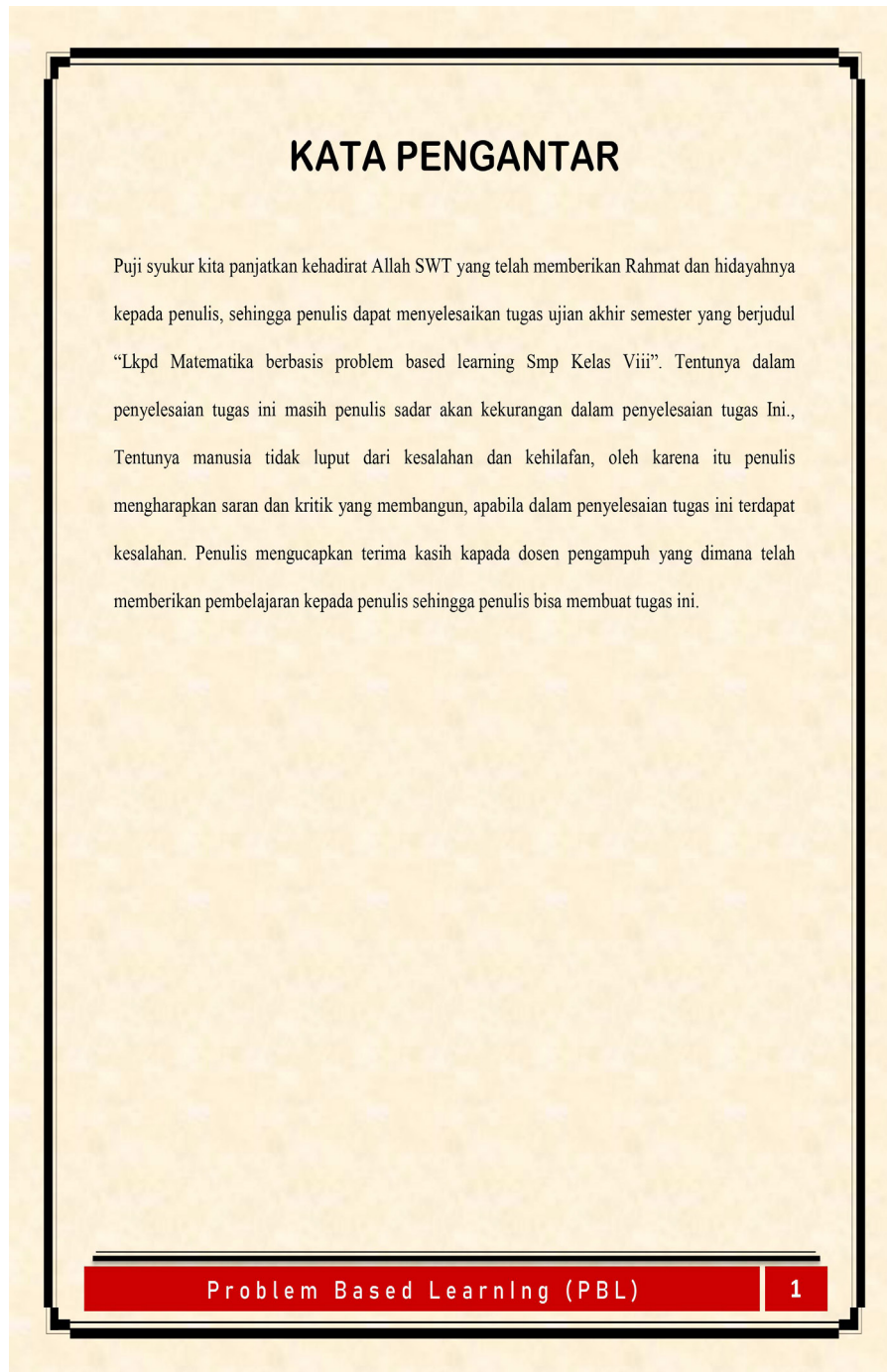


Figure 3. Foreword

3.2.3. Basic Competencies and Core Competencies

Description of Basic Competencies and Core Competencies and indicators of competency achievement. Core competencies and basic competencies can be seen in Figure 4.

KOMPETENSI DASAR

3.7 Menurunkan rumus untuk menentukan rumus keliling dan luas lingkaran yang dihubungkan dengan masalah kontekstual

4.7 Menyelesaikan masalah kontekstual yang berkaitan dengan keliling dan luas lingkaran

Indikator Pencapaian Kompetensi

3.7.1 Menurunkan rumus untuk menentukan keliling lingkaran mengguakan masalah kontekstual

3.7.2 Menurunkan rumus untuk menentukan luas lingkaran mengguakan masalah kontekstual

4.7.1 Menyelesaikan msalah kontekstual yang berkaitan dengan keliling lingkaran dan luas lingkaran

Problem Based Learning (PBL) | **5**

Figure 4. Basic Competencies and Core Competencies

3.2.4. Instructions for use

Instructions for using student worksheet. Shown design drawings which contain steps for using student worksheet, and icons that show indicators of Problem-based learning and problem-solving can be seen in figure 5.

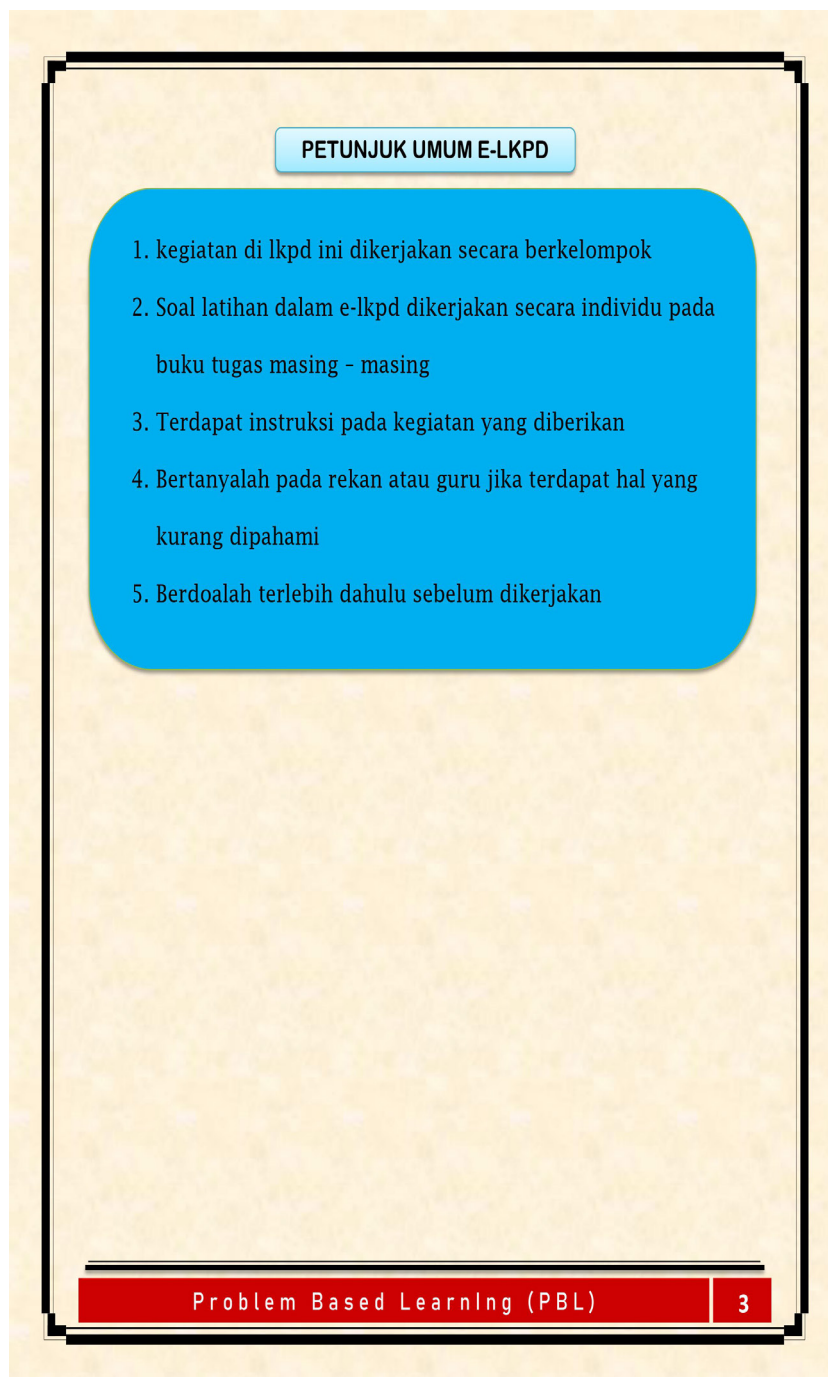


Figure 5. Instructions for use

Table 1. Suggestions and Comments

No	Suggestions and comments	Improvement
1	On the cover of the image used to be the dominant white color. Not stated in what semester will be used, as well as school institutions that use SMP / Mts	Already repaired
2	Writing the table of contents is not complete	Already repaired
3	writing the title does not use bold letters	Already repaired

To develop the students worksheet design, we need to

find out whether the students worksheet is to be developed, therefore the design of the students worksheet is validated by experts and provides comments and suggestions for improvement. Student worksheet has been assessed as feasible by two mathematics teachers. The validators of the student worksheet design were Lalu Indar Putra Anggara and also Zunita Hernawati which consisted of mathematics teachers. Suggestions and comments for improving student worksheet can be seen in Table 1.

Based on the table 1, it can be concluded that students worksheet is feasible to use. However, there have been

several revisions. Some input and suggestions from material and media experts that have been summarized can be seen in the displayed images. Some parts of student

worksheet that have been improved after receiving input and suggestions from the validator are as shown in Figure [6-8]:

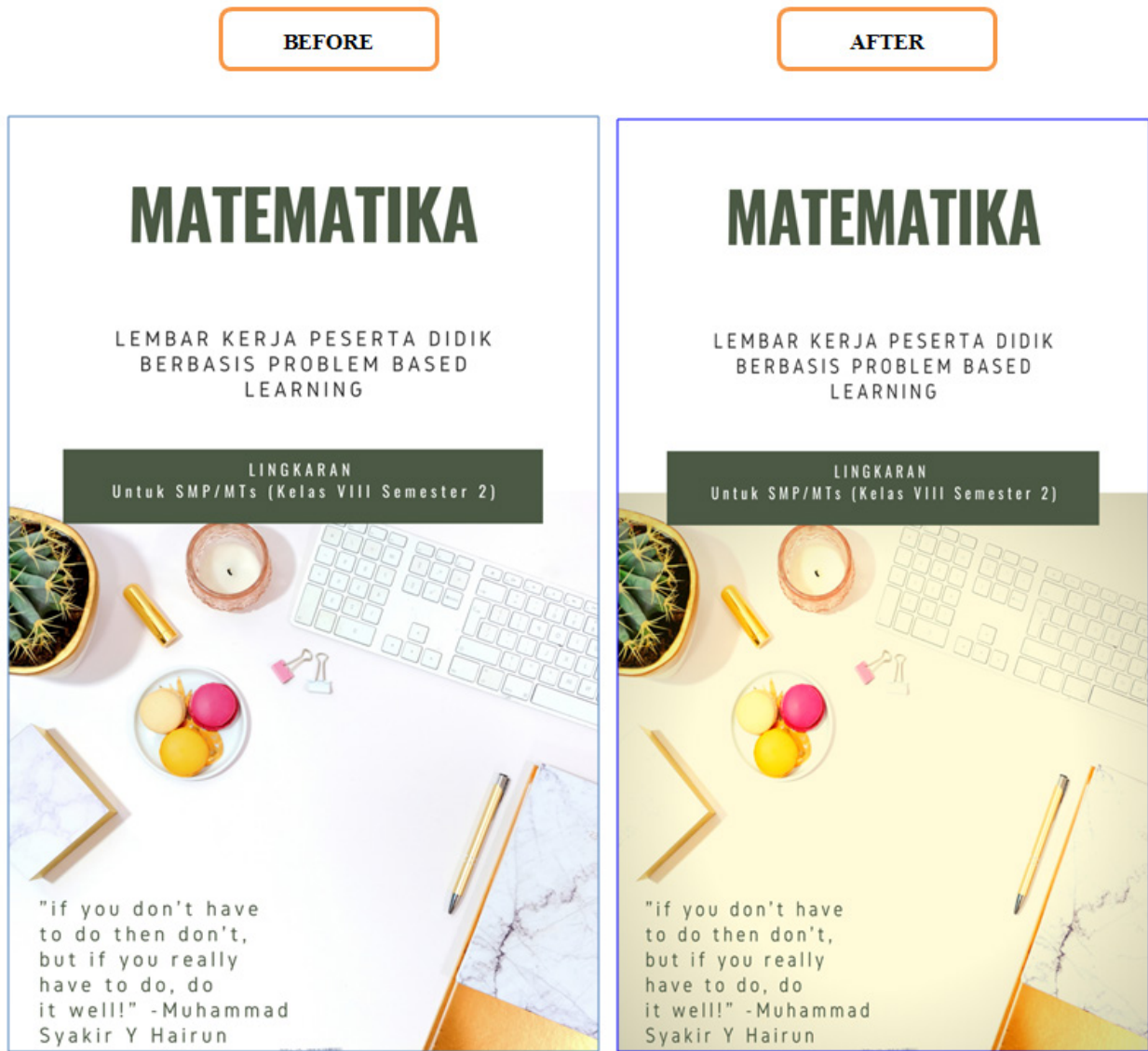


Figure 6. Cover Repair

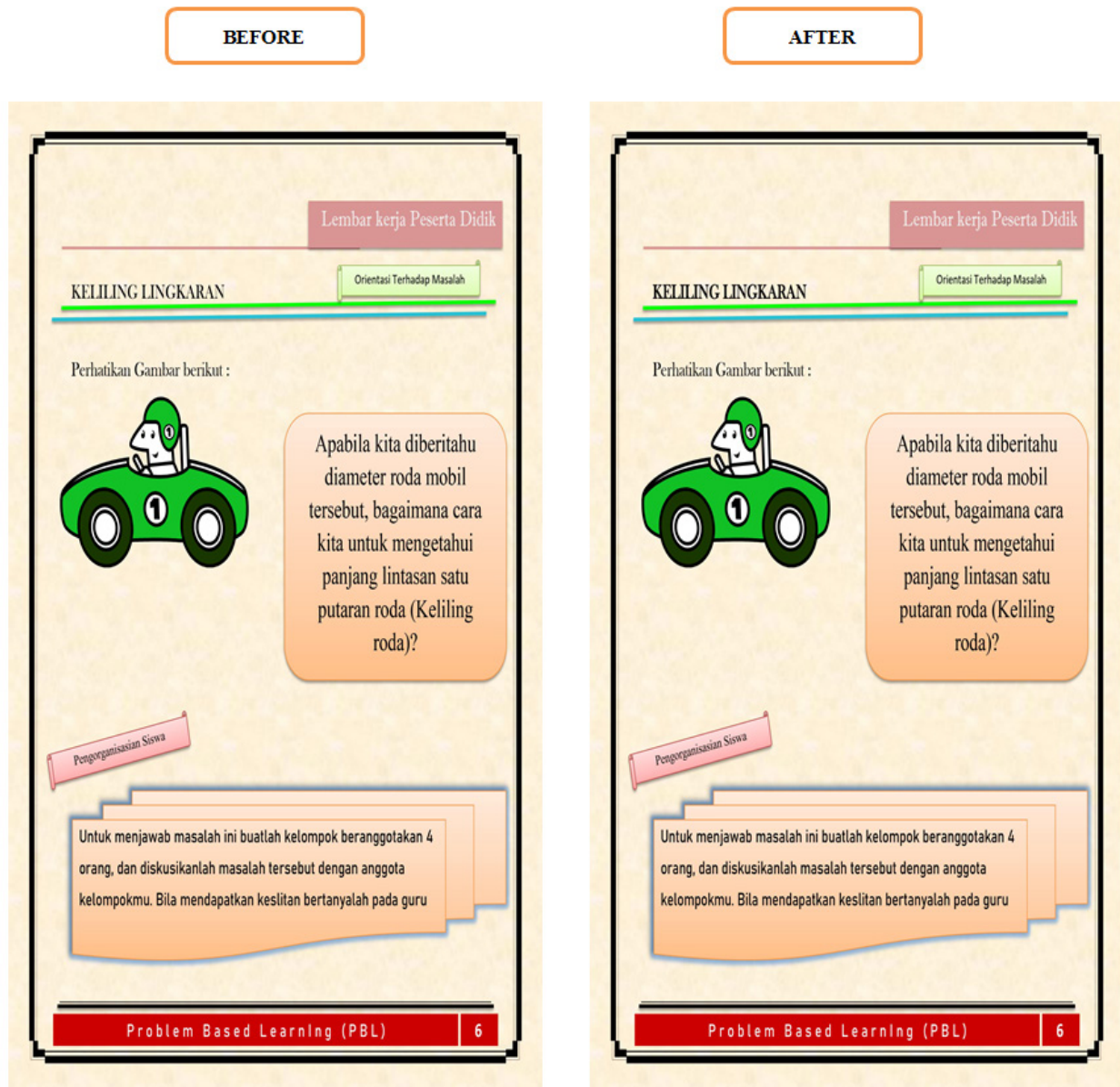


Figure 7. Table of Contents Repair



Figure 8. Revision of Title

Table 2. Design Assessment Results

No	Validator	Score	Category
1	Lalu Indar Anggara	77	Good
2	Zunita Rahmaniawati	80	Good
	Total Score	157	
	Average Score	78.5	Good

Enter along with suggestions from the validators that have been revised. The results of the questionnaire calculations given to the validator regarding the developed designs can be seen in Table 2.

Based on table 2, the average score obtained from the assessment of media experts is 78.5. So it can be concluded that the learning media are in a good category. Learner worksheets have been validated by the validator and declared eligible with revisions. At this stage,

products that have been developed and met the eligibility and effectiveness criteria are given to the school that will be used as a research site. This stage is carried out to ensure students achieve their goals in learning outcomes and can improve students' creative thinking abilities. At this stage, a process to provide value to the learning program has been developed. Students will be evaluated to the extent to which students can learn. The material so that can develop students' critical thinking. The development, implementation, and evaluation stages are further research. The linkages between problem-based learning models and student activities in the student worksheets are presented in figure 9. Figure 9 also shows the linkages between student worksheets that are designed to bring up indicators of students critical thinking skills through student activities.

Figure 9 explains the relationship between

Problem-Based Learning model syntax, student activities and indicators of critical thinking skills. The stages of the Problem-Based Learning model include: the first stage is the introduction of problems to students, the second stage is organizing students to assignments related to the problem, and the third stage is guiding students to gather information needed to solve existing problems. The first, second, and third stages are implemented in the form of student activities to gather information appropriate to the teacher's directions for solving existing problems. Through this activity, students can understand and interpret existing problems, so that the first indicator of critical thinking skills appears in students. The fourth stage is implemented in the form of student activities to develop and present the work. Through this activity,

students solve existing problems and present the results of problem solving that has been done, so that the second and third indicators of critical thinking skills emerge in students. This can be seen when students are able to analyze and infer to be able to solve existing problems, which will then be developed and presented the results of the problem solving that has been done. The fifth stage is implemented in the form of student activities to analyze and evaluate the problem solving process that has been done. Through this activity, students provide reflection and evaluate the material they have learned, so that the fourth, fifth, and sixth indicators of critical thinking skills emerge in students. This can be seen when students evaluate, explain, and review lessons.

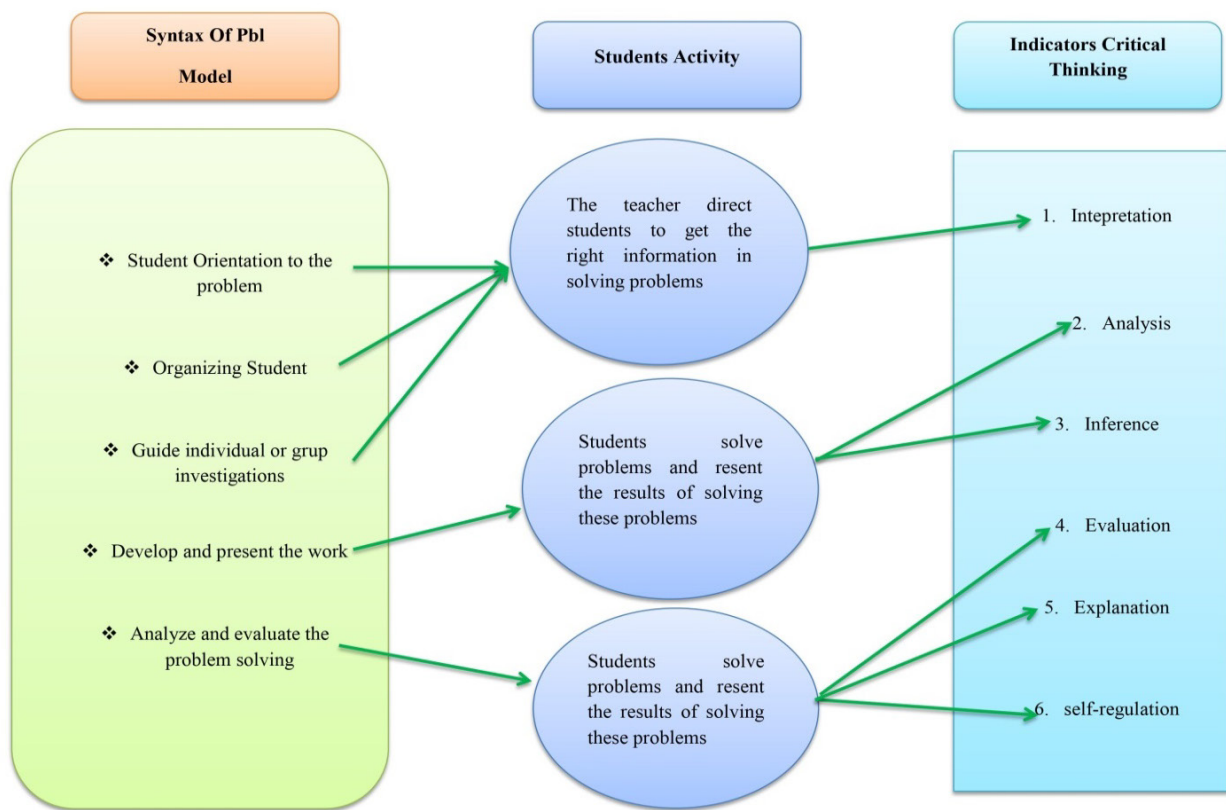


Figure 9. The linked between problem-based learning models and students activity

4. Conclusions

This study produces an analysis of the needs of learning resources that are appropriate to the characteristics of students, curriculum, and material. Based on needs analysis, this study also produced a student worksheet design that facilitated the development of critical thinking skills. The design developed is integrated with the problem based learning model. Research can be continued at the development, implementation and evaluation stages.

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