Implementation of causalitic-learning devices to improve creative thinking ability and problem-solving of students in physics

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Abstract. This study aims to test the effectiveness of the causalitic model learning device to improve students’ creative thinking ability and problem-solving. The design of this study was a one group pre-test and post-test design with a purposive sampling technique so that 15 students were obtained. The research instruments used were lesson plans, preliminary assignments, student worksheets, with data collection tools in the form of tests of creative thinking ability and problem-solving. Data were analyzed using calculation of N-Gain. Thus, the implementation of causal learning tools to improve creative thinking skills and physics problem-solving students is effectively used in learning. For further researchers, it is necessary to increase the frequency or duration of learning so that students can better understand learning.

1. Introduction

Education is a program that involves various components that are related to one another, namely students, teachers, models, and learning tools. Education is a form of human culture that is dynamic and close to change. One of the sciences that is close to advances in science and technology is physics [1].

Physics is one of the sciences that plays an important role in technological advancement. About to education, physics is a part of science that focuses on studying matter, energy, and the relationship between the two [2]. The focus of the study on this causes the concept of physics that is real and is abstract. Abstract physics concepts make it difficult for teachers to convey physics concepts difficulties for students in understanding physics concepts.

Science and technology in the 21st century are always experiencing developments. This development needs to be balanced with ability. Student must possess these ability to keep up with the development of knowledge in the 21st century. Standard updating is needed so that students have the ability needed in the 21st century [3].
The ability that students in the 21st century must-have is the ability to think creatively. The ability to think creatively allows students to determine solutions to problems to solve physics problems more easily. The ability to think creatively needs to be developed so that students can solve problems in life. Indicator of creative thinking can identify the determination of the level of creative thinking ability of students. There are 4 indicators of creative thinking, namely 1) thinking fluently, 2) thinking flexibly, 3) original thinking (originality) and 4) thinking in detail (elaboration) [4]. Indicators of creative thinking that are achieved represent that the participants' students have been able to think creatively well.

In addition to the ability to think creatively, the ability emphasized for students are problem-solving abilities. Problem-solving abilities are the basis for students to solve various problems, especially physics problems. Problem-solving abilities are among the high-level cognitive abilities that allow students to gain knowledge and abilities [5]. In line with this, in learning activities, problem-solving abilities are among the methods students can use for learning physics problems [6]. The problem-solving ability has six indicators, namely 1) understanding, 2) selecting, 3) differentiating, 4) determining, 5) applying, and 6) identification [7, 8, 9].

Researchers made observations on high school students and found that students were less active in learning, students only took notes and the teacher presented the material on the blackboard. This shows that the learning that takes place is still teacher-centered. Learning activities that do not place students as learning subjects but learning objects indicate that learning is still teacher-centered [10]. The impact of teacher-centered learning is that students experience difficulties in 1) determining elements of the phenomenon in the form of factors or causes, 2) predicting possible consequences, 3) distinguishing causes that are related or not related to a particular result, 4) determining the concept, principles, theories, and/or laws of physics related to the occurrence of an effect, 5) applying concepts, principles, theories and/or laws of physics to explain why an effect may occur, and 6) identifying a condition for each related cause so that a certain result can occur [11]. In short, teacher-centered learning causes students to be unable to understand physics concepts which result in a lack of creative thinking ability and students' physics problem-solving abilities.

One of the learning models that can be applied to improve problem-solving ability is causalitic. This learning model facilitates students to think comprehensively to improve creative thinking ability. The causalitic thinking approach applies a combination of causality thinking and analytic thinking. Causality thinking emphasizes a way of thinking to determine the possible causes and possibilities of a physical phenomenon. In general, the essence of the causality thinking process is to apply multi-effect phenomena, namely there are more than one correct answer to a phenomenon [11]. There are several models of causality, namely the Simple Causality Model, the Divergent Causality Model, the Convergent Causality Model, the Chain Causality Model, and the Combined Causality Model. Furthermore, analytical thinking is a process of developing thinking capacity with various considerations, including in determining differences, processing data, solving problems, and using information [12]. The use of causal models because in learning students are directed to understand physical phenomena and formulate aspects of the causes and possible effects to facilitate students to develop creative thinking ability in determining the possible causes and effects. Activities to understand phenomena and determine cause and effect, make it easier for students to solve problems with the proposed physical phenomena. Based on research conducted by Rokhmat [11], Tamami, Rokhmat, and Gunada [13], as well as Yuliana, Rokhmat, Gunada [14], it proves that the causalitic thinking approach has a positive influence on solving ability learners in physics problems.

Typical learning tools in the causalitic learning model include lesson plans, preliminary assignments, student worksheets, and test instruments. Lesson plans are a guide for teachers in implementing learning both in the classroom, laboratory, and/or field for each basic competency [15]. A preliminary assignment is a task given to equip students' initial knowledge. Students' worksheets are learning media that is oriented between material and situations in the real world. The test instrument is a test used to measure learning achievement. The causalitic model of learning tools allows students to be able to improve creative thinking a problem-solving ability. In the causalitic lesson plan, there is a
learning phase that facilitates students in understanding phenomena to compile arguments. This is also supported by the provision of student worksheet as a learning medium that directs student activities. Based on the description above, in this paper the researcher implemented the causalitic model of learning tools to improve students' creative thinking ability and physics problem-solving.

2. Method
The research design was a one group pre-test post-test design. The research sample was taken by purposive sampling and obtained as many as 15 students of MA Hikmatusysyarief (4 male, 11 female). Research and data collection were carried out online. The research instruments used were lesson plans, students worksheets, and physics test tools to measure creative thinking and problem-solving ability. The resulting data were analyzed using the t-test with a significance level of 0.05 and the $N$-gain calculation (Equation 1).

\[ g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \]  

Where:
- $S_{post}$ = posttest score
- $S_{pre}$ = pretest score
- $S_{max}$ = maximum score

The $N$-Gain values are further classified into three categories which are listed in the following table [16].

Table 1. Category of increasing the ability to think creatively and solving problems

| N-Gain value | Category     |
|--------------|--------------|
| 0.00 < $g$ < 0.30 | Low          |
| 0.30 < $g$ < 0.70  | Moderate     |
| 0.70 ≤ $g$ ≤ 1.00  | High         |

3. Result and Discussion

3.1. Result
3.1.1. Results Of The T-Test for Creative Thinking and Problem Solving Ability
3.1.1.1. Creative Thinking Ability

Table 1. Average Creative Thinking Ability Score

| One-Sample Statistics | N | Mean | Std. Deviation | Std. Error Mean |
|-----------------------|---|------|----------------|-----------------|
| Nilai                 | 15| 66.0000 | 9.77606 | 2.52417 |

Table 2. Result of The t-test of Creative Thinking Ability

| One-Sample Test | Test Value = 75 |
|-----------------|-----------------|
| t               | Df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |
| Nilai           | -3.566 | 14 | 0.003 | -9.000000 | -14.4138 | -3.5862 |
3.1.1.2. Problem-solving Ability

Table 3. Average Problem-solving Ability Score

| One-Sample Statistics | N  | Mean | Std. Deviation | Std. Error Mean |
|-----------------------|----|------|----------------|----------------|
| Nilai                 | 15 | 78.4667 | 20.85962       | 5.38593        |

Table 4. Result of The t-test of Problem-solving Ability

| One-Sample Test | Test Value = 75 |
|-----------------|-----------------|
| t               | df              | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |
| Nilai           | 0.644           | 14              | 0.530           | 3.4667 | -8.0850 to 15.0183 |

3.1.2. Increased Creative Thinking Ability and Physics Problem Solving Students

3.1.2.1. Increased Creative Thinking Ability

Table 5. Results of the N-Gain Test for Creative Thinking Ability

| IC 1 | IC 2 | IC 3 | IC 4 |
|------|------|------|------|
| N-Gain | 0.62 | 0.31 | 0.23 | 0.33 |
| Average | 0.37 | | | |
| Criteria | Moderate | | | |

3.1.2.2. Increased Problem Solving Ability

Table 6. Results of the N-Gain Test for Problem Solving Ability

| IPS 1 | IPS 2 | IPS 3 | IPS 4 | IPS 5 | IPS 6 |
|-------|-------|-------|-------|-------|-------|
| N-Gain | 0.63 | 0.53 | 0.40 | 0.68 | 0.33 | 0.59 |
| Average | 0.53 | | | | | |
| Criteria | Moderate | | | | | |

3.2. Discussion

This study aims to test the effectiveness of the causalitic model learning devices to improve students' physics problem solving-based creative thinking ability. The research design was a pre-test post-test design which was conducted on 15 high school students. The learning tools implemented were lesson plans, preliminary assignments, student worksheets, and test instruments. The effectiveness of the implementation of learning tools is known from the increase in creative thinking ability and problem-solving after implementing the learning tools. The increase in the ability of creative thinking ability and problem-solving was calculated by using the N-Gain analysis from the pre-test and post-test.

3.2.1. The Effectiveness of The Implementation of Causalitic Learning Devices to Improve Students' Creative Thinking Ability and Physics Problem-Solving Ability

Creative thinking ability (CTA) has increased. This is known based on the increase in the ability of students in every indicator of creative thinking. The indicators of creative thinking (IC) include fluency, flexibility, originality, and elaboration [9]. IC-1 (fluency) is characterized by the ability of students to choose the possibilities that occur related to the phenomena presented, IC-2 (flexibility), namely when students explain an argumentation of concepts, principles, theories, and/or laws of physics, IC-3 (originality) is if students put forward arguments with a unique wording of the idea itself, not from books and/or sources, then IC-4 (elaboration), which is when students can detail and/or develop each element that causes the phenomenon to occur.
As with the CTA, the problem-solving ability has also increased. The increase in problem-solving ability is marked by the increase in the ability of students on each indicator. Indicators of problem-solving ability (IPSA) include IPSA-1 (understanding), which is when students' answers show that students understand the meaning of the questions stated in verbal representations or equipped with conceptual images or lead to the answers requested. IPSA-2 (selecting) is if the student's answer shows that the student can predict or choose at least 1 of the possible answers. Furthermore, IPSA-3 (differentiating) is if students show that students can distinguish the components of the causes that affect a selected result with other consequences. IPSA-4 (determining) is when students show that students in explaining how a predicted/chosen effect occurs involve at least one of the concepts, principles, theories, and physics laws related to the phenomenon being discussed. IPSA-5 (applying) is when students show that students explain how a predicted/selected effect occurs correctly using at least one of the concepts, principles, theories, and laws of physics associated with a phenomenon. The last indicator, namely IPSA-6 (identifying), is if the student shows that the student meets at least 50% of the total IPSA and is based on the appearance of the keyword [8].

The mean pretest score of creative thinking and problem-solving abilities was 47.22 and 55.37, respectively. From these results, it can be seen that the initial ability to think creatively is still quite creative [19] and the problem-solving ability is still in the medium category [20]. After implementing the causalitic model, the students' CTA and PSA scores experienced an increase. In Table 1, it is obtained that the average posttest CTA score is 66. This score indicates that students have the ability to think creatively with the creative category and the average posttest score for PSA is 78.45. This score indicates that the student's problem-solving ability is in the high category. When compared with the pretest score, the ability of creative thinking and problem solving of students has increased.

Directly, the increase in students' CTA and PSA can be seen from the increase in the pre-test and post-test scores which were analyzed using the N-Gain test. The results of the N-Gain analysis for creative thinking ability are 0.37 and problem-solving ability is 0.53. From these results, it can be seen that there is an increase in the ability to think creatively and solve problems in the moderate category. This is in line with Sundayana [15] that the N-Gain score which ranges from 0.3 to 0.7 has a high increase category. So that from the results of the validation and N-Gain test, it is proven that the causalitic model learning device is feasible to use to improve students' creative thinking ability and physics problem-solving ability.

From the results of the t-test, it was found that \( t_{\text{count}} (3.566) < t_{\text{table}} (1.75) \) with a significance of 0.0015 and for the problem-solving ability showed that \( t_{\text{count}} (0.644) < t_{\text{table}} (1.75) \) with a significance of 0.265. Based on these results, it is found that there is no significant effect of the causal learning model on CTA and PSA. Although there was no significant effect, the fact was that there was an increase in the ability to think creatively and solve problems as indicated by the N-Gain calculation result. This causal learning model facilitates the ability of students to 1) choose the causes and effects of the physical phenomena presented, 2) provide arguments involving concepts, principles, and/or theories of physical laws, 3) make arguments in their word order instead of from books or other sources, and 4) detailing and / or developing every element of the causes the phenomenon can occur. These abilities can be increased because in this lesson plans model there is a phase of developing the concept of causality and compiling arguments that are applied through the causalitic model student worksheets. The causal learning model can also facilitate students to improve their abilities as follows: 1) understanding phenomena, 2) choosing answers that are likely to occur, 3) distinguishing the components of the causes that affect an effect, 4) explaining how an effect is predicted / selection occurs by involving concepts, principles, theories, and physical laws related to the phenomenon, 5) explaining how a selected predicted effect occurs using the correct concepts, principles, theories, and physical laws related to the phenomenon, and 6) meet the 5 criteria based on the occurrence of keywords. The improvements mentioned indicate that there has been an increase in the ability of CTA and PSA after implementing the causalitic model learning device.

This discrepancy can occur because learning carried out online conditions students to learn from their respective homes so that the environmental factors where students live are not conducive and
unstable internet access can cause students not to fully concentrate on learning. Online learning also makes researchers limited to supervising and directing students. If learning is done directly, learning activities can be carried out in a more conducive and directed way. In line with this, online learning has also not been tested for its effectiveness. Learning with a direct causal model has been carried out by Ansori, et al. [18] and Tamami, et al. [14] and proves that the causal learning model has a significant effect on the creative thinking ability and physics problem solving of students.

The causalitic learning model can improve the ability to think creatively and solve problems because learning activities facilitate students in determining the causes of physical phenomena or problems and predicting possible causes supported by arguments to explain a cause. Starting with working on students' worksheets, students are directed to solve problems that have more than one correct answer. These activities can improve students' creative thinking ability which includes fluency, flexibility, originality, and elaboration. Along with the increase in the ability to think creatively during the learning process facilitated by students, worksheets causalitic thinking students also experienced a problem-solving abilities, namely the indicators of understanding, selecting, differentiating, determining, applying, identifying. This statement is supported by the research of Rokhmat, et al. [7, 8, 9] and Tamami, et al. [13] that the causalitic learning model can improve students' creative thinking ability and physics problem-solving ability. The last stage is the dissemination stage, namely the dissemination of the development of learning tools. The results of the development are disseminated through the writing of this article.

3.2.2. Research Limitation
In this study, there are limitations. During learning activities, an internet network can occur so that there are students who cannot participate in full learning activities. Bold learning also makes researchers limited to learning activities. Online learning also affects the attitudes of students to teachers. Students feel less responsible for following lessons or assignments because they are not directly supervised.

3.2.3. Efforts to Overcome Limitation
Some efforts can be made to overcome the limitations of research, namely, researchers can facilitate students who cannot participate in learning by sending videos of learning materials. In supervising discussion activities, the researcher can direct the group leader to supervise its members. Also, researchers can increase the frequency or duration of learning.

4. Conclusion
Implementation of the causal learning model is effective to improve the ability to think creatively and solve problems. This shows that the causalitic learning model to improve students' problem solving-based creative thinking ability is effective for use in the learning process. For further research, it is necessary to pay more attention to the condition of students so that they can always access learning and facilitate students with video learning material to overcome the limitations of research conducted by researchers.

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