The Effect of Experimental Skills toward Senior High School Students' Critical Thinking Abilities through Discovery Learning Model

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***Abstract*—The experimental skill is an ability in which students are able to do the experiment, observe the processes, and write the result of their experiment. Critical thinking is skillful in thinking deeply about the problem or something, such as knowledge about methods, investigation and rational thinking, and such an ability to apply those methods. Discovery learning is a learning model that given the students a chance to search and find out by their selves, using problem approach, whereas teachers only give instruction and direction. This study aimed to know the effect of experimental skills by using discovery learning toward Senior High School students' critical thinking skills. The subject in this study were 29 students of XI IPA 2 Class. This study conducted at SMAN 14 Samarinda in the Academic Year of 2017/2018. The data collected using experimental skills observation form and critical thinking skills test. The result showed that the mean score of students' experiment skills was 68, and the mean score of students' critical thinking skills was 72. Those data were analyzed by simple linear regression and revealed that there was an effect between students' experiment skills and their critical thinking skills, i.e. 67,8%.**

Keywords—experimental skills, critical thinking skills, discovery learning, senior high school

I. INTRODUCTION

Education is one of the important aspects of human life to develop itself so that it is able to become a quality and potential human being and able to compete in the era of globalization. Through human education can develop the ability to think [1]. Education has a big role in shaping the character, scientific and mental development of a child to give birth to a young generation who are intelligent and dignified [2]. This is in accordance with the national education system listed in the Law No. 20 Year 2003 on the National Education System which explains that education is a conscious and planned effort to realize the learning atmosphere of students to be more active in developing their potential. There are so many problems facing the world of education, one of which is the problem of students' weak ability to use their thinking skills to solve problems. In the learning process, students are less encouraged to understand concepts in depth and develop their critical thinking skills [3]. The learning process in the classroom directed only to the students' ability to memorize information, practice exercises with the formula that is already available, the students' brain is forced to remember and hoard various information provided by the teacher without being required to think about solving the problem based on facts and information that has been given. This causes students to be poorly trained to develop their reasoning power in solving problems and applying concepts that have been learned in real life so that students' critical thinking skills are poorly developed.

Based on our observation, the physics education process in the senior high school in the Samarinda also focused on teaching physics as a social subject and not emphasize on laboratory activities. Many senior high school students faced a problem with laboratory tasks during their first year on the undergraduate program in the Physics Education Department, Mulawarman University. It is also indicated that not only in Samarinda but in the other region in the East Kalimantan and other regions of Indonesia, the physics education process not focus in the experiment activities but only teaching physics to solve the mathematical problem that associated with physics. In the other hand, physics learning occurred majority via traditional teaching way, not the inquiry as of the main characteristic of physics as the natural science, so it has a negative impact to the students' experimental skills and students' critical and creative skills.

Physics as a component of natural science is a science where students are not only required to memorize formulas and work on problems with formulas that are already available but are also required to know the problem, describe problems, and provide ideas and opinions of each problem found. Critical thinking is a way for students to solve problems logically, systematically, carefully, effectively and efficiently. Critical thinking can be honed in the learning process, one of which is through experimental activities [4]. Physical learning which is also not free from experimental and practical activities requires students to be skilled in designing and carrying out experiments in order to find knowledge. Teaching students to gain scientific skills is important for the student to search for new knowledge and to solve the problem because their cognition can be simulated using an innovative intervention [5, 6].

Students' experimental skills obtained after conducting a physics experiment will hone students' critical thinking skills because when designing and implementing experiments

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students are required to be able to determine the objectives of the experiment, determine the necessary tools and materials, determine work steps, determine variables, and determine the facts that must be measured, recorded and observed. Selection of discovery learning model itself is based on the central role of students in learning, besides that students can find concepts, ideas, principles and various learning experiences through their own mental processes so as to make students motivated to be critical, active, and acquired knowledge will longer on his memory. One way of discovery in discovery learning model can be in the form of experiments, the experimental skills obtained after experimenting can train students to be able to think critically.

II. METHODS

The study used one shot case study method. The subject in this study were 29 students of XI IPA 2 Class at SMAN 14 Samarinda in the First Semester of Academic Year 2017/2018. The subject in this study were obtained by purposive sampling [7]. In this study, we chose Dynamics Fluid concept as the reference concept of study design (didactic design). The instruments used in this study were: (1) student experimental skill test; (2) students' critical thinking skills test; and (3) observation form. The data analysis used descriptive and inferential statistics.

III. RESULT AND DISCUSSION

A. Experimental skills Using Discovery Learning

In this study, we conducted several observations based on indicators of students' experimental skills, namely determining goals, determining problems, determining hypothesis, determining variables, determining tools and materials, determining work steps, collecting data, analyzing data, answering questions, and draw conclusions (Table 1).

TABLE I. PERCENTAGE OF THE STUDENTS' EXPERIMENTAL SKILLS

Range of Scores	Criteria	Percentage (%)
80-100	Excellent	0
70-79	Decent	41.38
60-69	Sufficient	44.83
50-59	Deficient	13.79
0-49	Less	0

Based on the results of the experimental skills observation, we founded that the highest score of students' experimental skills was 73 and the lowest score of the students' experimental skills was 53. The observations also conducted at each meeting to see how the development of students' experimental skills. In the first meeting, the average experimental skill of students was 64, the average second meeting was 68, and on the third meeting, the average was 70. The experimental skills also known as procedural skills or science investigation [5]. Based on this result, the discovery learning model as an intervention in this study, can improve students' experimental skill that associated with science process skills.

Discovery learning model emphasize the students to do an experiment based on scaffolding in the student worksheet form during the meeting in the classroom. The learning activities in the discovery model designed to direct the students for science investigation and feel the "eureka" moment. Discovery learning facilitated the students because they "discovered" the knowledge by themselves [8]. Based on data, the students' experimental skills increased on every meeting based on the average score. This indicated that discovery learning model have an impact on the students' experimental skills. The students developed a better understanding of real-life problem through discovery learning model [8]. On the other hand, according to the data, the students need more time to adaptation to the student-centered learning activities like discovery learning model. In every meeting, the students showed a positive trend based on the average score of students' experimental skills. There also about 13.79% of the students in this study, still did not increase their experimental skills.

B. Students' Critical Thinking Skills

Students' critical thinking abilities in this study were obtained by using a test that consists of 10 essay questions. This test conducted after the completion of dynamic fluid material learning activities with indicators of critical thinking skills that are giving simple explanations, building basic skills, making inferences, giving further explanation, and measure strategies and tactics. The result of the average of students' critical thinking skills test showed in the Fig. 1.

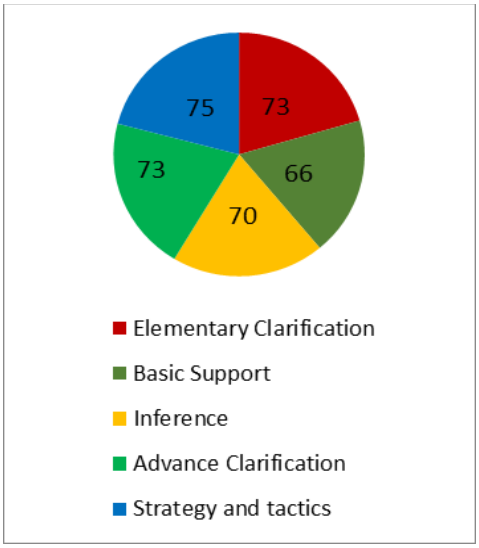

Fig.

Figure 1. The average indicator of students' critical thinking abilities

The result of the students' critical thinking skills through discovery learning model based on 5 (five) criteria on dynamic fluid concept, showed in the Table 2.

TABLE 2. PERCENTAGE OF THE STUDENTS' CRITICAL SKILLS ABILITIES

Range of Scores	Criteria	Percentage (%)
80-100	Excellent	13.79
70-79	Decent	51.72
60-69	Sufficient	20.69
50-59	Deficient	13.79
0-49	Less	0

Based on Fig. 1 we knew that in the elementary clarification indicator the average score was 73, on the basic support indicator the average score was 66, in the inference indicator average score was 70, in the advanced clarification indicator the average score was 73, and on the strategy and tactic indicator the average score was 75. Based on Table 2, physics learning through discovery learning model have a positive effect on students' critical thinking skills abilities.

Discovery learning model was able to train the students' critical thinking skills. Student-centered learning activities would stimulate the students' critical thinking skills such as making decisions. The critical thinking skills will also be better trained if the students are given the opportunity to develop their own knowledge and skill in the physics subject. Discovery learning model that provide the students with more learning experiences and also facilitate the students to develop their critical thinking skills. Physics learning with discovery learning model also in accordance with the characteristics of physics itself which is inductive and uses an experimental approach. The physics learning with discovery learning models will foster the students' experimental skills. The experimental skills will also stimulate the students to use their critical thinking skills because students experience "eureka" moments in the learning process that require critical thinking skills. The students' critical thinking abilities supported by the students' experimental skills through an active learning process like discovery learning model.

Based on data in the Table 2, the majority of the students have successfully developed their critical thinking skills. The criteria for students' critical thinking skills are even in the category of "excellent" in physics learning based on our study result. This also proves that physics learning must be taught through active learning activities and centered on experimental or laboratory activities. The learning process that emphasizes active students and experimental approaches are two effective strategies in the teaching and learning process [8]. This is also evident in this study, namely the discovery learning of critical thinking skills and experimental skills students also experience positive development and show a fairly good category. It also indicated that during the learning, the students can maximize their potential based on scaffolding based the context that given during the intervention. The tasks based on experiment and student' centered activities scaffold the students to develop their reasoning and problem solving [9].

C. The Impact of Experimental Skills Using Discovery Learning toward the Students' Critical Thinking Abilities

Based on the analysis of students' abilities to think critically after being given a test of experimental skills, it was found that the percentage of students who had achieved the minimum completeness criteria on the dynamic fluid concept was 62%. The completeness of students' critical thinking skills guided by the minimum school completeness criteria on physics subjects, i.e. 72. Looking at students who were declared complete by 62%, then this indicates that the experimental skills obtained by students during learning processes play an important role in improving students' critical thinking skills, because students are able to answer each indicator of experimental skills during intervention, so they trained in critical thinking to solve the problems during evaluation (post-test). There are still around 38% who still have not reached the maximum completeness criteria.

Based on the calculation of the correlation coefficient, the value (r) is 0.824. Based on the coefficient interval of r value, if the r value is 0.80 – 1.000, it can be said that there is a very strong correlation between experimental skills and students' critical thinking skills. It can be concluded that there is a significant correlation of experimental skills using discovery learning model to students' critical thinking skills. Determinant coefficient value in this study is $D = 0.678$. The coefficient of determination, D shows that 67.8% of students' critical thinking abilities are influenced by the skills of student experimentation and 32.2% are influenced by other factors.

The calculation results are also obtained by intercept estimator coefficient value (a) equal to $-21{,}899$ this number was a constant number which means that if there is no experimental skill then the value of critical thinking abilities was $-21{,}899$ and (b) the coefficient value intercept the regression equation amount to 1.386. this number means that every time the addition of 1% level of students' experiment skills, the students' critical thinking skills will increase by 1.386. Because the coefficient value of regression is positive, then it can be said that experimental skills have a positive effect on students' critical thinking skills, so the linear regression equation was $Y = -21.899 + 1.386X$. The intercept estimator value and intercept coefficient were obtained from the combination of experimental skill scores and critical thinking abilities scores. The equation above shows that there was a significant influence between experimental skills using discovery learning methods on students' critical thinking abilities. Our hypothesis accepted, this is also supported by a value of t_{result} 7.546 > t_{table} 2.05183. So, it concluded that there was a significant influence between experimental skills through discovery learning toward students' critical thinking skills. Based on the results of this study and direct observation, students who have high experimental skills, have high critical thinking abilities.

These results also prove that the students' experimental skills and the students' critical thinking abilities influence each other. The discovery learning model that focus on student activity in laboratory-based learning design also increasingly support the development and level of mastery of experimental skills and critical thinking skills. In addition, the distribution of scaffolding during the intervention also helps

students to solve the given problem. Learning using the discovery learning model provides more opportunities for students to have greater knowledge because they find themselves by solving problems that given during the intervention [8, 9].

Furthermore, physics learning with emphasis on experimental activities, is the main essence in science process skills. Science as a product results from scientific processes. Science process skills are imitations of the work processes of scientists in the laboratory [5, 7]. The science process skills are generic skills needed by a scientist to research and study phenomena, solve problems, and make a new invention. The science process skills have an important role in the knowledge acquisition [10]. In this study, we also found the science process skills are also related to the experimental skills and the critical thinking skills. If we examine the components of the experimental skills and the critical thinking skills, then several components of the indicators of the experimental skills and the critical thinking skills have similarities. Examples of decision-making skills (making an inference) that appear in the experimental skills and critical thinking skills indicators. The existence of an intersection of the indicator component will also theoretically support the mastery of students' physics concepts. Based on these intersections and the results of the study, we get the fact that physics learning designed with the emphasis on student activities and experimental approaches will also increase the mastery of experimental skills and critical thinking skills. The majority of students succeeded in increasing mastery of the experimental skills and the critical thinking skills (see data in the Table 1, Fig. 1, and Table 2). These results are also strengthened by the significant influence between experimental skills on the students' critical thinking skills through learning with discovery learning model. These results also show that physics learning must be discovery-based, laboratory or experimental activity, and student-centered. Learning processes that are oriented towards increasing the mastery of the critical thinking skills and the experimental skills will help students to compete and learn independently in the 21st century that characterized by disruptive innovations and open science. Innovation will grow if the students are accustomed to active learning and the discovery process will bring a great sense of knowledge ownership, especially in the open science era.

IV. CONCLUSION

Based on the results of our study at SMAN 14 Samarinda, despite some limitation, this study showed that there was a significant impact between students' experimental skills model toward students' critical thinking skills through discovery learning. It suggests that the implementation of discovery learning model regularly on the physics teaching that provides the students to develop their experimental skills and critical thinking abilities. The sustainability of the discovery learning model implementation on the physics teaching is needs because students must have more time to acquisition to engage with student-centered activities and experimental approach.

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