THE EFFECTIVENESS OF PROBLEM-BASED LEARNING ON DEVELOPING STUDENTS' CRITICAL THINKING ABILITY

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Abstract

Critical thinking is one of the most important 21st century skills that students must have. One of the instructional methods considered to be capable of fostering students' critical thinking development is Problem-Based Learning. This study was designed to investigate the effectiveness of problem-based learning on developing students' critical thinking ability in Physics. The participants of this pre-experimental study with one-group pretest-posttest design were 35 tenth-grade students at a senior high school in South Sulawesi Province, Indonesia. In this study, problem-based learning was implemented in Physics class on Heat lessons for four weeks. The syntax of the learning process included: 1) orienting students to problem; 2) organizing students to study; 3) assisting students to conduct independent or group investigations; 4) developing and presenting the work; and 5) analyzing and evaluating students' problem-solving process. Test of critical thinking ability was administered in pre-test and post-test. The categories of critical thinking assessed were students' ability to: 1) identify or formulate questions; 2) analyze arguments; 3) ask and answer questions for explanation or clarification; 4) induce and judge inductions; and 5) make and judge value judgements. Apart from the test, a Likert-Scale questionnaire was also used to find out the participants' motivation in learning Physics. The finding of this study showed that problem-based learning was effective on developing students' critical thinking ability. This could be seen from the results of N-Gain analysis of students' pre-test and post-test scores where the obtained scores falled into middle category. The study also revealed that students' motivation in learning Physics was classified into high category. The findings prove that problem-based learning can be used as one of learning methods to develop students' critical thinking ability in Physics.

Keywords: Problem-based learning, critical thinking ability, N-Gain, motivation, Physics.

1 INTRODUCTION

In the life aspect, critical thinking is used in various situations and opportunities in solving life problems. According to Johnson (2014, p. 183), critical thinking is a well-directed and clear process that used in mental activities such as problem solving, decision making, persuading, analysing assumptions, and conducting scientific research.

Critical thinking is the ability that gained through the process. A person is not necessarily able to think critically without going through the learning process. So that, there is an effort to teach about how to think critically to students in school as early as possible.

Physics has a role to improve critical thinking ability because Physics has a structure and a complete study and clear between concepts. Physics is considered important to be taught as a separate subject because Physics intended as a vehicle to grow the ability to think useful for solving problems in everyday life. In addition, a high school student has been considered mature and expected to be able to think critically to achieve results or take the right decision and wise.

Critical thinking ability of students can be developed through the provision of meaningful experiences. The meaningful experience can be either verbal or written opinion like a scientist. Opportunity of opinion can be a discussion that arises from the questions or problems in life. Other meaningful experiences can also be experimental activities that require observation or symptoms or phenomena that will challenge the thinking ability of students.

Based on the interviews that conducted with teachers obtained information that tenth-grade students at a senior high school in South Sulawesi Province, Indonesia tend to be less active in the learning process. Students are less able to focus the questions, analyze the questions, ask and answer the questions about explanation or challenge that given by the teacher. It encourages the need for learning that can overcome the conditions experienced by the students.

One suitable learning method to respond the condition is Problem-based learning. For its application in Physics learning, problem-based learning is designed by presenting problems to students. The problems are contextual problems that exist in everyday life, then students solve the problem by doing investigation through experiment.

Based on that analysis, so the author does the research about "The Effectiveness of Problem-Based Learning on Developing Students' Critical Thinking Ability".

2 LITERATURE REVIEW

2.1 Problem-Based Learning

Problem-based learning is often regarded as an effective way to provide students opportunities to be exposed to real-world situations and to be able to absorb new ideas in various disciplines, perceive patterns, and work actively and collaboratively to reach better solutions to specific problems (Lee & Bae, 2008, p. 656).

Tan (Rusman, 2011, p. 229) stated that problem-based learning is an innovation in learning because in problem-based learning, critical thinking ability of students really optimized through a group process or a systematic team, so that students can empower, hone, test, and develop their thinking ability on an ongoing basis. Margetson (Rusman, 2011, p. 230) also points out that problem-based learning helps students to improve the development of lifelong learning skills in an open, reflective, critical, and active learning.

Problem-based learning is developed to help students develop thinking skills, problem solving skills, intellectual skills, learn various roles of adults through their eyesight in real experience or simulation, and become an autonomous and independent learner.

Problem-based learning usually consists of five major phases that begin with a teacher's orienting students to a problem situation and culminate with the presentation and analysis of student work and artifacts. When the problem is modest in scope, all five phase of the model can be covered in a few class periods. However, more complex problems may take as long as a full school year to accomplish (Arends, 2012, p. 399). The five phases of problem-based learning can be seen in Table 1.

Unlike the tightly structured learning environment required for direct instruction or the careful use of small groups in cooperative learning, the learning environment and management system for problem-based instruction are characterized by open, democratic processes and by active student roles. In fact, the whole process of helping students become independent, self-regulated learners who are confident of their own intellectual skills necessitates active involvement in an intellectually safe, inquiry-oriented environment. Although the teacher and students proceed through the phases of a problem-based learning lesson in a somewhat structured and predictable fashion, the norms surrounding the lesson are those of open inquiry and freedom of thought. The learning environment emphasizes the central role of the learner, not of the teacher (Arends, 2012, p. 399).

TABLE 1. Syntax for Problem-Based Learning (Arends, 2012, p. 411)

Phase	Teacher Behaviour
Phase 1: Orient students to the problem	Teacher goes over the objectives of the lesson, describes important logistical requirements, and motivates students to engage in problem-solving activity.
Phase 2: Organize students for study	Teacher helps students define and organize study tasks related

	to the problem.
Phase 3: Assist independent and group investigation	Teacher encourages students to gather appropriate information conduct experiments, and search for explanations and solutions.
Phase 4: Develop and present artifacts and exhibits	Teacher assists students in planning and preparing appropriate artifacts such as report, videos, and models, and helps them share their work with others.
Phase 5: Analyze and evaluate the problem-solving process	Teacher helps students to reflect on their investigations and the processes they used.

This problem-based learning characterizes the student-centered, students construct their own knowledge and develop their actual understanding. Thus, it is expected that competencies demanded in the curriculum can be well developed.

2.2 Critical Thinking

Critical thinking is a systematic process that allows students to formulate and evaluate their own beliefs and opinions. Critical thinking is an organized process that allows students to evaluate evidence, assumptions, logic, and language that underlies others' statements (Johnson, 2014, p. 185).

According to Richard W. Paul (Liberna, 2012, p. 192) that critical thinking is an intellectual process of discipline which students actively and skilfully understand, apply, analyze, synthesize, and evaluate the various information that they collect from their experiences, observations, reflections, reasoning, or communications.

The indicator of critical thinking ability (Ennis, 1985, p. 46) is classified into several groups: (1) elementary clarification, (2) basic support, (3) inference, (4) advanced clarification, and (5) strategy and tactics.

Indicators of critical thinking ability of students can be developed through the provision of meaningful experiences. Significant experience in question may be a chance argues orally and in writing as a scientist. It could be argued opportunities that arise from the discussion of the questions or problems in life. Other meaningful experience can also be a practical activity that requires observation of symptoms or a phenomenon that will challenge the thinking ability of students.

Therefore, demanding Physics of students do not just memorize formulas but also have to understand the concepts and issues served so that students can resolve the case in the matter. To be able to solve problems in Physics needs the capability to understand the concept, hypothesizes, and analyze. These stages are some steps that are in the category of critical thinking.

3 RESEARCH METHODOLOGY

3.1 Types of Research

This research is Pre-Experimental with design One-Group Pretest-Posttest Design (Tuckman, 1999, p. 160).

3.2 Place and Time of Research

This research was conducted at a senior high school in South Sulawesi Province, Indonesia. The subjects were 35 tenth-grade students that consist of 13 male and 22 female of students, in second semester, academic year 2014-2015.

3.3 Research Working Procedure

The procedure that carried out in this research consist of preparation phase and implementation phase. In preparation phase includes observation activity at research location to get the research subject, consult with headmaster and Physics teacher about problem-based learning that will be implemented in the learning process, making learning tools such as: (1) teaching materials about heat, (2) lesson plan, (3) student worksheet, and (4) instrument of critical thinking ability in multiple choice form. After instrument was validated, next step is instrument testing by expert or called a Gregory test or content validity test or content test.

After preparation phase, next is implementation phase. Implementation of learning activity adjusted to the class schedule that selected as research subject and held for four weeks by using problem-based learning.

Critical thinking ability test was conducted before and after research implementation. As for motivation questionnaire were given after research implementation.

Data that obtained from the results of this research were analyzed by using descriptive analysis techniques. This analysis descriptive is used to describe the characteristics of distribution of critical thinking ability scores and motivation in learning Physics.

Criteria of critical thinking ability scores and motivation in learning Physics (Arikunto, 2013, p. 272) presented in Table 2.

TABLE 2. Criteria of Critical Thinking Ability Scores and Motivation in Learning Physics

Interval Scores	Category
80% < score ≤ 100%	Very high
60% < score ≤ 80%	High
40% < score ≤ 60%	Middle
20% < score ≤ 40%	Low
0 < score ≤ 20%	Very Low

The increasing of critical thinking ability is calculated by normalized gain formula (Archambault, et al., 2008, p. 9) that presented in Table 3.

TABLE 3. Category of N-Gain Level

Limitation	Category
g ≥ 0,7	High
0,7 > g ≥ 0,3	Middle
g < 0,3	Low

4 RESULTS AND DISCUSSION

The general overview of pre-test and post-test score of critical thinking ability of students presented in Table 4.

TABLE 4. Statistic Results of Pre-test and Post-test Score of Students' Critical Thinking Ability

Statistic	Statistic Value	
	Pre-test	Post-test
Sample	35	35
Ideal Score	20	20
Lowest Score	5	11
Highest Score	10	17
Mean Score	8,13	14,41
Standard Deviation	1,35	1,96
Variance	1,83	3,85

Based on the Table 4 show that students' critical thinking ability was increase where critical thinking ability before implementing problem-based learning was in middle category and after implementing problem-based learning was in high category

The result of descriptive analysis from students' motivation in learning Physics score after implementing problem-based learning presented in Table 5.

TABLE 5. Statistic Results of Students' Motivation in Learning Physics

Statistic	Motivation in Learning Physics
Sample	35
Ideal Score	168
Lowest Score	108
Highest Score	157
Mean Score	130,50
Standard Deviation	12,56
Variance	157,65

Based on Table 5 the mean score of students' motivation in learning physics is 130,50 was in high category.

The increasing of students' critical thinking ability calculated by using normalized gain formula. Based on the analysis of N-gain obtained mean score of N-Gain 0,52. This indicates that students' critical thinking ability was in middle category. Distribution of percentage of N-gain of students' critical thinking ability presented in Figure 1.

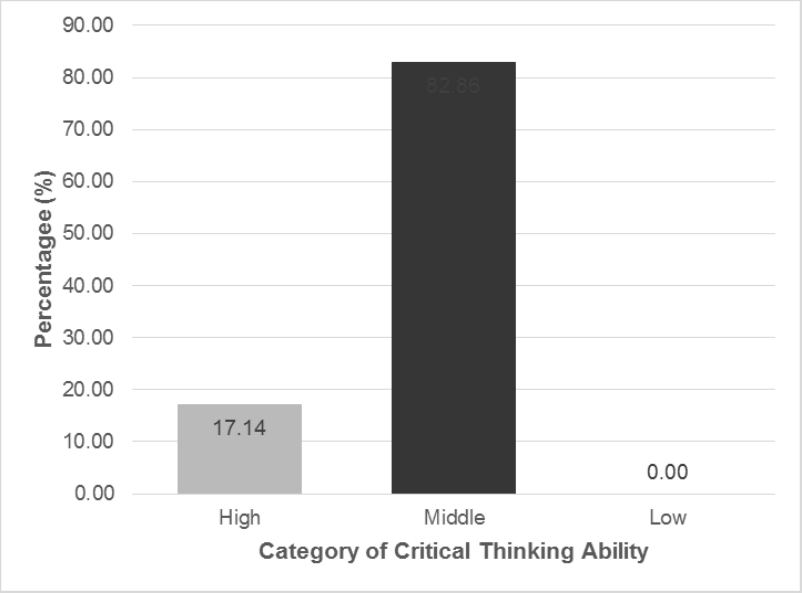

FIGURE 1. Percentage Chart of Developing Students' Critical Thinking Ability

From the result of this research can be seen that after the students do the learning process with problem-based learning, the critical thinking ability of students was increased. It can be seen from Fig.1 that 17,14% students have increasing of critical thinking ability in high category and 82,86% students with increasing of critical thinking ability in middle category.

This result indicates that the increasing of critical thinking ability of students through problem-based learning is optimal. Because students who are taught by using problem-based learning can construct the knowledge in their cognitive structure more freely. In addition, in the problem-based learning process, students are

actively involved in learning process and train students' critical thinking ability so that students can solve the problems that encountered.

The average of N-Gain for each indicator of students' critical thinking ability presented in Table 6.

TABLE 6. The Average of N-gain for Each Indicators of Students' Critical Thinking Ability

Indicators	Sub-Indicators	Average of N-Gain	Category
1. Focusing on a question	Identify or formulate questions	0,66	Middle
2. Analyzing Arguments	Identify conclusions	0,24	Low
	Identify stated reasons	0,59	Middle
3. Ask and answer questions about for explanation or clarifications	Answering the question about the main reason	0,50	Middle
	Giving Example	0,51	Middle
4. Induce and judge inductions	Generalize	0,70	High
	Provide reasonable assumptions	0,11	Low
5. Make and judge value judgments	Creating and determine the outcome of the consideration by the background of the facts	0,59	Middle
	Consider alternatives	0,57	Middle
	Consider and deciding	0,50	Middle

Based on Table 6 indicate that indicator of critical thinking ability that more increase or appear in students is induce and judge inductions with sub-indicator generalize. From analysis of critical thinking ability for each indicator, from five indicators with total of ten sub-indicators, it is found that two of ten sub indicators are in low category. This result can be understood because the learning only done for four weeks. The most critical thinking experts agree that researching the process of thinking must be done systematically. Likewise, with the improvement of critical thinking ability, a systematic and organized approach is needed to think critically because it basically thinks difficult to understand. In addition, the ability to think critically is not a given ability but a skill that can be trained and must be learned in school (Johnson, 2014, p. 190).

In addition, the effectiveness of problem-based learning in developing students' critical thinking ability can be interpreted that the success achieved after the use of problem-based learning. The success of class can be seen from the number of students who have increased critical thinking ability in accordance with the aspect applied that significant gain between preliminary understanding and understanding after learning, and motivation of students. The effectiveness of problem-based learning in developing students' critical thinking ability can be seen in Table 7.

TABLE 7. Relation between Critical Thinking Ability, Learning Achievement, and Motivation in Learning Physics of Students

Motivation	Learning Achievement	
	Very High	**High**
Very High	Developed of critical thinking ability in high category (17,14%)	Developed of critical thinking ability in middle category (37,14%)

High	Developed of critical thinking ability in middle category (14,29%) Developed of critical thinking ability in middle category (8,57%)	Developed of critical thinking ability in middle category (22,86%)

Based on Table 7, shows that 17,14% students who increased critical thinking ability are in high category and 14,29% who increased critical thinking ability in middle category also have motivation in learning Physics in very high category. Moreover, 37,14% with the increase of critical thinking ability in middle category also have very high motivation in learning Physics. And 8,57% and 22,86% of students with the increase of critical thinking ability in middle category also have high motivation in learning Physics.

In this research proves that problem-based learning can be used as an alternative in science learning especially Physics. In addition, based on the calculation of data analysis has been proven that problem-based learning is effective in developing students' critical thinking ability.

5 CONCLUSION

Based on the result of research and discussion, it can be concluded that problem-based learning was effective on developing students' critical thinking ability. It can be seen from the increasing of students' critical thinking ability was in middle category. Besides that, the students have an average score of motivation in learning Physics was in high category.

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