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The Effectiveness of Collaborative Problem-solving Using Decision-making Problems to Improve the Pre-service Physics Teachers' Critical Thinking Skills

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Abstract - Research on the effectiveness of collaborative problem-solving using decision-making problems in improving pre-service physics teachers' thinking skills has been carried out. This research aims to find out the effectiveness of the application of collaborative problem-solving using decision-making problems to improve the pre-service physics teachers' critical thinking skills. The method used was pre-experiment with one group pretest-posttest design. The research subjects were 76 pre-service physics teachers at a university in the city of Makassar, South Sulawesi. An essay test of critical thinking skills was employed to collect the data that 6 items. The results showed that after implementing collaborative problem-solving using decision-making problems, students' critical thinking skills increased to high category, and most of the students' critical thinking skills improvements are also categorized as high. Thus, collaborative problem-solving using decision-making problems is effective to improve the pre-service physics teachers critical thinking skills.

Keywords: Collaborative Problem-Solving, Critical Thinking Skills, Decision-Making Problems, Pre-Service Physics Teacher

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I. INTRODUCTION

One of the skills needed to face the challenges of the 21st century is critical thinking skills (Binkley et al., 2012). Critical thinking skill is a part of the higher order thinking skills (Presseisen, 1984). Therefore, critical thinking skills are very important to be trained and developed in the learning process in higher education. Students' critical thinking skills can be used after graduating as a provision for life in society so that they are

able to compete in facing the challenges of the 21st century. Critical thinking skills are skills needed in the world of work (Oliveri, 2017).

Science is a subject that plays a role in developing critical thinking skills because it can involve innovative learning materials. Science creates innovative learning materials to make students more interested in studying science and practicing their critical thinking skills (Putri & Aznam, 2019). Critical thinking skills are trained by incorporating them into

the designed science instruction (Swartz, 2001). However, the learning used so far has not trained students' critical thinking skills. This is proven by the results of the investigation conducted by the researcher on critical thinking skills among the university students. The results of the investigation show that students' critical thinking skills are still in the low category (Yusal, 2021).

The combination of decision-making and problem-solving with critical thinking leads to great ideas and solutions (McMurtry & Humphrey, 2000). Critical thinking is a process involved in decision-making to solve a problem (Joshi, 2017). Critical thinking is a mental activity that requires cognitive skills in solving problems, making decisions and drawing conclusions (Mitrevski & Zajkov; 2012). In developing and evaluating alternative solutions, students need to be engaged in critical thinking to be able to identify solutions (Eggert et al., 2012). Thus, the decision-making process in solving problems involves students' critical thinking activities. Therefore, problem-solving learning that involves a decision-making process is suitable for practicing students' critical thinking skills. In problem solving, there is a decision-making process (Dunca, 1981). However, not all problem-solving processes include a decision-making process in it (Jonnasen, 2011). The problem-solving framework used is influenced by the types of problems faced by students (Leak et al., 2017). The type of problem whose solution takes the

decision-making process is the decision-making problem (Jonnasen, 2011). Decision-making problem is a problem that requires problem solvers to choose a solution from a series of alternative solutions (Jonnasen, 2011). Decision-making problems present a variety of alternative problem-solving solutions, and students are asked to choose the most advantageous one so that they can reach the right decisions. Thus, the problem-solving learning using decision-making problems as a type of problem analyzed can lead to decision-making activities that will establish students' critical thinking skills.

Meanwhile, collaboration is needed in problem-solving learning. The students' problem-solving process through collaborative activities is very satisfying to carry out (Kelly et al., 2016). Through collaborative problem-solving, students will have mutual dependence on knowledge and reciprocal relationships such as caring for the knowledge and learning of others (Kim & Tan, 2014). Problems given as a decision-making task should be done collaboratively (Tekbiyik, 2015). Integration of collaborative activities in problem-solving learning results in collaborative problem-solving learning.

Many previous studies have examined problem-solving or collaborative problem-solving. However, most of the previous studies examined problem-solving or collaborative problem-solving learning by integrating it with technology, such as collaborative problem-solving with multi-touch technology (Mercier

& Higgins, 2014), computerized science problem-solving (Fund & Madjar, 2018), online problem-based learning (Eldhy & Sulaiman, 2013), and mobile problem-based learning applications (Ismail et al., 2018). There has not been any problem-solving or collaborative problem-solving learning that develops the type of problem, for example the decision-making problem.

Based on the background that has been stated above, the researcher is interested in conducting research on the effectiveness of collaborative problem-solving using decision-making problems to improve students' critical thinking skills. The problems that are going to be answered through this research are as follows: "How is the effectiveness of collaborative problem-solving using decision-making problems to improve the pre-service physics teachers' critical thinking skills? This study describes the process and results of research that has been carried out related to the application of collaborative problem-solving using decision-making problems and how effective it is to improve the pre-service physics teachers' critical thinking skills.

II. METHODS

The method used in this study was pre-experimental method with a pretest-posttest one group design. This design begins with carrying out the pretest to measure the pre-service physics teacher' critical thinking skills before given a treatment. The next step was giving the treatment in the form of

collaborative problem-solving learning using decision-making problems, and then the last was administering the posttest to measure pre-service physics teacher' critical thinking skills after the learning process is complete. This method was chosen in accordance with the research objectives to see the effectiveness of the collaborative problem-solving using decision-making problems in improving pre-service physics teacher's critical thinking skills. The research design used is as shown in Figure 1.

Pre-test	Treatment	Post-test
O ₁	X	O ₂

Figure 1. Research Design

The research subjects were 76 student teachers of a university in the city of Makassar, South Sulawesi. For the purposes of data collection, the research instrument was a critical thinking skill test about the concept of heat transfer in the form of an essay test that 6 items. This test was prepared based on the indicators of critical thinking proposed by Tiruneh (2018) which include reasoning, hypothesis testing, argument analysis, likelihood and uncertainty analysis. These four aspects were presented in critical thinking activities which consisted of: (1) detecting false statements; (2) identifying the relationship between variables; (3) drawing conclusions by selecting the correct statement from a set of statements given; (4) understanding the additional information

needed in decision making; (5) predicting the likelihood or physical event that will occur; and (6) identifying important parts of the argument.

The pre service physics teacher' critical thinking skills improvement after the application of the collaborative problem-solving learning using decision-making problems was determined based on the average normalized gain score ($\langle g \rangle$) using the following equation “(1)” (Hake, 1998).

$$\langle g \rangle = \frac{S_{pos} - S_{pre}}{100 - S_{pre}} \quad (1)$$

where:

$\langle g \rangle$: average *N-Gain*

S_{pre} : pre-test average score

S_{pos} : post-test average score

To describe the average normalized gain $\langle g \rangle$ which describes the improvement in pre service physics teacher' critical thinking skills, the following criteria were used (Hake, 1998).

Table 1. Criteria of the Average Normalized Gain $\langle g \rangle$

Average Normalized Gain Value	Interpretation
$\langle g \rangle > 0,70$	High
$0,30 < \langle g \rangle < 0,70$	Medium
$\langle g \rangle < 0,30$	Low

III. RESULTS AND DISCUSION

The research was conducted on group were given treatment in the form of the application of collaborative problem-solving learning using decision-making problems.

Before the treatment is carried out, a pretest was first carried out to determine students' initial critical thinking skills, then the implementation of the collaborative problem-solving learning using decision-making problems is carried out. After the treatment process is complete, the activity ends with the posttest of critical thinking skills, which was intended to determine the increase in the pre service physics teacher' critical thinking skills after the learning process was carried out. Collaborative problem-solving learning using decision-making problems was used in discussing the concepts of heat transfer material including (1) conduction; (2) convection; and (3) radiation. The results of pre-test and post-test obtained is presented in the following Figure 2.

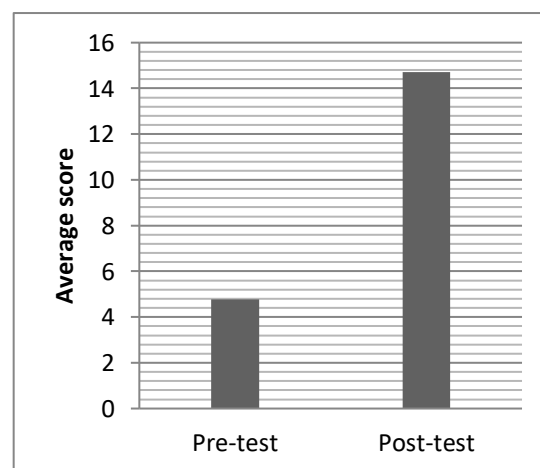


Figure 2. The average score of students' critical thinking skills

Based on Figure 2, it was found that the average pretest score of students' critical thinking skills before the treatment was 4.77 and after the treatment it became 14.71. This indicates that the average score of pre service physics teacher' critical thinking skills after

learning through the collaborative problem-solving learning using decision-making problems is better than the scores of students' critical thinking skills before using the collaborative problem-solving learning using decision-making problems.

Table 2. The percentage of the number of students in each category of students' critical thinking skills improvement

Normalized Gain (<g>) Category	Number of Students (%)
High	88
Medium	12
Low	0

Table 2 shows that the student' critical thinking skills improvement in two levels, medium and high levels, while none of them achieved low category improvement. Most of the students (88%) experienced an increase in critical thinking skills in high category, while the rest of the students (12%) achieved medium improvement. This also indicates that shows that after taught using collaborative problem-solving using decision-making problems, the number of students who had an increase in their critical thinking skills in high category was more than those who were in medium or low category.

Therefore, collaborative problem-solving learning using decision-making problems is effective to improve pre service physics teacher' critical thinking skills. This finding is in line with the research findings reported by Romanoff & Zakrzewski (2019) stating that students who practice through

problem-based learning experiences will learn to be critical. The application of problem solving in learning can direct students to be actively involved in learning (Kadir et al., 2020; Tampubolon & Sitindaon, 2013). Complex science problems can be solved well through collaborative problem-solving (deMontjoye et al., 2014). As explained earlier, collaborative problem-solving learning using decision-making problems as a stimulus will direct students to do decision-making activities that practice their critical thinking skills so that they are trained. Decision making problem is a problem that provides various alternative solutions, where these alternative solutions have their respective advantages and risks, and students must choose the best one. Campbell et al. (1997) stated that a decision is a choice from a variety of options, with each option having advantages and risks. Thus, in solving decision-making problems, students take the decision making process. In the decision-making process, students are triggered to use all their knowledge and reasoning power to critically assess and evaluate each alternative solution given to be decided later. Decision making is the process of providing assessments and making choices to achieve goals (Jackson, 2015).

Given the decision-making problems in the collaborative problem-solving process, students are asked to solve the problem collaboratively with their group friends. In developing and evaluating alternative solutions, students need to be engaged in

critical thinking to be able to identify solutions, to combine several perspectives and to monitor and manage their own problem-solving processes, especially during collaborative thinking (Eggert et al., 2012). Information-based discussions have a great impact on students' understanding and beliefs (Arya & Maul, 2016). The results of students' work show that each group has carried out a series of collaborative problem-solving well and has also obtained good results from the activities. The mistakes and obstacles faced by each group when carrying out collaborative problem-solving activities using decision-making problems will be immediately undertaken by the instructor who observes the whole time and the instructor will immediately facilitate students to overcome obstacles and revise any mistakes that occur.

In the activity at the beginning of the lecture, students experience difficulties and obstacles in solving decision making problems that must take decision-making steps. In fact, the decision-making steps serve as a guide for students so that they can consider problems from various perspectives (Siribunnam et al., 2014). Good decision-making steps influence the selection of the best decisions (Gresch et al., 2015; Gresch & Bogeholz, 2013). According to Chattabud et al. (2015), students' decision making models can be classified into six steps: (1) identifying criteria; (2) classifying information into each criterion; (3) evaluating the advantages and disadvantages of each alternative; (4) analyzing options, and

(5) selecting the best alternative. Students' mistakes and obstacles are possible because students are still new to making decisions through structured decision-making steps. Students who have not previously implemented collaborative problem solving, only use an intuitive trial-and-error strategy in solving problems (Chang et al., 2017). Students who are new to collaborative problem-solving activities will have difficulty solving problems that have complex or simple scenarios (Malach et al., 2012). Therefore, instructors immediately facilitate the difficulties and constraints faced by students by teaching a series of structured decision-making steps through joint simulations. Collaborative simulations mediate students to carry out collaborative problem solving activities (Chang et al., 2017). The ability to make decisions can be improved by teaching a series of structured decision-making steps (Arvai et al., 2004). Contrary to what Kuo et al. (2017) stated, students who follow a specific problem-solving framework limit their view of what is considered good problem solving.

Although the results of the analysis show positive results in the application of collaborative problem-solving using decision-making problems, there are still obstacles that make pre service physics teacher' critical thinking skills did not increase significantly. The real obstacle that can occur is the cognitive load experienced by students because problem solving activities using decision-making

problems are based on the application of relevant physics concepts, so the students' success in passing through each stage of decision-making activities from the beginning to the end of the activity is largely determined by the cognitive abilities of the students. Students' knowledge about science is used and influential in solving decision-making problems (Evagorou et al., 2012; Asha & Hawi, 2016; Hadjichambi, 2015; Lindahl & Linder, 2015). In this case, students who have low-level cognitive abilities will find it difficult to follow decision-making steps in solving problems. Thus, it would be better if the students are ensured to have good cognitive knowledge before entering the collaborative problem-solving sessions using decision-making problems. This is because their low-level cognitive abilities will influence their skills. Chen et al. (2020) claims that those who have low cognitive abilities will also have collaborative problem-solving awareness. During the learning process, students need integrated knowledge and knowledge development (Kim & Tan, 2014). However, despite these shortcomings, collaborative problem-solving using decision-making problems has the potential to be used as an alternative for students to provide experiences and practice the 21st century skills, particularly critical thinking skills.

IV. CONCLUSION AND SUGGESTION

Based on the research results, it can be concluded that is collaborative problem-

solving using decision-making problems effective in improving pre-service physics teacher's critical thinking skills. Therefore, the application of this learning deserves to be considered for use in order to enhance the students' critical thinking skills of the students.

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