Development Of PJBL-Based LKPD With STEM Approach Design To Improve Critical Thinking Skills

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Abstract: Critical thinking is one of the important skills in the 2013 curriculum and the industrial revolution 4.0. Students who have lower critical thinking skills will have difficulty in solving the type of HOTS. Teaching materials that do not contain critical thinking skills have an impact on the ineffectiveness of the achievement of learning objectives. This research aims to design instructional materials by the learning model that will be used and can enhance students’ critical thinking skills. The method used is ADDIE models. Subjects were students of class X SMK Muhammadiyah 2 Yogyakarta. The instruments used were interviews, observation, and tests. Interview guidelines used to obtain data on the characteristics of the students. The observation guide used to obtain data on teaching materials, curriculum, and materials used. The test is used to obtain data on students’ critical thinking skills. The data analysis consisted of reduction, presentation, and conclusion. Phase analysis was used to determine the needs of the development of teaching materials. The design phase is used to perform LKPD development of teaching materials as needed. This research is expected to be a reference for developing PJBL-based LKPD with STEM approach to further enhance critical thinking skills.

Index of Terms: ADDIE, critical thinking, design, LKPD, Mathematics, PJBL, STEM

1. INTRODUCTION

EDUCATION is an important requirement for the Indonesian people to meet the demands of critical and creative human resources. Education also creates greater employment opportunities so that the Indonesian people are encouraged to get a decent education and current. Technology is growing rapidly creating new challenges in the sector in the country and abroad in the era of the industrial revolution. Labor resources and education to stimulate the emergence of the industry to the state stage 4.0. In the revolution of the 21st century, digital will be growing in the service, networking, and knowledge [1]. Summarized in the Partnership for 21st Century Skills (P21), the skills that will be needed in the next five years is Critical Thinking 78%, IT 77%, Health and Wellness 76%, Collaboration 74%, Creativity and Innovation 74%, Personal Financial Responsibility 72%. An organization identifies that the priorities needed for employee development, talent management, and planning Critical Thinking success was 73.3%, 79.2% Communication Skills, Collaboration/team building 72.3%, 66.6% Creativity and Innovation [2].

Critical thinking is a skill that is a must be possessed by humans. Therefore, critical thinking must start with education. In the world of education, critical thinking can be applied to solve the HOTS. Based on observations, some students were able to master the material can not solve applied problems. These events indicate a lack of critical thinking skills. Critical thinking is the ability to imagine that requires skill and sensitivity, a desire to try to find the right answer, clarify, concluded based on the correct view, and present [3]. Critical thinking is also an effective way to improve students’ understanding of mathematical concepts to interpret, analyze, evaluate, and presents the answer to a problem [4]. A researcher has observed that Swedish students do not have critical thinking skills. Teachers of the Swedish students have sought to improve students’ critical thinking skills, but it did not work [5]. Though critical thinking is essential to teach students when learning in the classroom to improve their knowledge and hone the students’ learning ability [6]. Besides, critical thinking is an important skill in life to choose learning strategies in the classroom [7]. The conclusion is that the student should have the ability to think critically. Several steps indicators can be used to determine the ability of critical thinking, among others: (1) interpretation, analysis, evaluation, inference, explanation, self-regulation [8], (2) focus, reason, inference, situation, clarity, overview [3], (3) inference, recognition of assumption, deduction, interpretation, evaluation of arguments [9]. In this research, four steps suitable indicator applied to the subject of research in critical thinking is interpretation, analysis, evaluation, inference.

Critical thinking can be improved by applying the learning model Project Based Learning (PJBL) with STEM approach. PJBL is a learning model that has a strategy to improve students’ critical thinking abilities through teamwork [10]. This learning model centered on students to apply the concepts when solving a problem. Learning is done by creating small groups to come up with ideas and opinions of students to complete a project [11]. Teachers are more passive when implementing this model. Thus, students will gain a lot of experience of learning when students become a maker of products [12]. Step work can be done by the students are more active students gather information from relevant sources. Teachers and the surrounding environment can be a source of learning. After that, students communicate findings. Thus, students are trained to understand a real problem that occurs in the surrounding environment. Besides, students are directed to hone social skills and communication skills in group discussions to learn. It is important from the application of the PJBL is to bridge the fields of different studies into the components in a project to address a problem [13]. The fields of study that are different can collaborate to become STEM. So that the learning model Project-Based Learning approach can be supplemented with STEM (Science, Technology, Engineering, and Mathematics). STEM has a good contribution to improve the skills of the 21st century STEM integrated on changes in technology and science that are very fast [14]. STEM implements 4C on 21st century skills. The prototype implementation is directed students to work together in creating critical and creative solutions to solve real-world problems and communicate them to others [15]. STEM approach supports the 4.0-based technology of the Industrial
Revolution. STEM also innovating economic growth with advances in science, technology, engineering, and mathematics. It can foster an innovative mindset and interdisciplinary relevant to life. So that students can excel in the economy based on the knowledge that he had [16]. PJBL with STEM approach directs students to master concepts before solving the problem [17]. In a study conducted for teachers in the southern US, researchers found that teachers did not understand how to implement PJBL STEM in the classroom [18]. While on MarineTech has successfully implemented project-based learning activities PJBL with STEM approach. Based on the project found that the PJBL STEM was very easy for students to solve the problem by designing the step pattern, construct and operate a real problem solving [19]. It proves that the PJBL with STEM approach recommended helping students to solve problems. Syntax learning model PJBL with STEM approach is a reflection, research, discovery, application, communication [20]. The PJBL with STEM approach needs materials to guide students to solve the problem. LKPD is one type of teaching material that will be used because there is no PJBL with STEM approach based on LKPD. Based on the interviews with the students produce answers that LKPD is used for this difficult to understand in terms of language, concepts, and questions. Based on interviews with teachers of mathematics produce answers that existing LKPD no change from the previous LKPD and not developed according to curriculum development. The curriculum used today is the 2013 curriculum. 2013 curriculum requires the skill to solve a problem. LKPD are sheets contain student work to be done to facilitate communication between teachers and students in scientific discussion [21]. On the other hand, researchers conducted an assessment of the LKPD that had been used in schools. Values obtained by 65.71%. As for some of the deficiencies found are (1) LKPD not encourage students to ask questions, (2) Display LKPD not following the material, (3) LKPD not to display illustrations or images that clarify the matter, (4) Pictures and illustrations are less attractive, (5) LKPD does not make it easy for students to understand the content of the material, (6) there is a matter that can not be resolved, (7) LKPD has not a learning model. Based on the above exposure, this research aims to develop teaching materials in the form of PJBL-based LKPD with STEM approach to improve students' critical thinking skills.

2 RESEARCH METHODS
As in [22],[23], and [24], this is a research development using the ADDIE model. Steps in the ADDIE model are analysis, design, development, implementation, evaluation. ADDIE model can be seen in Figure 1.

![ADDIE Model](image)

Figure 1. ADDIE Model

The purpose of this research was to develop designs based LKPD PJBL with STEM approach. In the phase of analysis, the authors found a description of the student needs based LKPD PJBL with STEM approach to improve critical thinking skills. After that, the researchers conducted observations and interviews with students and teachers to know the characteristics of the students, the materials that are considered difficult, and the materials needed. After that, researchers are looking for ways to implement PJBL with STEM approach in the study of mathematics by material trigonometric ratios in the right-angled triangle corresponding to the characteristics of the students. In the design phase, researchers set learning goals, create a description of learning activities to be carried out and choose the media that will be used to support the learning process. After that, Researchers create LKPD designs that follow the characteristics of the students based on learning objectives and activities to do in learning. Based on learning activities contained in LKPD design, researchers determined a tentative picture of evaluation tools to assess the learning process. The data collection technique used observation, interview, and assessment instruments. Observations and interviews were conducted to determine the characteristics and needs of students. Feasibility assessment instruments used to assess the feasibility of the design has been created to be used as the basis for making LKPD stages of development.

3 RESULTS AND DISCUSSION

3.1 analysis
Phase analysis is part of the background of why the teaching materials developed. At this stage contains the analysis of the learning needs of students in a PJBL with STEM approach to improving the ability to think critically, analyze the characteristics of students, the material that is considered difficult, supporting facilities, and solutions to implement PJBL with STEM approach to the media that will be created. At this stage there are some conclusions: (1) students need-based teaching materials PJBL approach STEM to improve critical thinking as an alternative learning, (2) students are accustomed to using the Internet to search for learning materials, (3) school there are ample facilities and complete that classrooms and an adequate wifi, (4) students enjoy learning outside the classroom, (5) teaching material that can contain PJBL learning models with STEM approach is LKPD.

3.2 design
At the design stage, materials are developed based on the results of the analysis. The teaching materials used are LKPD. LKPD contains covers, the identity of the author, preface, table of contents, usage instructions LKPD, KI and KD, learning objectives, materials, concept maps, worksheets, and student activities. LKPD cover design can be seen in Figure 2.

![Cover Design](image)

Figure 2. Cover Design

4 CONCLUSION
Figure 2 shows the title LKPD which include the purpose, learning model, grade and semester. The next sheet lists the
identity of the author, the introduction of gratitude to those who support the creation of LKPD, and the table of contents contains a sequence of events. This sheet can be seen in Figure 3.

The next page contains instructions describing the use of syntax LKPD PJBL with STEM approach, indicators of critical thinking, and terms that exist in LKPD. This sheet can be seen in Figure 4.

The next sheet lists KI, KD, learning objectives, and the material to be studied for the student activities to take place. This sheet can be seen in Figure 5.

The next sheet lists a concept map. Concept maps contain a learning path to achieve the learning objectives. This sheet can be seen in Figure 6.

The following pages contain student activity sheets following the syntax of PJBL with STEM approach. This sheet contains directives or questions to hone students’ critical thinking according to the indicators. Multiple sheets containing it can be seen in Figure 7.

Next, there are pieces of student work. There are two types of student worksheets that sheet of exercises and evaluation sheets. Sheets exercises contain questions to gauge understanding of the concept of trigonometric ratios in right triangles. Evaluation sheet contains matter which is the purpose of learning that students can apply the concepts to solve everyday problems. These sheets can be seen in Figure 8.

The design is made has been validated by 2 validators. There are several sections to be repaired on LKPD designs that have been created. Things that must be repaired can be seen in Table 1.
Table 1. Comments validator

Based on these comments, the design was changed as per the comments of 2 validators. Design changes can be seen in Figure 9 and Figure 10.

Before

MotivasiKu
“Belajar adalah cara untuk menang dalam kompetisi kesuksesan”.

After

MotivasiKu
DELAJAR adalah cara untuk MENANG dalam kompetisi KESUKESEAN

Figure 9. Improved motivation box

Table 2. Criteria for eligibility of products

<table>
<thead>
<tr>
<th>The average scores</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X &gt; 4.2$</td>
<td>Very good</td>
</tr>
<tr>
<td>$3.4 &lt; X \leq 4.2$</td>
<td>Good</td>
</tr>
<tr>
<td>$2.6 &lt; X \leq 3.4$</td>
<td>Enough</td>
</tr>
<tr>
<td>$1.8 &lt; X \leq 2.6$</td>
<td>Less</td>
</tr>
<tr>
<td>$X \leq 1.8$</td>
<td>Very Less</td>
</tr>
</tbody>
</table>

Table 3. Criteria for the design LKPD

Based on Table 3 it can be concluded that the design LKPD developed very good to use.

4 CONCLUSION

Based on the results above, conclusions can be drawn. First, the elevation angle material is material that is considered difficult. Second, the critical thinking ability of students is low. Third, teachers need teaching materials that contain a learning model in which there are student activities outside the classroom. Fourth, students need instructional materials interesting. Fifth, the teaching materials that have been used yet included the learning model. Sixth, the learning model PJBL with STEM approach can improve critical thinking skills. To improve the critical thinking skills necessary teaching materials that fit the character of students and the learning model used. LKPD design produced relatively decent with an average score of 4.65.

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REFERENCES


