The effect of a causalitic-learning model on problem-solving abilities reviewed from creativity

I A Anshori¹, J Rokhmat¹², I W Gunada¹, Wahyudi², and S Ayub¹

¹ Department of Physics Education, Faculty of Teacher Training and Education, Universitas Mataram, Indonesia
² Department of Science Education, Postgraduate Program, Universitas Mataram, Indonesia

E-mail: imamalanshory96@gmail.com

Abstract. The purpose of this study was to investigate the effect of the implementation of the Causalitic-learning Model (CLM) on Problem-solving Ability (PSA) in terms of creativity. This study used an untreated control group design with pre-test and post-test. The sampling technique used purposive sampling and obtained students from XI-MIA-3 as the experimental class (11 male and 22 female) and XI-MIA-2 as the control class (14 male and 20 female). The assessment instrument uses 6 items in the essay test in physics. Data analysis used a two-way ANOVA test with a 2 x 2 factorial design. The results show homogeneous data (Ftable = 1.75), and normally distributed (X²able = 7.81), for the control class and experimental class. Hypothesis test results, with a significance level of 0.05, obtained Ha (sig.-value 0.01) and Hb (sig.-value 0.01) so that Ha and Hb are accepted, while for Hc (sig.-value 0.80) so Hc is rejected. Conclusion CLM affects PSA, creativity affects PSA, and there is no effect on the interaction between CLM and creativity on PSA. It is recommended to improve students’ PSA through CLM and or the development of student creativity.

1. Introduction

The development of science and technology today directly changes our perspective on education where one of the goals of education today is to produce students who can compete both nationally and internationally. Educational output, namely students are upgraded in quality to be able to compete in this era [1]. Teaching students 21st-century skills is one of the best ways to achieve these learning goals. The five skills that students in the 21st-century must have are creativity and innovation, critical thinking, problem-solving, decision making, and metacognitive [2]. Based on this, problem-solving abilities and creativity are two basic abilities that are important for students to develop.

Problem-solving is the ability to choose or deductively predict the various possible consequences of a physical phenomenon, which contains one or several given causes, and can explain how these causes produce the chosen effect [3]. Problem-solving Abilities (PSA) are also related to one's creativity. Creativity can be explained as anything that is produced by humans who use continuous thinking and physical energy and are useful for solving the problems at hand [4]. The level of student creativity affects problem-solving abilities in learning physics [5]. The PSA and creativity are needed in the learning process, especially physics lessons because in learning physics students are trained to
be able to solve problems or questions, both in the form of calculations and conceptually so that students are expected to meet the minimum standard value of graduation.

Today we often find that student learning outcomes in physics lessons are still lacking or have not met the passing standards. Such learning outcomes allegedly due to a lack of students' PSA as a result of the learning process is still teacher-centered. This statement is supported by observations made in the process of learning physics class XI MIA, one of the senior high school in the city of Mataram. The observations showed that the type of the tests used by teachers gives priority to the use of the equation (formula) physics. Application of intellectual tests or written tests used in the learning process affects the ability of divergent thinking and creativity where the ability to explore the various possible answers to a problem is very rarely measured so that the development of PSA and creativity of the students ignored [6, 7, 8].

Based on the above problems, a more effective learning model is needed in improving student PSA. To develop PSA learning must be designed able to stimulate thinking and encourage students to use his mind as a conscious effort to solve the problem [9]. The learning model refers to the approach used [10]. One of the possible solutions to the above problems is the causalitic-learning model (CLM). CLM is designed to guide students in developing the ability to analyze and explain causal links in a phenomenon. CLM is a learning model developed and designed based on a causalitic-thinking approach with four learning stages, namely: (1) orientation, (2) exploration and development of the concept of causality, (3) argument preparation, (4) evaluation [11]. The causalitic-thinking approach is a combination of causality and analytical thinking processes.

Causalitic-thinking is generally a thought process that develops the ability to understand the causal relationships of a phenomenon by selecting and matching the components in that phenomenon. There are five models of causalitic-thinking consisting of four basic models and one composite model (simple and complex) [12, 13]. The causality model used in this study is a simple-composite model. Analytical thinking is the process of developing the capacity to think in various ways such as identifying how conditions cause and effect an event, solving problems, analyzing data that includes the concepts, principles, theories, or laws involved, and using the information to produce an explanation [14, 15].

Learning using a CLM is also a student-centered one. Students in the CLM were directed actively to solve the Student Work Sheet (SWS) and discussions. In SWS there is a scaffolding that serves to guide students in solving problems. Causalitik-thinking with the scaffolding approach has a positive effect on problem-solving abilities [16, 17]. Causalitik-thinking with scaffolding also has a positive effect on creativity [18]. Based on the considerations in the discussion above, we will discuss how CLM can improve problem-solving ability in terms of student creativity.

2. Method

2.1. Sample of research

The subjects of this study were students of class XI, one of a senior high school in the city of Mataram, West Nusa Tenggara, Indonesia. The sampling technique used in research is a purposive sampling technique so that the experimental class consisted of 33 students (male = 11, female = 22) and a control class as many as 34 students (male = 14, female 20).

2.2. Procedures of research

This research used untreated control group design with pre-test and post-test. The initial step in the procedure of this research is to provide a pre-test to determine the problem-solving abilities (PSA) and creativity of students in both classes. The next step is teaching the experimental class using a causalitic-learning model (CLM), while the control class uses conventional learning. Learning in both classes is carried out for three meetings with an allocation of meeting time for 135 minutes. The final step in is to carry out the final test to determine student PSA after all the learning process ends.
2.2.1. Design of learning activities in the causalic-learning model (CLM).

CLM is applied to improve problem-solving ability through student-centered learning. Causalic-learning design generally can be seen in Table 1 below.

| Learning phase | Student Activities |
|----------------|-------------------|
| Orientation    | Pay attention to the teacher’s explanation |
| Exploration and Development of the concept of causality | Analyzing phenomena in terms of the concept of causality |
| Preparation of argument | Identify and predict the elements of the phenomenon which are causes and effects. |
| Evaluation     | Develop arguments for why each solution might come up with each of the above combinations by incorporating the above concepts, principles, theories, and/or laws. |

2.2.2. Media of causalic-learning model (CLM).

The learning instrument in the CLM, which is arranged based on a causalic-thinking approach is the set of Pre-Task (PT), Student Work Sheet (SWS), and test questions. PT designed to teach physics concepts to students by presenting problems through terminology commonly used in concepts physics and their implementation in reality [19]. PT presented to students before face-to-face learning, which is at the end of the previous meeting so that students have sufficient time to study it. The next instrument is the SWS, where this instrument will use in face-to-face learning activities. SWS generally is composed of instructions, physical phenomena, and causal tables that must be completed. The last instrument used was the test questions arranged based on a causal approach in the discussion of Work and Energy.

2.3. Data analysis

In this study, the data obtained through the results of the pre-test (problem-solving ability and creativity) and the post-test (problem-solving ability). The test instrument used was a written test in the form of 6 essay questions that were arranged based on a causalic-thinking approach (previously has passed validity and reliability). The problem-solving ability (PSA) and creativity was precisely measured using this test instrument. The measured PSA indicators (IPS) include IPS-1 understanding, IPS-2 selection, IPS-3 differentiation, IPS-4 determination, IPS-5 application, and IPS-6 identification. Creativity indicators (ICT) measured based on a causalic-thinking approach can include ICT-1 fluency, ICT-2 flexibility, ICT-3 originality, ICT-4 elaboration.

The pre-test creativity results used as the basis for grouping student creativity using by the Z Score value (high creativity > Z score and low creativity < Z score). The next test is a homogeneous test with F_{table} = 1.75, and normally test with X^2_{table} = 7.81. Furthermore, the research hypothesis test (H_s = the effect of CLM on PSA, H_c = the effect of creativity on PSA, H_x = the interaction effect of CLM and creativity on PSA) using a two-way ANOVA statistical data test assisted by application SPSS24.

3. Results and discussion

This research is focused on the application of the causalic-learning model (CLM) in physics class XI for energy and work materials. The effect of CLM on problem-solving abilities (PSA) in research
in terms of student creativity. The pre-test creativity data from the experimental and control classes were grouped into two categories, high and low (Table 2).

Table 2 shows that the maximum score and average score in the experimental class is greater than the experimental class. However, the data above shows that there are 14 and 13 students with high creativity and 19 and 21 students with low creativity. Furthermore, the general effect of CLM on PSA can be observed based on the results of the pre-test and post-test. The following is the PSA test result data in the experimental class and control class.

| Class     | Creativity | N | Max score | Min score | Average |
|-----------|------------|---|-----------|-----------|---------|
| Experiment| High       | 14| 33        | 79        | 53      |
|           | Low        | 19|           |           |         |
| Control   | High       | 21| 34        | 74        | 36      |
|           | Low        | 21|           |           |         |

Table 2. Data from the creativity pre-test results

Table 3. The results of the pre-test and post-test problem-solving abilities

| Test      | Class     | N | Max score | Min score | Average | Information       |
|-----------|-----------|---|-----------|-----------|---------|-------------------|
| Pre-test  | Experiment| 33| 81        | 36        | 52      | Homogenous (1.79 < 1.75) |
|           | Control   | 34| 81        | 11        | 42      |                   |
| Post-test | Experiment| 33| 100       | 42        | 72      | Normal (6.13 > 7.81) |
|           | Control   | 34| 94        | 17        | 53      | Normal (7.01 > 7.81) |

Based on the data in Table 3, it can be seen that the increase in the average PSA value in the experimental class (20 points) increases higher than that of the control class (11 points). The next increase was seen in the PSA indicator assessment (Table 4).

Table 4. The average score of the problem-solving ability test results per-Indicator (ideal score = 6)

| Class     | Test | Problem Solving Ability Indicators (IPS) | IPS-1 | IPS-2 | IPS-3 | IPS-4 | IPS-5 | IPS-6 |
|-----------|------|----------------------------------------|-------|-------|-------|-------|-------|-------|
| Experiment| Pre  | 5.82                                   | 5.12  | 1.48  | 4.06  | 1.67  | 2.45  |
|           | Post | 6.00                                   | 5.64  | 3.88  | 5.64  | 3.09  | 2.85  |
| Control   | Pre  | 5.68                                   | 4.35  | 1.26  | 2.24  | 1.00  | 0.71  |
|           | Post | 5.85                                   | 4.62  | 2.15  | 3.47  | 1.65  | 1.06  |

Table 4 shows the difference in the average PSA score per indicator in the two classes. Students with CLM teaching experience better PSA development than students with conventional teaching on each indicator. CLM teaching with a student-centered process, can stimulate students to be able to build their knowledge through understanding the causal relationship of a phenomenon and using the concept of physics as a basis for thinking to formulate arguments in the settlement. Furthermore, to clarify the effect of CLM to PSA in terms of student creativity was analyzed using two-way ANOVA analysis with the help of SPSS24 (Table 5 and Figure 1).

Table 5. Hypothesis test results with SPSS 24

| Source               | Type III Sum of Squares | Df | Mean Square | F     | Sig. |
|----------------------|-------------------------|----|-------------|-------|------|
| Corrected Model      | 9413.40                 | 3  | 3137.80     | 14.36 | 0.01 |
| Intercept            | 262419.13               | 1  | 262419.13   | 1200.72 | 0.01 |
| a. CLM               | 5045.75                 | 1  | 5045.75     | 23.09 | 0.01 |
| b. Creativity        | 3657.54                 | 1  | 3657.54     | 16.74 | 0.01 |
| c. CLM * Creativity  | 13.71                   | 1  | 13.71       | 0.06  | 0.80 |
| Error                | 13768.78                | 63 | 218.55      |       |      |
| Total                | 282718.00               | 67 |             |       |      |
| Corrected Total      | 23182.18                | 66 |             |       |      |
Figure 1. The interaction between CLM and student creativity

The hypothesis test in table 5 uses a significant value of 0.05. The results obtained are \( H_a \) (sig value 0.01) and \( H_b \) (sig value 0.01) so that \( H_a \) and \( H_b \) are accepted, while \( H_c \) (sig value 0.80) so that \( H_c \) is rejected. Several causes can be the reasons for the results obtained above. The following is a discussion of the causes and reasons.

3.1. There is an effect of CLM on problem-solving abilities (\( H_a \) accepted).
The effect of CLM on PSA can occur due to several factors such as the use of a causalitic-thinking approach to CLM and student-centered learning processes. The application of causalitic-thinking processes in every stage of CLM learning [11], can build students' understanding and structural ability in solving problems. The causalitic-thinking process with scaffolding can make it easier for students to identify and analyze [12, 14, 15, 20], especially analyze physics problems in the form of phenomena. Causalitic-thinking with the scaffolding approach has a positive effect on PSA [6, 16, 17]. CLM learning is also centered on students [7], where students actively train and develop open and comprehensive thinking skills [6], in completing the set of Student Work Sheet (SWS) to improve students' problem-solving abilities. Based on the reasons above, the use of CLM can affect students' PSA.

3.2. There is an effect of creativity on problem-solving abilities (\( H_b \) accepted)
The effect of student creativity on problem ability can occur because the problem process of student problems requires children to be able to determine possible answers to be taken. The level of student creativity affects problem-solving abilities in learning physics [5]. Student creativity can provide benefits in solving problems [4]. The concepts obtained will develop well through creativity so that they can produce better problem-solving. Also, student creativity can generate new ideas to solve the problem. The statement above is the reason for the effect of student creativity on PSA.

3.3. There is no interaction between creativity and CLM on PSA (\( H_c \) is rejected)
Figure 2 shows that there is no interaction effect between CLM and creativity on PSA. The variable lines in graph 2 do not intersect at one point, meaning that CLM and creativity are independent variables that affect PSA separately, the interaction does not occur when the independent variables have separate consequences [21]. The learning model used generally cannot interact with students' creativity [22, 23], because it has a significant effect separately. The effect of the causal learning model and student creativity on PSA can be seen separately in the previous discussion. CLM and creativity can improve PSA separately so that the interaction between CLM and creativity is not visible because these two variables do not influence each other. CLM in this study also indirectly affects students' creativity [11, 18, 24] so that the ability to choose or predict deductively to solve a
problem can be improved properly. In this case, PSA is described as a settlement process based on known information [25, 26].

4. Conclusion
The learning model is essential in the teaching and learning process. A good learning process is supported by the selection of a good learning model as well. CLM is a learning model that can be applied as a way to train and develop students' problem-solving abilities. Furthermore, CLM is an answer to educational challenges that require students to be able to have problem-solving abilities by promoting reasoning abilities. By solving problems using causalitic instruments, students become accustomed to high-level questions so that CLM can improve and produce highly competitive students. It is recommended that the application of the causal learning model should be carried out continuously so that students become accustomed to developing their creativity in solving problems.

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