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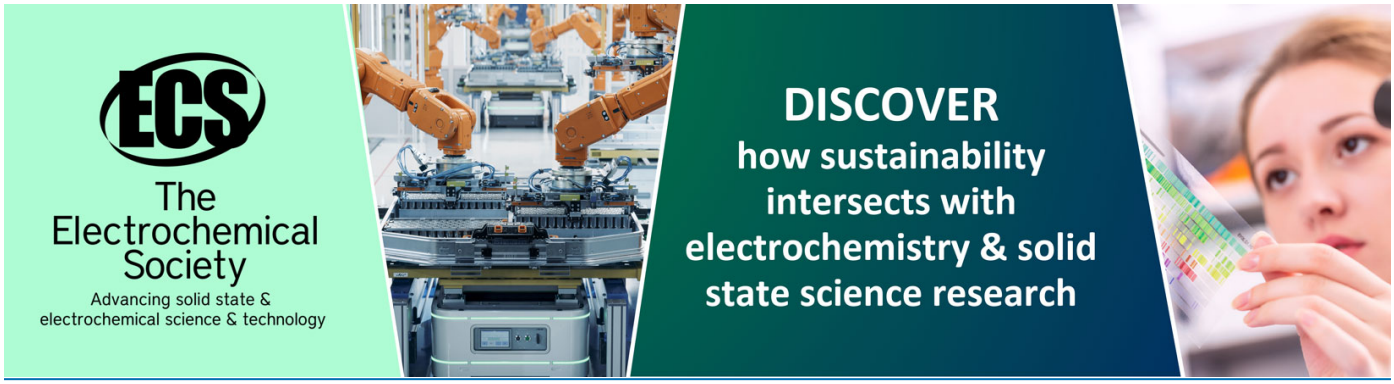

Effect of problem based learning models with 3D thinking maps on creative thinking abilities and physics learning outcomes in high school

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Abstract. The purpose of this study is to examine the effect of Problem Based Learning with 3D thinking maps on the ability to think creatively and physics learning outcomes. This research is a true experimental research design with the Posttest Only Control Design. The data analysis technique used is a statistical test with a different test technique (t-test) using SPSS 23. Experimental class learning using Problem Based Learning accompanied by 3D thinking maps, whereas for the control class do not use it. The normality test results of student learning outcomes in the experimental and control classes are not normal, so the t test on student learning outcomes uses the Mann Whitney U Test. T test results of student learning outcomes that have a Sig (2-tailed) value of 0,000 then the value is below 0.05 which indicates that Ha is accepted (Ho is rejected) then it can be concluded that the Problem Based Learning model with 3D thinking map affects the physics learning outcomes in high school.

1. Introduction

The quality of education and learning in schools is a topic that is often discussed by the general public. The problem that often occurs in the world of education is the low ability of students to think at high levels. According to an international study, TIMSS (Trends in Mathematics an Science Study) which discusses students 'cognitive abilities states that students' high-level thinking skills in Indonesia are still low. Based on data obtained from [12] the results of the PISA study in 2015, Indonesia is in the ninth position of all countries that joined PISA. From these results, it shows that the abilities of students in Indonesia are very far behind the abilities of students in other countries.

The factors that cause the low quality of education in Indonesia are, among others, the lack of stimulation from the teacher so that students are more serious in following the learning process [14]. One of the factors that can increase student responses in learning is applying problem based learning. Problem based learning is a learning strategy that integrates problems in learning with the aim of being able to develop more skilled thinking [2]. It can also be defined that problem-based learning is learning whose context is related to the real world [16]. Giving problems to students refers to problems that occur in everyday life, so that students no longer need to interpret a problem in a complicated way, because the problems students are facing are familiar and often experienced by students in everyday life.

Problem based learning as a student-centered learning model where students build their own knowledge and work together to solve problems that drive learning success [1]. Mind maps are scaffolding which contains a collection of concepts, ideas, tasks or important information which is presented in the form of non-linear radial-hierarchical diagrams. The information presented is related to the topic being discussed in the form of keywords, symbols, pictures or certain markers. Scaffolding aims so that certain information can be learned and remembered quickly and efficiently [16]. The thinking map contains the relationship between concepts that have a relationship between one variable and another, so that it can make it easier for students to classify the important points contained in a material [6]. The 3D thinking map is a collection of several components such as images, problem information, relationships between concepts and key words as well as hypotheses from reasoning obtained from investigations so that students can combine their knowledge into a map called 3D thinking maps [6]. 3D thinking maps are an implementation of external representations, where the external representations are obtained from existing knowledge or information which is then manifested in the form of maps, diagrams, tables or images that are interrelated with one another [6]. The 3D thinking map consists of three parts, which include: a concept map, a data table, and a reasoning map. These parts have their own characteristics in compiling a 3D thinking map. Concept maps reflect more about causal or causal relationships from a concept to another concept that underlies a problem. The data table contains the results of experiments that have been carried out that can be used as scientific evidence. The reasoning map is a representation of the relationship between the evidence that has been obtained and the hypotheses that have been previously made, the reasoning map can also be obtained by linking several concepts to form proof of the problem being solved. Student learning activities that are based on a 3D thinking approach are a form of scientific step, where students are invited to think by linking existing phenomena and then are assigned to conduct experiments by collecting data. Furthermore, the last activity is to test and prove the hypothesis that has been made by the students themselves. Problem based learning accompanied by 3D thinking maps is a learning activity that emphasizes the problem as a focus, accompanied by activities to make concept maps, create tables, and reasoning maps. In physics learning, the model learning steps can be described as in Figure 1 below.

Learning outcomes are performance that can be observed in a person and are called capabilities [11]. Learning outcomes can be defined as the results of an interaction of learning and teaching actions [9]. Based on this description, the teaching action process ends with the process of evaluating learning outcomes. Another opinion about learning outcomes is the ability students have after receiving their learning experience [15]. Learning outcomes are changes in behavior, where these changes are reflected in cognitive, affective and psychomotor aspects [3]. Theoretically, there are several theories regarding the assessment of learning outcomes, but the ones that are commonly used are cognitive, psychomotor, and affective learning outcomes [4]. Learning outcomes can be seen from the evaluation of learning outcomes in which it contains activities to determine the extent of students' abilities in obtaining knowledge from the learning process. So it can be concluded that learning outcomes are an ability that students have after receiving the learning process or learning experience.

Creativity is the ability to produce new works from several combinations of works based on existing data, facts, information, or elements. Creative is something that results from an unusual way through the ability to think that can be used as a unique solution to a problem. [16] Creative thinking is needed in learning. Thought can be divided into two, namely: Convergent thinking is thought that aims to produce the correct answer from a test related to conventional intelligence. Meanwhile, divergent thinking is to produce many answers to the same questions and have more creative characteristics [16]. Creative thinking has several aspects, including fluency, flexibility, originality and elaboration [10]. Each aspect that is presented in the test used to measure creative thinking skills has several indicators that can be used to see the level of student creativity.

The application of problem based learning accompanied by 3D thinking maps can affect student learning outcomes. This is because problem solving activities through three-dimensional concept maps, data tables, and reasoning maps can train students to understand concepts in meaningful ways. Likewise, the problem based learning of a 3D thinking map dissertation can affect students' creative thinking abilities. This is because problem solving activities through concept maps, data tables, and reasoning maps can train students in terms of fluency, flexibility, originality, and elaboration. This study was to examine the effect of problem based learning accompanied by 3D thinking maps on creative thinking skills and student learning outcomes.

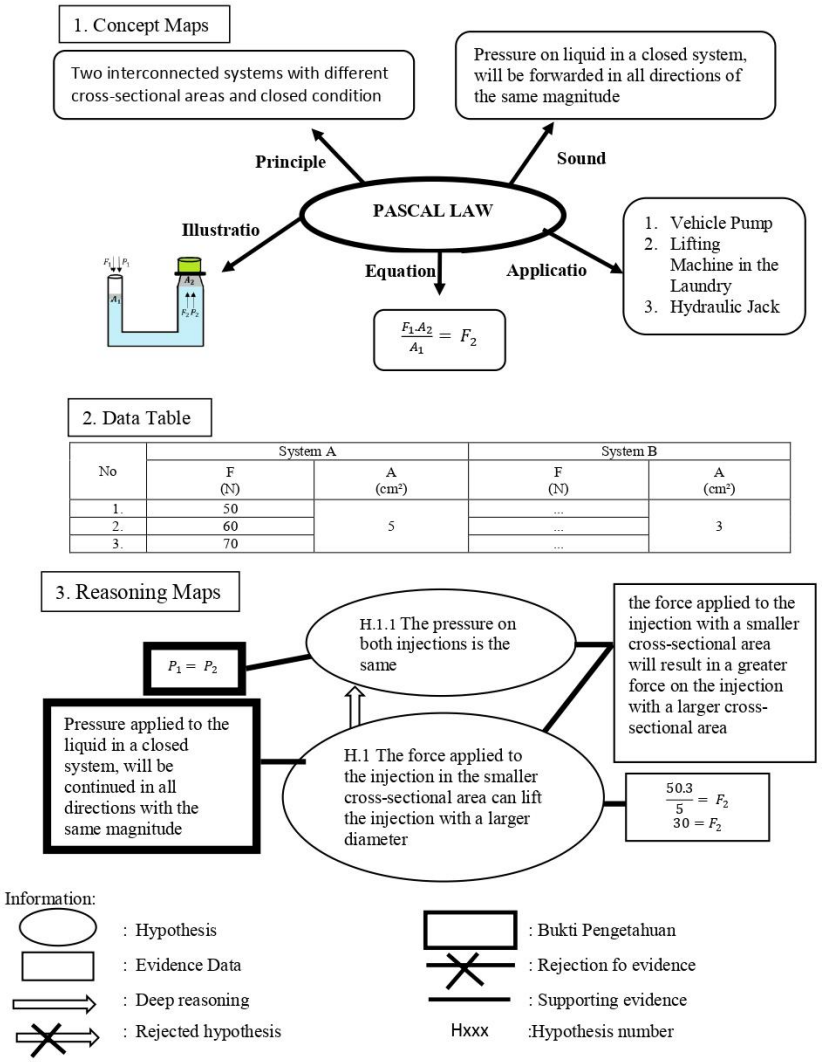

Figure 1. The steps of the learning model in physics learning

2. Methods

This type of research is experimental research. Experimental research is a type of quantitative research that compares one variable to another or connects two variables to determine a causal relationship between them [8]. The population of this research is the students of SMA Negeri Jenggawah. The research sample was the second grade students of SMA Negeri Jenggawah which consisted of two classes with 32 students each.

This research was conducted by giving different treatments to the control class and the experimental class. The treatment is in the form of giving learning using a problem-based learning model accompanied by a 3D thinking map and the control class being given learning using a model that is usually done by the teacher. The learning outcomes of the two classes were then compared. The research design used Post-test Only Control Design as shown in the figure:

R	X	O_1
R	-	O_2

Figure 2. Research Design Posttest Only Control Design

This study uses tests as a means of measuring students 'physics learning outcomes and students' creative thinking skills from the results of the learning process using a problem-based learning model with 3D thinking maps. The test given is in the form of questions obtained from the question bank in the form of physics textbooks for class XI, textbooks used by students, questions from the national exam preparation books, and teaching materials so that the posttest questions given to students do not need to be validated and reliability. Besides being used to measure learning outcomes, the test given can also be used to measure students 'creative thinking abilities, the test is in the form of descriptions that are adjusted to indicators of creative thinking where the answers to these tests can be used to measure students' creative thinking abilities. Posttest essay questions on creative thinking skills are questions made by researchers by modifying the questions used to measure creative thinking skills. The test kit contains several elements, namely questions, answer keys, test question grids and scoring rubrics. Analysis of the effect of the problem based learning model accompanied by 3D thinking maps on creative thinking skills used parametric analysis. The data normality test is used to determine the normal distribution of the sample under study. This statistical test uses the SPSS 23 application. If the sample has a Sig (2-tailed) value greater than 0.05, the study sample is normal. Normality test using Kolmogorov-Smirnov (K-S). Furthermore, a different test was performed using the independent sample t-test technique.

The analysis of the effect of the problem based learning model with 3D thinking maps on students' physics learning outcomes was carried out using non-parametric analysis. The data normality test is used to determine the normal distribution of the sample under study. This test uses SPSS 23 provided that if the sample has a Sig (2-tailed) value greater than 0.05, the sample is normal. Normality test using Kolmogorov-Smirnov (K-S). Furthermore, the difference test with non-parametric analysis using the Mann Whitney U-test technique.

3. Results and Discussion

3.1 Analysis of the Influence of the Problem Based Learning model and 3D Thinking Map on Creative Thinking Ability

The purpose of this study was to examine the effect of applying a problem-based learning model accompanied by a 3D thinking map on creative thinking skills. Based on these objectives, the post-test results will be compared in the control class and the experimental class. The result, the average in the experimental class is higher than the control class, but to be able to find out whether the Problem Based Learning model with 3D thinking maps has a significant effect on students' creative thinking skills in high school, further statistical tests are needed.

3.1.1. Normality test

The purpose of the normality test is to determine the normality of the posttest data on the ability to think creatively. This normality test is the first stage in analyzing statistical tests. The normality test used in this study is the Kolmogorov Smirnov test. The results of the normality test can be seen in Table 1 as follows:

Table 1. Results of the analysis of normality test data on creative thinking skills

		Experiment Class	Control Class
N		32	32
Normal Parameters[a,b]	Mean	79.03	59.72
	Std. Deviation	8.675	12.657
Most Extreme Differences	Absolute	.148	.147
	Positive	.148	.147
	Negative	-.131	-.107
Test Statistic		.148	.147
Asymp. Sig. (2-tailed)		.074[c]	.077[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Based on table 1, it is found that the significance value in the experimental class is 0.074 and the significance value in the control class is 0.077. To determine the normality of the data, the following guidelines are used:

- Data is normally distributed if the significance value (Sig. 2-tailed)> 0.05 then the test used must use a parametric statistical test (Independent Sample T-test).
- Data is not normally distributed if the significance value (Sig. 2-tailed) <0.05, then the test used must use a nonparametric statistical test (Mann Whitney U test).

Based on the Kolmogorov Smirnov normality table, the significance value of the ability to think creatively in the experimental class is 0.074 and 0.077 in the control class so that the value (Sig. 2-tailed)> 0.05. Based on the guidelines for determining the normality test decision-making, it can be concluded that the post-test data on the ability to think creatively are normally distributed, so that further data analysis uses a parametric statistical test, namely the Independent Sample T-test.

3.1.2. Difference Test

The difference test aims to see the difference in the results of the post-test on the ability to think creatively using the Independent Sample T-test. The results of the Independent Sample T-test can be seen in Table 2 below:

Table 2. The results of the analysis of the Independent Sample T-test for creative thinking skills

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	4.437	.039	7.120	62	.000	19.313	2.713	13.890	24.735
	Equal variances not assumed			7.120	54.859	.000	19.313	2.713	13.876	24.749

Based on the results of statistical tests using the Independent Sample T-test in table 2 above, it can be seen that the Sig value on the Levene's test is 0.039, which means that the sig value ≤ 0.05, it can be said that the data variant is not homogeneous so that the lines used are equal variances not assumed. Judging from the Equal variances not assumed it appears that the sig (2-tailed) value is 0.000. This study uses a one-sided test (t-tailed), then the sig. (p-value) is divided by 2 so that the p-value is 0,000. So 0.000 ≤ 0.05, therefore, according to the decision making guidelines above, it can be concluded that the null hypothesis H_0 is rejected and the alternative hypothesis H_a is accepted. Or in other words, the problem-based learning model with 3D Thinking Map has a significant effect on students' creative thinking skills in physics learning in high school.

3.2 Analysis of the Influence of the Problem Based Learning model with 3D Thinking Maps on Learning Outcomes

The second objective of this study is to examine the effect of the application of a problem based learning model accompanied by a 3D thinking map on learning outcomes of physics. From this goal, the researcher will compare the post-test results in the control class and the experimental class. As a result, the average post-test learning outcomes in the experimental class were higher than in the control class, but to be able to find out whether the problem-based learning model accompanied by 3D thinking maps had a significant effect on student physics learning outcomes in high school, a statistical test was needed which included:

3.2.1. Normality test

The normality test aims to determine whether the posttest data results are normally distributed or not normally and this normality test is the first stage in analyzing statistical tests. The normality test used in this study is the Kolmogorov Smirnov test. The results of the normality test can be seen in Table 3 as follows:

Table 3. Results of the analysis of normality test data on cognitive learning outcomes

		Experiment Class	Control Class
N		32	32
Normal Parameters[a,b]	Mean	81.25	70.94
	Std. Deviation	9.070	8.561
Most Extreme Differences	Absolute	.239	.261
	Positive	.167	.212
	Negative	-.239	-.261
Test Statistic		.239	.261
Asymp. Sig. (2-tailed)		.000[c]	.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Table 3 shows that the significance value in the experimental class is 0.000 and the significance value in the control class is 0.000 to determine that the data is normally distributed or cannot use the following guidelines:

- Data is normally distributed if the significance value (Sig. 2-tailed)> 0.05 then the test used must use a parametric statistical test (Independent Sample T-test).
- Data is not normally distributed if the significance value (Sig. 2-tailed) <0.05, then the test used must use a nonparametric statistical test (Mann Whitney U test).

Based on the Kolmogorov Smirnov normality table, the significance value of cognitive learning outcomes in the experimental class is 0.000 and 0.000 in the control class so that the value (Sig. 2-tailed) <0.05. Based on the guidelines for determining decision-making in the normality test, it can be concluded

that the post-test data on cognitive learning outcomes are not normally distributed, so that further data analysis uses a non-parametric statistical test, namely the Mann Whitney U test using SPSS 23.

3.2.2. Difference Test

The difference test aims to see the difference in the post-test results of cognitive learning outcomes using the Mann Whitney U test. The results of the Mann Whitney U test can be seen in Table 4 below:

Table 4. Analysis of the Mann Whitney U test results of cognitive learning outcomes

	Nilai
Mann-Whitney U	219.500
Wilcoxon W	747.500
Z	-4.105
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kelas

The results of the t-test in table 3.4 above show the value of Sig. (2-tailed) is 0.000. This study uses a one-sided test (t-tailed), then the sig. (p-value) is divided by 2 so that the p-value is 0,000. So 0,000 ≤ 0.05, therefore, according to the decision making guidelines above, it can be concluded that the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted, which means that there is a significant effect of the problem based learning model between the experimental class and the control class after being given different treatment. . It can also be said that the problem-based learning model with 3D thinking maps has a significant effect on students' cognitive learning outcomes in physics learning.

The results of the research hypothesis testing had a significant effect on the application of problem based learning accompanied by 3D thinking maps on students' creative thinking abilities. It was found that the hypothesis was accepted. Thus, giving different treatments to the control class and the experimental class resulted in a significantly different impact on students' creative thinking abilities. In theory, the problem based learning model provides training for students to solve problems. Students practice using materials and tools to test the hypotheses that have been made. This problem-solving exercise can be an impetus for the emergence of students' creativity in completing activities. In the process of testing the hypothesis, 3D steps are used, namely concept maps, data tables, and reasoning maps. The test results indicate that problem based learning accompanied by 3D thinking maps has a significant effect on students' creative thinking abilities. Thus, the results of this study are relevant to the results of research which states that the application of the problem based learning model has a significant effect on students' creative thinking abilities [13]. Likewise, the results of other studies which state that learning using integrated thinking map activities affect students' creative thinking skills [18]. Based on this description, it can be concluded temporarily that the problem based learning model accompanied by a 3D thinking map has a significant effect on students' creative thinking abilities.

The results of the research hypothesis testing had a significant effect on the application of the problem based learning model with 3D thinking maps on students' physics learning outcomes. It was found that the hypothesis was accepted. Thus, giving different treatments to the control and experimental classes has a significantly different effect on learning outcomes. In theory, the steps of problem-based learning accompanied by 3D thinking maps are to train students to solve problems through making concept maps, data tables, and reasoning maps. Thus, through repeated practice it will result in good learning performance. Based on this description, it can be interpreted that the results of this study are relevant to the results of research which states that the application of the problem-based learning model has a significant effect on learning outcomes in physics [5]. Likewise, the results of other studies which state that learning using 3D visualization techniques have a better impact on critical thinking skills and scientific attitudes [7]. Based on this description, it can be concluded temporarily that the use of a problem based learning model

accompanied by a 3D thinking map has a significant effect on the physics learning outcomes of high school students.

4. Conclusion

Based on the results and discussion, it can be concluded that there is a significant effect of applying the problem-based learning model with 3D thinking maps on the creative thinking skills of high school students and there is a significant effect of the application of the problem based learning model with 3D thinking maps on the cognitive learning outcomes of high school students

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