

Analysis of Critical Thinking Skill Through Conceptual Change Model Learning Assisted with PhET Simulation

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ABSTRACT

The aims of this research were 1) to analyze the level of critical thinking skills of students through learning based on the Conceptual Change Model (CCM) assisted by PhET simulation on momentum and impulse material; 2) to determine the differences in critical thinking skills between students who received learning with CCM assisted by PhET simulations and students who received conventional learning. The type of this research is a quasi-experimental research design with Posttest Control Group Design. The study population was all students of class X MIPA SMAN 1 Ngaglik with the sampling technique using simple random sampling. The research sample was students in class X MIPA 2 which were used as the experimental class and students in class X MIPA 1 as the control class. Critical thinking skills are obtained using multiple-choice tests and description tests. The aspects of critical thinking that are measured are basic clarification, inference, analysis, evaluation, and explanation. The analysis in this study uses descriptive statistics and independent t-test. Statistical test results provide a conclusion that there are differences in students' critical thinking skills in the experimental class with the control class. The critical thinking skills of students in the experimental class are higher than those of students in the control class for aspects of basic clarification, inference, evaluation, and explanation. As for the analysis aspect, the control class students were higher than the experimental class. The Critical thinking skill in the experimental class is good with an average of 68.03 and the control class in the moderate category is 59.22.

Keywords: *Critical Thinking Skill, Conceptual Change Model, PhET Simulation.*

1. INTRODUCTION

Physics is the study of physical phenomena. Physics is also an experimental science because of physics theory in its development through a two-way process that begins and ends with observation or experiment. Physics is the most basic science of science that reveals the workings of nature around us [1]. Physics is one branch of natural science. Like the nature of science, physics includes processes, products, and attitudes. Physics as a process means understanding various information especially physics obtained through observation, measurement, and publication. Physics as a product means the results of scientific activities carried out in the form of concepts, principles, theories, and the laws of physics itself.

Learning in schools requires teachers to teach physics following its essence as a process, product, and attitude.

This means that in teaching physics the teacher must emphasize the process not only on the product. The fact is learning physics emphasizes more on products (learning achievement). On the other side, along with the demand learning in 21st century. Educational demands are moving towards higher other thinking skills related to 4C (Critical thinking and problem solving, Creativity and innovation, Communication, and Collaboration). Education in 21st century learning leads to higher-order thinking skills. Critical thinking is one of the skills that students must have in the 21st century [2]. Indonesia is one of the countries that participated in developing critical thinking skills by incorporating them into the 2013 curriculum as one of the high other thinking skills that must be possessed by students [3]. This is because the profile of students' critical thinking skills in Indonesia is still relatively low [4]. The lack of critical thinking skills is caused by several factors such as not accustomed

to practicing these abilities and the lack of precise learning strategies used [5]. Referring to this, learning should be directed to develop critical thinking skills. Students will be able to analyze something before taking conclusions if their critical thinking skills are good. Students who have good critical thinking skills will be able to distinguish between facts and opinions [6]. Students who have good critical thinking skills will be able to decide and think rationally based on several points of view in different contexts. Most students have not been able to connect the material being studied with the knowledge used when learning physics. Students tend to memorize formulas without understanding the concept. This problem will lead to a very monotonous learning mindset for students. Also, the learning process does not pay attention to the initial concepts of students. Students assume that what is learned is meaningless because it has nothing to do with past learning or events in their environment. Another problem is that learning in schools emphasizes learning that allows students to have the limited ability to answer questions and students' thinking skills are rarely trained, especially critical thinking skills. Critical thinking is an "active process" and "a way of thinking regularly or systematically" to understand the information in-depth, thus forming a belief in the truth of the information obtained or the opinion conveyed. Students' reasoning and mindset will be more developed if early learning at school has been packaged in such a way as to provide opportunities for them to develop their reasoning and thinking patterns.

Based on this, it is necessary to apply strategies, models, or learning approaches that allow students to improve their thinking skills, especially critical thinking skills. One alternative that can be used is learning based on constructivist theory. Constructivism as an innovative learning theory that places the teacher as a partner learning for students. The learning process needs to be improved towards conceptual change so that students' thinking skills can increase and learning becomes meaningful. The use of learning models, strategies, and approaches need to be considered as meaningful learning solutions. CCM (Conceptual Change Model) is one of the many learning models that can be used to make learning meaningful. The use of CCM allows students to exchange ideas through discussion and presentation. Students find their concept sometimes wrong and sometimes conflict with the scientific concept. This often results in dissatisfaction with old concepts and students looking for new ways that are acceptable, reasonable, and understandable [7]. There are four conditions that must be met to create students undergoing a conceptual change, namely: 1) dissatisfaction with conception which exists; 2) intelligibility with respect to new conception;

3) logic (plausibility) against new conceptions; 4) success (fruitfulness) where the new conception must be valued or judged in a pragmatic context [8][9]. Learning with CCM is also able to improve students' critical thinking skills. Cognitive conflicts that occur when learning with CCM provide opportunities for students to convey their conceptions and criticize their concepts so that at the end of learning students understand the concepts as well and the skill to think related to critical thinking can increase [10]. The use of media to conduct experiments or demonstrations will optimize learning with CCM. PhET is one alternative media that is valid and suitable to be used that can facilitate the emergence of anomalous situations during learning when experiencing limitations on practical tools. PhET is an interactive virtual simulation and can be used in learning to clarify concepts or phenomena in physics [11].

This study aims to analyze students' critical thinking skills in the material momentum and impulses after learning with a conceptual change model assisted by PhET simulation and to compare the critical thinking skills of students who experience learning with a conceptual change model assisted by PhET simulation with students who learn conventionally.

2. METHODS

This type of research is a quasi-experiment. This research is quasi-experiment because there are still external variables that influence the formation of the dependent variable, not solely influenced by the independent variable [12]. The research design used was the Posttest Only Control Group Design according to Table 1 [13].

Table 1. Research Design

Class Type	Treatment	Posttest
Experiment	X	O ₁
Control		O ₂

X is CCM learning assisted by PhET simulation, O₁ is the posttest of students in the experimental class, O₂ is the posttest of students in the control class. The populations in this study were all students of class X MIPA SMAN 1 Ngaglik Academic Year 2019/2020. The sampling technique in this study used a random sampling technique and obtained student in X MIPA 2 as an experimental class with 32 students and student X MIPA 1 as a control class with 32 students. Analysis of critical thinking skills using the equation:

$$Critical\ Thinking\ Level = \frac{Score\ Obtained}{Maximum\ Score} \times 100\% \tag{1}$$

The results of the calculation of the level of critical thinking skills according to the equation above will be

interpreted to the following table of critical thinking categories. There are five level of critical thinking skills [14].

Table 2. Levels of Critical Thinking Skill of Students

Percentage (%)	Critical Thinking Skill Categories
80 < Score ≤ 100	Very good
60 < Score ≤ 80	Good
40 < Score ≤ 60	Moderate
20 < Score ≤ 40	Less
0 ≤ Score ≤ 20	Very less

To find out the difference in critical thinking skills between students who received CCM learning assisted with PhET simulation and those who received conventional learning, it was analyzed by using the inferential statistical independent t-test with a significant level of 5%. Normality test was also conducted to see the distribution of student abilities (normally distributed or not) and a homogeneity test to see the variance of students in both classes (homogeneous or not).

3. RESULT AND DISCUSSIONS

This study aims to analyze the level of critical thinking skills of students and to determine the differences in critical thinking skills between students

who received learning with CCM assisted by PhET simulations and students who received conventional learning. Critical thinking ability is the ability to apply, analyze, synthesize, and evaluate information to find out the truth [15]. There are five indicators of critical thinking skills measured in this study, namely basic clarification, inference, analysis, evaluation, and explanation. Based on the posttest results, it was found that the average critical thinking skill of the experimental class students was included in the good category while the control class students were included in the moderate category. The level of critical thinking skills of students in the experimental and control class is presented as in Table 3.

Table 3. Comparison of Critical Thinking Abilities

Class Type	Total Students	Score Critical Thinking Skill		
		Lowest	Highest	Average
Control	32	25	89	59.22
Experiment	32	36	90	68.03

It can be seen from Table 1 that the critical thinking skill of the experimental class in terms of the lowest, highest, and average values is higher than the control class. This shows that students who experience learning with CCM will have better critical thinking skills in terms of the average critical thinking skills of students in the experimental class who study with CCM have critical thinking skills with good categories while students in the control class have critical thinking skills with sufficient categories. Students in the experimental class who study with CCM will have the opportunity to practice their critical thinking skills through criticizing and scientifically proven if there are concepts that contradicting with their preconceptions. Students find their concepts wrong and sometimes contradicting with scientific concepts. This often results in dissatisfaction

with old concepts and learners looking for new ways that are acceptable, reasonable, and understandable [7]. This CCM learning will direct the thinking process of students to achieve conceptual change so that students can understand the concept in that topic and can believe in new concepts that are accepted. PhET simulations make students believe in new concepts learned because PhET simulations provide simulations that are following scientific concepts and following facts in life. PhET simulation presented at the beginning of learning can be a contradiction in the emergence of the situation of students so that the minds of students create cognitive conflict due to the incompatibility of preconceptions with the concepts that appear on the PhET. Cognitive conflict occurs when students experience a discrepancy or a mismatch in their cognitive effects due to anomalous

conditions between experience and scientific concepts [16]. Students will try to solve the problem if they realize the conflict or anomalous situation between scientific

concepts and preconceptions [17]. In detail, the comparison of students' critical thinking skills is presented according to the following Figure 1.

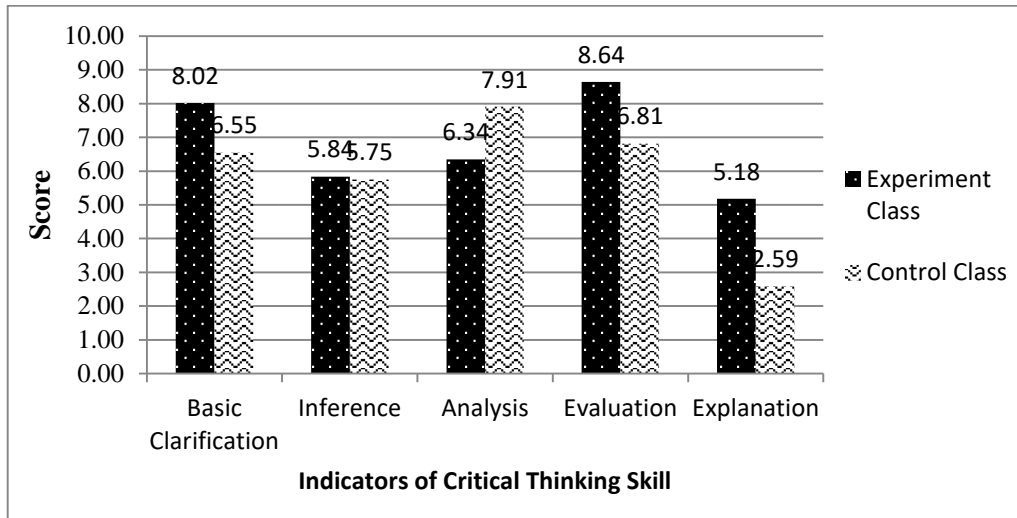


Figure 1. Comparison of Critical Thinking Skill

Based on the Figure 1, it can be seen that students in the experimental class have higher average values than students in the control class for critical thinking skills of aspects of basic clarification, inference, evaluation, and further explanation. Whereas in the aspect of analysis, the students of the control class were higher because when

learning the students in the control class were more directed at answering the analysis questions so that they were more accustomed to the students in the experimental class. While the distribution of the level of critical thinking skills in students is presented as the following Table 4.

Table 4. Distribution and Critical Thinking Categories of Students

Class Type	Critical Thinking Categories (Students)					Average Category
	Very Less	Less	Moderate	Good	Very Good	
Experiment	-	-	10	17	5	Good
Control	-	4	12	12	4	Moderate

Furthermore, to find out whether or not there are significant differences in the critical thinking skill in experimental class students with control class students, and the inferential statistical test is performed with the Independent t-test. Before conducting the test, normality and homogeneity test was carried out on both groups of

samples as a prerequisite in conducting a hypothesis test. Prerequisite test results showed that both sample groups were normally distributed and homogeneous (sig. >0.05). While the results of hypothesis testing indicate that there are significant differences in critical thinking skills in the two sample groups.

Table 5. Independent t-test Results in Critical Thinking Skill

Test	df	Mean Difference	Std. Error Difference	Score t-test	Sig. (2-Tailed)
Posttest Experiment-Control	62	8.812	3.620	-2.435	0.018

Based on the results of the hypothesis test it is known that there are significant differences in the critical thinking skills of students in the experimental class with the controls (sig. <0.05). This means that the treatment given in the form of CCM-assisted PhET simulation provides a different effect on students' critical thinking skills. This significant difference can be seen in Table 4 and Figure 1 which shows that students' critical thinking skills in the experimental class are better than those in the control class. The learning model used in the experimental class (CCM-assisted PhET simulation) can train and develop students' critical thinking so that in learning critical thinking skills are better. Practicing critical thinking in schools should focus on the skills needed in real life. Apart from all the positive effects, the critical thinking skill of these students is not optimal because CCM assisted by PhET simulations is not accustomed to being used as well as critical thinking skills including abilities that are still rarely trained by students. Continuous learning is needed so that students' critical thinking skills become maximal (very good category). This critical thinking skill can be improved because the worksheets of students are equipped with critical thinking exercises and the syntax of the CCM that directs students to practice their thinking skills and make conceptual changes in their cognitive structures. Critical thinking skill increase because learning with cognitive conflict allows students to express their initial conceptions and criticize concepts that are different from their conceptions, to be able to direct students to a complete and scientific conceptual change [18][19]. Students are faced with new situations through experiments/demonstration activities to solve problems in learning so that new concepts are formed that are more complete and more appropriate [20][21]. In the process of thinking, the knowledge that students acquire cannot be separated from the knowledge that has been previously acquired. Maintaining the link between old knowledge and knowledge that will be accepted by students so that it will become students' new knowledge is very important. So conceptual change model (CCM) is very well used to improve students' critical thinking skills.

4. CONCLUSION

Students' critical thinking skills in the experimental class using CCM-based learning assisted with PhET simulations are better than students in the control class at four categories (basic clarification, inference, evaluation, and explanation). The average critical thinking skill of students in the experimental class is in a good category and the category is moderate in the control class. There is a significant difference in the skill of students to think critically in the experimental class with students in the control class which means that the treatment given has a different effect on the critical thinking skills of participants' students.

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