Student's critical thinking skills in authentic problem based learning

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Abstract. This study aims to determine students' critical thinking skills in authentic problem based learning, especially on geometric optics. The study was conducted at the vocational school. The study used a quantitative descriptive method with the open question to measure critical thinking skills. The indicators of critical thinking skills measured in this study are: formulating problems, providing simple answers, applying formulas and procedures, analyzing information, making conclusions, and synthesizing ideas. The results showed that there was a positive change in students' critical thinking skills with the average value of N-Gain test is 0.59 and effect size test is 3.73. The critical thinking skills of students need to be trained more intensively using authentic problems in daily life.

1. Introduction
Physics is one of the subjects in school. Physics materials in vocational schools are basic knowledge of vocational support to develop science and technology [1,2] so that students in vocational school need to be equipped with critical thinking skills. The critical thinking skills are demonstrated by giving systematic, logical, organized reasoning and decisions [3,4] and reflective in decision making [5]. Students need to have the critical thinking skills to be able to apply the knowledge to solve the existing problems in daily life [6] and the world of work [7].

Package of Production Engineering and Television Program Broadcasting is one of the skill packages at Public Vocational Secondary Schools 1 Bondowoso. Graduated from this program are competent in the utilization of audiovisual equipment. The result of observation and interview with teacher indicates the ability of students to solve the problem is still low compared to other programs so that students' critical thinking skills need to be stimulated in order to develop.

The ability to think critically is one of the educational outcomes [8] and needs to be trained so that students have a brilliant idea [9] and are ready to work in society [10]. Critical thinking skills of students can be trained through five ways, namely; simple observation; work in groups; the delivery of something observed; testing through experimentation and acceptance of all explanations as "something right" for the moment [11]. The process of training that skills can be done with authentic problem-based learning.

Authentic problem-based learning is a student-centered learning model, providing motivation and challenges to solve problems independently, involving problem-solving skills, thinking skills, self-directed learning, and teamwork [7]. Authentic problem-based learning is a breakthrough learning that combined authentic learning and problem-based learning. Authentic learning related to real life,
complex issues and solutions, role-playing exercises, problem-based activities, and case studies [12]. The use of authentic learning can be done at all levels. Authentic learning can develop students' thinking skills. Students solve problems and think more comprehensively in problem-solving [13]. One of the learning strategies that support authentic learning is problem-based learning (PBL).

Authentic problem-based learning is a constructivist learning model designed to solve a new problem in the world of work [7]. Authentic problem-based learning has several principles, which are student-centered, students learn actively in groups, using authentic tasks, effective communication between individuals and groups, investigation through experiments and keeping up-to-date in knowledge and skills [7]. Authentic problem-based learning introduces authentic problems to develop students' critical thinking skills so that students are responsive in solving real problems in accordance with the world of work.

Problems with authentic problem based learning to phenomena that occur in the workplace. The problem may be something to be accomplished, fixed, or given action. Mysterious events to look for the solution, the case in a community, or something to look for the solution to make a product. Authentic problem based learning in this study includes seven stages, namely: 1) orientation, is the stage of preliminary, delivery of learning objectives, group division and explanation of student responsibilities in learning activities; 2) encountering the problem is the stage of problem formulation and the writing of a temporary answer or hypothesis of the learning problem; 3) tackling the learning issues is the stage of investigation to obtain solutions from learning problems; 4) Reiterating and reassessing the problem is the stages of analyzing learning problems by comparing answers while students with the results of the investigation; 5) summarizing and knowledge abstraction is the stage of making conclusions and flowcharts as a picture of students in solving problems; 6) conducting self and peer evaluation is the stages of students evaluating themselves and group friends as feedback group activities; and 7) conducting tutor evaluation is the evaluation stage of the learning process to improve the quality of learning [7].

This study is a quantitative descriptive research. The purpose of the study was to identify critical thinking skills at Public Vocational Secondary Schools 1, Bondowoso, East Java, Indonesia. This school is one of the schools of expertise in the field of production engineering and television broadcasting program. Graduate school is expected to have competence in the use of audiovisual equipment that can be used in the workplace. The study is done with authentic problem based learning on optical geometry material. Students are given a direct phenomenon and gain a concrete experience to solve the optical problem.

2. Method

2.1. Participant
The subject of study consists of 25 students and consist of 17 male students and 8 female students. The data collected were an implementation of learning and critical thinking skills of students. Data on learning implementation is obtained by observation every authentic problem-based learning meeting by using observation sheets. Students' and teachers' activities are recorded by using observation sheets and video cameras. Data of students' critical thinking skills are obtained from pretest and posttest.

2.2. Instrument
The study used teaching materials and open-ended questions. These instruments include syllabus and lesson plans on geometric optics, observation sheets, and open-ended questions for critical thinking skills. The observation sheets were used to observe the implementation of the learning model with checklists that already have their respective assessment rubrics and the success indicator for learning model implementation is 85%. Indicators of critical thinking skills that are measured in this study were adapted from [14] and are presented in Table 1.
Table 1. Indicators of Students’ Critical Thinking Skills

| Critical Thinking Skills                  | Indicators                                                   |
|------------------------------------------|--------------------------------------------------------------|
| Giving a simple explanation              | Formulate problems and answer simple questions               |
| Basic decision making                    | Apply a formula or procedure                                 |
| Conclusion                               | Analyze an information based on data, ideas or concepts     |
| Giving a further explanation             | Make a conclusion from generalizing the data                 |

2.3. Data Analysis

Data analysis was conducted by using N-gain score test and effect size test. The normalized gain score is used to determine the improvement of students' critical thinking skills after being given authentic problem-based learning. Effect size test is used to determine the effect of authentic problem based learning on students’ thinking skills.

3. Result and Discussion

Implementation of authentic problem based learning in 11 grade at SMKN 1 Bondowoso on geometric optics consist of mirror, lens, and camera. The results of the implementation of learning observations are presented in Table 2.

Table 2. Implementation of authentic problem based learning on Geometric Optics

| No | Aspects of learning         | Mirror (%) | Lens (%) | Camera (%) |
|----|----------------------------|------------|----------|------------|
| 1  | Orientation                | 83.30      | 91.70    | 100.00     |
| 2  | Encountering The Problem   | 75.00      | 100.00   | 100.00     |
| 3  | Tackling The Learning Issues | 75.00   | 75.00    | 87.50      |
| 4  | Reiterating and Reassessing The Problem | 87.50 | 87.50    | 87.50      |
| 5  | Summarizing and Knowledge Abstraction | 87.50 | 100.00   | 93.80      |
| 6  | Conducting Self and Peer Evaluation | 87.50 | 87.50    | 100.00     |
| 7  | Conducting Tutor Evaluation | 87.50      | 87.50    | 100.00     |
|    | Average                    | 83.33      | 89.89    | 95.54      |

Critical thinking skills of students in each of the indicators presented in Table 3 and the graph of the increase is presented in Figure 1.

Table 3. Normalized-Gain Score and Effect Size Test on Critical Thinking Skills

| No | Indicators                                               | N-Gain Score | Effect Size |
|----|----------------------------------------------------------|--------------|-------------|
|    |                                                          | Score        | Category    | Score | Category |
| 1  | Formulate problems and answer simple questions           | 0.60         | 3.87        |       |          |
| 2  | Apply a formula or procedure                            | 0.59         | 3.09        |       |          |
| 3  | Analyze information based on data, ideas or concepts    | 0.60         | Medium      | 3.87  | very large |
| 4  | Make a conclusion from generalizing the data             | 0.52         | 3.54        |       |          |
| 5  | Synthesize ideas into a unified whole                    | 0.62         | 3.48        |       |          |
|    | Average                                                  | 0.59         | Medium      | 3.57  | very large |
Implementation of learning with authentic problem-based learning at Public Vocational Secondary Schools 1 Bondowoso has been done well. This is indicated by the percentage of each meeting on the sub-subject, covering mirror 83.33%, lens 89.89% and camera 95.54%. This percentage is greater than the indicator of successful learning model implementation by 85%. The successful implementation of this learning is due to the conditioning of the authentic problem-based learning stages so that students are familiar with the stages of the authentic problem-based learning and the feedback in the conditioning stages and each meeting. Feedback is one of the stages of the authentic problem-based learning that aims to evaluate the learning process undertaken by students and teachers so that there is an improvement in every meeting that will be done. Feedback is given by the teacher based on the answers to students' questions independently containing self-evaluation, peer group performance evaluation in groups and evaluation of the learning process as a whole.

Physics learning with authentic problem-based learning shows a positive change in students' critical thinking skills. This is indicated by the results of the study on the N-Gain Score test with an average value of 0.59 which means that students' critical thinking skills have improved in the medium category. The result of the effect size (d) the value of pretest and posttest students at 3.57 indicate that there is an influence on authentic problem-based learning against students' critical thinking skills. This is because at every stage in authentic problem-based learning accommodates the development of students' thinking skills.

The result of the study shows that there is the authentic problem-based learning influence to critical thinking skills. At the stage of orientation, students learn in discussion groups. Group discussion is one way to give students the opportunity to think so that their thinking skills can develop [11]. Students are actively stimulated to provide arguments in group discussions. In the encountering the problem stage, students formulate the problem and arrange the hypothesis based on the given phenomenon. This stage can construct their critical thinking skills for the better [15, 16].

The ability to think can be developed by familiarizing students with the simple questions of phenomena that require explanation [17]. In the tackling stage of learning issues, engaging students actively in the investigation will stimulate students to think critically because students build their knowledge based on direct experience so that it is more meaningful [11]. At the experiment, students actively conduct appropriate laboratory procedures and observe the facts of the observed phenomenon. In laboratory activities, students perform minds-on activities and hands-on activities simultaneously. Laboratory activities can develop their science process skills [18] and their critical thinking skills [11]. Concrete learning experiences provide opportunities for students to develop their thinking skills [19].

In the reiterating and reassessing the problem, students explore the phenomenon to find solutions to problems by comparing answers while students with the results of the investigation. In this stage, students can develop critical, analytical, and logical thinking skills to test the hypothesis [20]. Students perform self-evaluation their inquiry and understanding so students can build new knowledge.
In this stage, students analyzed the information obtained through experimental results or literature review and synthesize it into a unified whole. In the stage of summarizing and knowledge abstraction, students formulate conclusions so that students develop a systematic thinking process of students in generalizing the results of experiments [15]. In this case, students receive facts and information that have been analyzed as scientific knowledge.

This research shows that authentic problem-based learning that is given to students gives the opportunity to develop students’ thinking ability. This is consistent with previous research that critical thinking is also influenced by the learning that students experience [21]. Lessons that practice the ability to think will affect the development of thinking ability. Other research findings indicate that systematic learning planning and based on a combination of learning principles will develop students' thinking skills [22].

4. Conclusions
The results show that authentic problem-based learning implementation on physics learning at Public Vocational Secondary Schools 1 Bondowoso can improve students' critical thinking skills. Learning should be presented with authentic problems in daily life. There are changes in each indicator of students’ critical thinking skills that include formulating problems and answering simple questions, applying formulas or procedures, analyzing information based on data, ideas, or concepts, drawing conclusions from generalizing data and synthesizing ideas into a unified whole with average values N-Gain score test of 0.59 with medium criterion and effect size test of 3.57 with very large criteria. These results indicate that there is a significant effect of authentic problem based learning against critical thinking skills.

To the future researcher, the study recommends analyzing high-order thinking skills as a whole. Analysis can be focused on problem-solving skills and conceptual change using authentic and contextual issues. The problem is raised as a phenomenon at the beginning of learning and becomes the source of learning problems.

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