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THE INFLUENCE OF CAUSAL THINKING WITH SCAFFOLDING TYPE 2A AND 2B ON OPTICS PROBLEM-SOLVING ABILITY

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ABSTRACT

The effectiveness of learning is affected by the assistance stages (scaffolding) provided. For example, the scaffolding of type 2a and type 2b supports the causal-thinking approach in learning. The type 2a informs the causal model, number of causes and effect, while 2b informs its argument sample. This research aimed to identify the effect of causal thinking process (CTP) with scaffolding type 2a and 2b on optics problem-solving ability (PSA) of students. The type of the research was quasi-experiment with the non-equivalent-group design. Data were obtained with PSA-test and analyzed with the two-tail test with separated variance formula at significance degree of 5% to determine the effect of each type of the CTP on the PSA, also to determine its difference. The results showed that t_{count} for each of the first two t-tests were greater than t_{table}, but t_{count} for the third one was smaller than its t_{table}. This research concluded that the implementation of the CTP with the scaffolding of type-2a and 2b were effective to improve the student's PSA. However, the improvements were not different.

ABSTRAK

Efektivitas pembelajaran dipengaruhi bantuan tahapan (*scaffolding*) yang diberikan. Dengan pendekatan berpikir kausalitik ini, diperkenalkan *scaffolding* tipe-2a dan tipe-2b. Kedua *scaffolding* ini menginformasikan model kausal serta jumlah Cause dan Effect tetapi pada tipe-2b ditambah contoh argumentasinya. Penelitian ini bertujuan mengidentifikasi pengaruh proses-berpikir-kausalitik (PBK) ber-*scaffolding* tipe-2a dan tipe-2b terhadap kemampuan-pemecahan-masalah (KPM) optik siswa. Jenis penelitian kuasi-eksperimen dengan desain *non-equivalent-group*. Data diambil menggunakan alat tes-KPM dan dianalisis dengan uji-t dua pihak menggunakan rumus *separated varians* pada signifikansi 5% untuk mengetahui pengaruh PBK tipe-2a dan 2b terhadap KPM, serta perbedaan kedua pengaruh tersebut. Hasil menunjukkan nilai t_{hitung} untuk dua uji-t pertama lebih besar dari t_{Table} terkait tetapi nilai t_{hitung} untuk uji ketiga adalah lebih kecil dari t_{Table}-nya. Simpulan penelitian implementasi PBK ber-*scaffolding* tipe-2a dan 2b masing-masing berpengaruh terhadap peningkatan KPM siswa tetapi kedua pengaruh tersebut tidak berbeda.

Keywords: Causal; Problem-Solving; Scaffolding; Optics

INTRODUCTION

Science does not only covers the activities of reading, remembering, or storytelling; but also encourages people to use their skills to solve problems in the actual world, such as creating, building, and developing new ideas and ways of thinking. Moreover, science learning must involve the student in problem-solving activities (Barba, 1998).

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Physics as a branch of natural science is critical to learning for fostering the thinking skills. Physics as a subject has the objective to develop the students' reasoning skills in thinking inductively and deductively. Students can apply concepts and principles of physics to explain various natural phenomena and to solve problems both qualitatively and quantitatively (BSNP, 2006). Therefore, it is urgent to develop a physics learning with the orientation of balancing between the provisions of material by the teacher with problem-solving practices to boost the students' thinking skills ability.

The example of the thinking processes

that can improve students' reasoning skills in problem-solving is creative thinking, critical thinking, and analytical thinking. Glaser defines critical thinking as an attitude of wanting to think deeply about problems, as well as knowledge of examination methods and logical reasoning (Fisher, 2009). Chance said that critical thinking is the ability to analyze facts, create and compile ideas, maintain opinions, make comparisons, describe conclusions, evaluate arguments and solve problems (Amer, 2005).

The analytical thinking is a component of critical thinking. This way of thinking represents the ability to scrutinize and unravel facts, and thoughts into its strengths and weaknesses such as the development of the capacity to think carefully (thoughtfully), how to discern, to solve problems, analyze data, and remember and collect information (Amer, 2005).

This study is inspired by previous research conducted by Rokhmat (2013) which implementing causal and analytical thinking processes (CATP) with a standardized pattern and proven to be able to improve the problem-solving ability of student teacher of physics. Based on the limitations of the study, the standardized CATP used was still general; therefore, one of the things that became a recommendation for other researchers was to use CATP with scaffolding. In this study, CATP refers to as a causal thinking process (CTP).

The causal thinking process is a combination of causal and analytic thinking skills. Lenzen explained that the essence of causal is the connection between two phenomena, the phenomena of the cause and the phenomena of the results (Rokhmat, Agus, & Dadi, 2012). Meanwhile, Hardy suggests that analytic thinking is the ability to think of students to describe, detail, and analyze information used to understand knowledge by using logical reason and mind, not based on feelings or guesses (Marini, 2014).

In the learning process, physical phenomena facilitate students' causal and analytical thinking abilities. Also, students are required to determine the causal components in a physical problem while they do the casual thinking. Then, students need to think deductively in predicting all events (consequences) that have the chance to occur based on the causes. When they do the analytical thinking, students must be able to identify the conditions of the causes which affect on specific event or effect based on the knowledge that has been possessed which includes concepts, principles, theories, or related physical laws (Rokhmat et al, 2012).

The pattern of CTP with scaffolding type 2a is the development of causal and analytical thinking facilitated by the main pattern of the causal table with some part of the results have been given in the table. Then, students must determine the components of the causes and other effects with the known amount of a physical phenomenon. Also, the students need to explain how the causes can produce such an effect. Meanwhile, the pattern of CTP with scaffolding type 2b is the development of the CTP with scaffolding type 2a pattern. In this pattern, there is additional assistance information and explanations (Rokhmat, 2013). In this study, the CTP with scaffolding type 2a and 2b was modified by adding a part of the causative component to the causal table.

There are six indicators of problem-solving (IPS), namely (1) *understanding*, it means the ability to understand ideas or ideas in each question, (2) *selecting*, which explains the ability to choose or select a variety of possible consequences that will occur regarding the causes in the matter, (3) *differentiating*, the ability to distinguish and choose causes that can produce a certain effect, (4) *determining*, the ability to determine the concepts, principles, theories, and / or laws of physics to support in identifying a number of causes to produce a consequence, (5) *applying*, the ability to use concepts, principles, theories, and / or physical laws to support a identify or cause certain consequences, and (6) *identifying*, that is, identifying the causes which produce a particular effect (Rokhmat, 2013; Rokhmat, Marzuki, Hikmawati, and Verawati, 2017; Helmi, Rokhmat, and Ardhuha, 2017; Tamami, Rokhmat, and Gunada, 2017; and Yuliana, Rokhmat, and Gunada, 2017). In solving the problem, students often have the difficulties in distinguishing the causal elements as the factors of the desired answer especially if the problem states that the real cause is not a factor of the effect but as a factor of the other. With the causal thinking approach with scaffolding type 2a and 2b, students can determine the causes and effects of a problem efficiently. In both types, the number of cause and effect elements are informed, and some examples are given. Specifically for type-2b scaffolding, there are examples of arguments that explain how the conditions of each cause and its effects can occur.

This objective of this study is to identify the influence of Modified causal thinking process with scaffolding type 2a and 2b which are

facilitated by the worksheet on the development of students' problem-solving ability/PSA (H_{01} and H_{02}). Also, to identify the difference of the influence between Modified causal thinking process with scaffolding type 2a and 2b facilitated by the worksheet on the development of students' problem-solving ability/ PSA (H_{03}).

METHOD

This study employed the Quasi-Experimental with Non-equivalent Group Design as shown in Table 1. The population was all students of class XI-MIA MAN-2 Mataram. The sample was taken by purposive-sampling technique. The research subjects obtained were XI-MIA-2 students (9 boys and 23 girls) as the experimental class 1 and XI-MIA-1 students (7 boys and 25 girls) as experimental class 2.

Table 1. Non-equivalent Group Design

Group	Pre-test	Treatment	Post-test
Experimental Class 1	O_1	X_1	O_2
Experimental Class 2	O_3	X_2	O_4

(Adapted from Setyosari, 2012)

Before treatment, the pre-test was conducted in both classes. After that, the treatment was given to both classes, i.e., experimental class 1 applied a modified causal thinking process with scaffolding type 2b facilitated by worksheet (X_1); whereas the experimental class 2 employed the modified causal thinking process with scaffolding type 2a facilitated by worksheet (X_2). After treatment, post-test was performed in both classes to measure the results of the treatment. The difference between worksheet for X_1 and X_2 is the example of cause-effect which is given in the worksheet X_1, while in worksheet X_2 the example of this explanation is not given.

The independent variable in this study is the modified causal thinking process with scaffolding type 2a and 2b assisted by the worksheet; whereas the dependent variable is the students' problem-solving ability; and the control variables are material, learning objectives, assessment methods, and time allocated to both classes.

The research instrument includes the syllabus, lesson plan, and worksheet to help the modified causal thinking process with scaffolding type 2a and 2b, and students' problem-solving ability (PSA) questions. The PSA items were analyzed for its validity and reliability. Validity analysis employed the r product moment correlation equation with rough numbers, and the reliability of essay items applied the Alfa formula. The instrument test results show eight valid and reliable questions. The pre-test and post-test data were then tested for normality using the chi-square formula (χ^2), the calculation results showed that the pre-test and post-test data were normally distributed. The hypothesis test uses a two-party t-test with a separated variance formula.

The questions were prepared based on the six PSA indicators to facilitate the emergence of the indicators. First, the question should be causal with a simple combined model, which has more than one cause or effect element (having more than one answer) (Rokhmat et al, 2017b). Secondly, the questions in the problems indicate an open answer. In this case, the answer and deception are provided for students to choose from. Thirdly, there is also a demand for students to explain the cause element as the effect of answers can occur. Finally, in explaining, students need to involve concepts, principles, laws, and or related theories (Rokhmat, 2013).

RESULTS AND DISCUSSION

Results

The results of the study include the pre-test and post-test of problem-solving ability (PSA) score analysis and the results of hypothesis testing for the experimental group 1 and group 2. Students in group 1 used causal thinking process (CTP) with modified scaffolding type 2b facilitated by students' worksheet while group 2 applied the Modified CTP with scaffolding type 2a assisted by worksheet.

Stages of learning activities: the application of Modified CTP with scaffolding type 2a assisted by worksheet in learning can promote the students to learn through the following stages: 1) understanding physical phenomena, 2) completing the causal table, by a) writing down the causal elements that have not been written in the Table, b) predicting the effects that have the chance to occur that have not been written in the Table, and 3) compile arguments to explain how the conditions of each effect are related to producing the predicted results. The preparation of this argument for each effect

including those that have been written in the causal table.

Table 2. Example of the causal table with scaffolding type 2a

Causes (5)	Effects (3)
Cause-1	Effect-1
Cause-2	…….
…….	…….
…….	
…….	

Explanation:
Effect-1:
……..

……...
Effect-2:
……..

……...
Effect-3:
……..

……...

In learning with CTP with scaffolding type 2b, students learned with the same stages as scaffolding type 2a. However, all arguments in type 2a were prepared by themselves, while in type 2b, there were some examples of references to direct the students in arranging their arguments.

Table 3. Example of the causal table with scaffolding type 2b

Causes (5)	Effects (3)
1. Cause-1	1. Effect-1
2. Cause-2	2. …….
3. …….	3. …….
4. …….	
5. …….	

Explanation:
Effect-1: The explanation of how each element of cause can give the effect 1 occurs.
Effect-2:
……..

……...
Effect-3:
……..

……...

Indicators of problem solving abilities (IPS) in learning process: The learning process applied the problem-solving ability (PSA) to students as follows (Rokhmat, 2013, Rokhmat, et al, 2017): First, students must be able to understand the purpose of the questions expressed in verbal representations together with conceptual images. Indicators of understanding are based on the ability to predict or choose the effect, whether predicted or selected is correct (at least predict or choose an effect) or lead to the requested answer (the indicator of problem-solving/IPS 1). Second, the related problems show that students can predict or choose at least 50% of the effects that are likely to occur (IPS 2). Third, the related problems show that students explained how a predictable or selected effect occurs at least 50% of the cause components as the factors in the occurrence of the effect (IPS 3). Fourth, it shows that students in explaining on how a predicted or selected effect occurs which involves at least one of the concepts, principles, theories, or physical laws associated with the problem (IPS 4). Fifth, it shows that students in explaining how a predictable or chosen effect occurs correctly using at least one of the concepts, principles, theories, or physical laws associated with the problem (IPS 5). Sixth, it shows that students in explaining how a predictable or chosen effect occurs to get a score of at least 50% of the maximum score, which is the same as the maximum score of “5” with the correct number of effects that have been predicted or selected (IPS 6).

The results of the pre-test and post-test of the Problem Solving Ability (PSA) showed that the enhancement average of PSA score was ranged between 1.62 to 1.78 times as shown in Table 2 and Table 3. It indicates that the implementation of learning with causal thinking process (CTP) with modified scaffolding type 2a and 2b assisted by students’ worksheet can improve students’ ability in solving physics problems.

The difference between the mean of post-test and pre-test in the experimental class 1 using Modified CTP with scaffolding type 2b facilitated by worksheet was 18.75. In order to determine the effect of this type of CTP, a separated variance t-test was performed with dk = n - 1. The calculation results show that the value of $t_{count} > t_{table}$ at 5.88 > 2.04. It indicates that H_{02} is rejected where there is an effect of modified CTP with scaffolding type 2b increased the students’ problem-solving ability.

The difference between the average

Table 4. P*re-test* score of students in Experimental Class 1 and 2

Class	Number of students (N)	Max Score	Min Score	Mean	S	s^2
Exp. 1	32	48	6	24.13	10.34	106.92
Exp. 2	32	40	4	26.31	8.05	64.8

Table 5. Post-test scores of students in Experimental Class 1 and 2

Class	Number of Students (N)	Max Score	Min Score	Mean	S	s^2
Exp. 1	32	79	23	42.88	14.79	218.74
Exp. 2	32	63	21	42.69	10.15	103.02

Table 6. Percentage of the average score of pre*-test* and *post-test* of the students' problem-solving ability in Experimental Class 1 and 2

Data	Class	The average of problem-solving abilities (%)					
		IPS 1	IPS 2	IPS 3	IPS 4	IPS 5	IPS 6
Pre-test	Exp. 1	83	20	15	20	5	0.4
	Exp. 2	91	25	16	15	10	0.4
Post-test	Exp. 1	100	42	44	37	25	9
	Exp. 2	100	52	55	34	13	2

post-test and the pre-test score of experimental class 2 using Modified CTP with scaffolding type 2a assisted by the worksheet was 16.38. In order to determine the effect of CTP, a separated variance t-test was performed with dk = n - 1. The calculation results showed that the value of $t_{count} > t_{table}$ at 7.15 > 2.04. It indicates that H_{01} was rejected where there is an influence of the causal thinking process (CTP) with modified scaffolding type 2a towards increasing the students' problem-solving ability.

Moreover, the difference of the influence of the causal thinking process (CTP) with modified scaffolding type 2a and 2b assisted by the worksheet was tested using separated variance t-test. This test applied the data of post-test and pre-test score difference from both classes. The results of the test showed that the value $t_{count} < t_{Table}$ at 0.87 < 2.04; thus, H_{03} was accepted where there is no significant influence of the Modified causal thinking process with scaffolding type 2a and 2b assisted by the worksheet to the students' problem-solving ability.

The percentage of pre-test and the post-test average score of each IPS of the students in class 1 and 2 are shown in Table 6.

Discussion

From the view of the pre-test and post-test ratio, the problem-solving ability of the students was highly increased showing more than one and a half times compared to the previous ability. Moreover, specifically for students in the experimental class 1, it increases almost two times. This phenomenon, qualitatively describes the excellent effectiveness of the CTP with two types scaffolding implementation in improving students' problem solving ability including the ability to understand the problem, choose Cause and Effect aspects, differentiate Cause which is a factor of each Effect, determine concepts, principles, theories, and or the laws of physics (cptIP). Moreover, it increases the ability to implement cptIP in composing arguments and explaining why each effect occurs by involving cptIP. This finding is in line with recommendations for the development of learning instruments with a causal thinking approach with scaffolding (Rokhmat, Marzuki, Hikmawati, & Verawati (2017). Meanwhile, the effectiveness of this form of scaffolding is in line with the research of Helmi, Rokhmat, & Arhuha (2017), Tamami, Rokhmat, & Gunada (2017), Putrie (2016), and Yuliana (2016), as well as Yuliana, Rokhmat, and Gunada (2017).

From the achievement level, students' problem-solving ability was still deficient. In the beginning, the PSA of students in two classes were about 25%. These results were actually because of the PSA questions applied are classified as unusual for the students. The questions were designed with a semi-open pattern, where students can choose more than one

correct answers. Surprisingly, there are some questions with all the correct choice of answers. Moreover, students were also allowed to give additional answers, and they were needed to make arguments in explaining how the condition of each element of Cause is seen as a factor of each selected Effect, which is indicated by the answers that have been chosen. The explanation of the PSA criteria is in line with the statement of Rokhmat (2013); Rokhmat et al (2017), Helmi, et al (2017), Tamami, et al (2017) and Yuliana, et al (2017).

Final achievement of the students' problem-solving ability (PSA) as a result of the posttest: It has been stated that this students' final PSA was more than one and a half times compared to initial PSA. However, its achievement is still below 50%, and even closer to 40%. If the final achievement benchmark is set at 80% with the assumption that the average achievement of the average student is "A" and this predicate is valid for the percentage of achievement of 80% or more, then the final achievement of PSA is still half of the desired ideal achievement. This fact shows that although the CTP with scaffolding type 2a and 2b approach is effective in increasing students' PSA, even though its achievement is still far from its ideal achievement.

This fact shows at least two things, i.e., 1) CTP has been effective in increasing students' PSA, and 2) the use of PSA questions of this type along with the development of relevant CTP needs to be exposed from lower levels of education. Therefore, it is possible to achieve the final PSA for each implementation of CTP development by ideal expectations, which is 80% or more.

Initial Problem Solving Ability (PSA) based on the pre-test results for experimental class 2 on IPS 1, IPS 2, IPS 3, and IPS 5 was higher to experimental class 1. However, the IPS 4 in experimental class 1 was more significant to experimental class 2. While for the IPS 6 in both classes showed the same percentage value.

Furthermore, the final PSA based on the post-test results indicate that both classes experienced an increase from the initial PSA. Current PSA conditions in experimental classes 1 and 2 were the same as the IPS 1. However, the IPS 2 and IPS 3 of the experimental class 2 were higher than the experimental class 1. Conversely, on the other three indicators, IPS 4, IPS 5, and IPS 6 in the experimental class 1 were higher than experimental class 2. This fact shows that students' PSA who implemented the causal thinking process with scaffolding type 2b were higher in the IPS 4 to IPS 6. Therefore, it represents that although overall there is no difference in effect between the causal thinking process with scaffolding type 2a and 2b; type 2b has a more positive effect on these three indicators than type 2a. The examples of typical questions and answers were used for students in experiment 1 and experimental class 2 to add to the depth of this discussion. Both of these experimental classes were tested with the same problem to show whether the six PSA indicators appeared in the two groups.

Examples of questions: P object is standing in front of a concave mirror. The position of the object can be at the center of the mirror curvature or between the vertex and the center of the mirror curvature. Based on this fact, note the following statements related to the P shadow: (1) real, inverse, equal to P, (2) real, upside down, smaller than P, (3) virtual, upright, bigger than P, (4) real, upside down, and bigger than P. Of the four statements, which one is likely to occur? Explain how it happened, state the concepts, principles, laws, and physics theories that are related!

How to solve the problem: Students are asked to write down which statement number of the four statements has the chance to occur. In the instructions should be notified to students that of all statements given there is a possibility that all statements may not occur, some statements may occur, or all statements may occur. Furthermore, outside of the statement provided, students are also given the opportunity to add answers or other statements that might occur.

Answer: Possible statements are statements (1), (3), and (4).
Explanation:
Statement-1: occurs when object P is right at the center of the mirror curvature
Statement 3: occurs when object P is between the vertex and the mirror's focal point
Statement-4: occurs when object P is between the center of the curvature and the focal point of the mirror
Additional answers: no shadows or shadows are formed at infinity.
Statement (additional answer): occurs when object P is right at the mirror's focal point.

The results of this study indicate that the Modified causal thinking process with scaffolding

type 2a with a 5% significance and also the type 2b can increase students' problem-solving ability (PSA). However, the improvements in PSA in both treatments were not significantly different. The results of this study are in line with previous studies conducted by Rohkmat (2013) that causal and analytical thinking processes (CTAP) with a significance level at 5% have a positive effect on increasing PSA. However, the type or pattern of the causal thinking process used is a standard pattern. Regarding the causal thinking process with scaffolding type 2a, Putrie (2016) and Tamami, Rokhmat, and Gunada (2017) have conducted similar research. The research results of Putrie (2016) show that the modified causal thinking process with scaffolding type 2a assisted by worksheet on dynamic electrical learning with a significance of 5% can increase students' PSA. Similar results also occur for the study of geometric optics (Tamami et al, 2017). Regarding the causal thinking process with scaffolding type 2b, Yuliana (2016) and Yuliana, Rokhmat, and Gunada (2017) stated that learning by applying causal thinking processes with scaffolding type 2b assisted by worksheet has a positive influence on students' PSA. Other research results by Helmi, Rokhmat, and Ardhuha (2017) stated that the modified causal thinking approach with scaffolding type 2b assisted by the worksheet has a positive effect on students' PSA on the dynamic fluid material.

Although each type affects increasing PSA, the assistance in the form of explanation added to the worksheet of CTP scaffolding type 2b does not have a significant effect on increasing students' PSA. It is because of some students in class 1 did not answer the reasoning since they were confused even though they had been given explanatory assistance, especially in determining the concepts, principles, theories, and related physical laws. It is related to the constraints faced in the research process, and it is proved as the limitation of the study.

The obstacle was the limited time to discuss physical phenomena; then each group was only provided by one worksheet. Therefore, the learning process was limited, only some students in each group could understand the problem. Next, students' ability to comprehend the worksheet was limited. The worksheet was unfamiliar to them, and it made them asked many questions related to the command in filling the worksheet space. Also, they were still confused in understanding the sentences in the physical phenomena presented in the worksheet.

To overcome these limitations, students need to do an initial task to recall their basic knowledge in solving physical phenomena and do not take long to find references. Also, it is better to provide the worksheet for students with at least two students one worksheet to facilitate the learning process. Furthermore, an explanation in using the worksheet must be conducted at the beginning of the lesson. The sentences modification to fit the students understanding is suggested to ease the learning process. Also, special handouts related to the material being discussed can be considered; therefore, the exploration process of reference material can be more effective. These recommendations are in line with Rokhmat, Marzuki, Hikmawati, and Verawati (2017), which means that to overcome the limitations of implementing the causal thinking approach, among others, by providing handouts, using only one phenomenon in each worksheet, is given an example of a phenomenon that has been answered in full, as well as the provision of preliminary assignments at least two days before face-to-face learning.

CONCLUSION

Based on the results of research conducted in MAN 2 Mataram in class XI students in the 2016/2017 school year, data analysis with a significant level of 5%, and discussion, it can be concluded that the modified causal thinking process with scaffolding type 2a influenced the improvement of the problem-solving ability (PSA) of students. However, there was no significant difference between the two CTPs. Assistance in the form of explanation on the causal thinking process with scaffolding type 2b was only seen in some indicators of problem-solving (IPS), and it did not significantly affect the increase in PSA.

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