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Application of the Project-Based Learning Model to Improve Students' Creative Thinking Skills on Thermodynamics Material

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ABSTRACT

Creative thinking skills are high-level abilities that must be possessed by students in this globalization era. Creative thinking skills can be developed through learning that can involve students directly in the learning process. The Project-based learning model is a learning model that can involve students actively in the learning process. This study aims to determine the effect of the Project-Based Learning (PjBL) learning model to improve students' creative thinking skills on thermodynamics material. The population of this study was all XI IPA classes at SMAN 1 Pandeglang. The research sample was 30 students in class XI IPA 8 as the experimental class and 31 students in class XI IPA 1 as the control class. The research method used is a quantitative. This type of research is a quasi-experimental research design with a pretest-posttest nonequivalent control group design. The instruments used in this study were essay test questions with indicators of creative thinking ability, student response questionnaires, and observation sheets of learning implementation. The results of this study indicate an increase in learning outcomes (posttest) resulting in an N-gain calculation with a score of 0.62 for the experimental class which is higher than the score of 0.27 for the control class. With the help of the SPSS application version 26, it produces a prerequisite test that show the data is normally distributed and has the same/homogeneous variance. The results of the hypothesis test (t-test) using the Independent Sample T-Test test, the results show that there is an influence using the project-based learning (PjBL) model on students' creative thinking skills with a significance value of 0.000. This concludes that the project-based learning learning model can improve and influence students' creative thinking skills on thermodynamic material.

Keywords: *Project-based learning (PjBL), Creative thinking skills, Thermodynamics.*

INTRODUCTION

In developments in the era of globalization or the 21st century, humans must be faced with various challenges related to the field of technology and the field of knowledge, especially in the field of education. The skills or abilities or capacities that students must have in the era of globalization are 4C, namely: (1) ability to think critically and solve problems, (2) Ability to convey (Correspondence), (3) ability to collaborate, and (4) ability to imagine and developing (Mariam, Ismet, dan Kistiono, 2023). To support 21st century skills or abilities, the

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government in Indonesia has made improvements to the curriculum which was initially implemented in the 2006 curriculum into the 2013 curriculum. Learning also emphasizes students' ability to formulate problems, learn from various sources, think analytically, cooperate, and work together to solve problems. Students must have the ability to collaborate and think at a higher level (Simamora, 2022).

The learning process to achieve the 2013 curriculum objectives which are closely related to 21st century skills, requires learning methods or models that prioritize 21st century skills. Models that enable students to improve students abilities related to 21st-century skills, one of which is a learning-based model project (PjBL). In a project-based learning model, students determine their way of learning in groups and carry out research and creative projects that allow them to explore their knowledge (Artika, Uyun, and Isnaini, 2023). The Project-Based Learning (PjBL) model is a learning model that focuses on student activities. The use of learning models is important so that students are interested in participating correctly, actively, and creatively in the learning process (Rafik, Febrianti, Nurhasanah et all, 2022). The project-based learning model is an ideal model to be able to complete the goals of 21st-century education (Rusydiana, Nuriman, and Wardoyo, 2022).

The demands of the 2013 curriculum are student-centered learning, where teachers act as facilitators, motivators, and alternative learning sources. By curriculum needs, teachers design teaching materials that can train students to master the competencies that will be identified (Usmeldi and Amini, 2022). In the study of science, students learn not only how to understand concepts, but also how to acquire skills in the scientific process and apply them to projects. Students can play an active role in their learning, thereby increasing their awareness of the subject matter and achieving competency indicators in the scientific process (Setiawan, Suwondo, and Syafii, 2021). Physics lessons are concepts, knowledge, and ideas about the surrounding nature that are obtained based on experience through observation and applied in real life (Maulidina and Bhakti, 2020). Therefore, physics learning should provide a real and direct experience so that students can be more active in carrying out scientific processes.

Based on direct observation using an interview by one of the physics teachers at State High School 1 Pandeglang, several problems arise in the physics learning process. The first problem is the lack of motivation and interest of students in studying physics. This is because students only know physics about formulas without knowing the application of physics in real life. Second, the learning models and methods used still tend to use the lecture method, which causes students to become bored during learning. The third problem is that teaching and learning activities in class are still less effective because students tend not to pay attention to the teacher when presenting physics material, therefore, the average student’s final results tend to be low. To overcome this problem, there are various learning models and methods that can be applied in physics learning activities to improve students' creative thinking. One of the many appropriate learning models is the Project-Based Learning (PjBL) learning model.

Based on research conducted by (Kanza, Lesmono, and Widodo, 2020) it is stated that project-based learning is a learning model that can encourage students to be dynamic in learning in a joint effort to overcome problems so that they can grow a center of examples based on discoveries in assignments or efforts that have been made done. Research conducted by (Nurfa and Nana, 2020) revealed that the project-based learning model in physics learning can influence students' imaginative reasoning abilities because it is supported by project plans that suit the problem, teamwork in creating projects and teacher assignments, as well as imaginative thinking that students found. Likewise, project-based learning can be utilized as a fundamental option to realize materials science that effectively includes students.

The Project-Based Learning (PjBL) learning model is a learning process that can produce a project and involve students directly. Project-based learning is a learning model that requires skills using the principle of learning by doing (Lion, Ludang, and Jaya, 2022). According to research (Munandar, 2012) learning using the project-based learning model can improve creative thinking skills through involving students in real experiences and becoming autonomous and independent learning. Students can develop their creative thinking abilities by fulfilling aspects of creative thinking, namely thinking fluently (fluency) in solving a problem, thinking flexibly (flexibility) which can produce several thoughts to solve problems, thinking original originality) to provide opinions that are different from other people and detailed thinking (elaboration) to be able to develop ideas. Research conducted by (Nuraini and Muliawan, 2020) shows that 95% of students are interested in studying science if the material is related to everyday problems or in real life. Project-based learning can be used to develop science process skills, so that students can be more creative, active, and have the skills to create a project/product that has benefits and quality (Nasir, Fakhrunnisa, and Nastiti, 2019).

Based on several existing studies, the Project-Based Learning learning model can be said to be a learning model that can improve students' creative thinking skills. The author chose the Project-Based Learning learning model as a learning model that was tested on class XI students on Thermodynamics material. The subject matter was chosen because thermodynamics is a material that is widely applied to everyday life. There are many everyday equipment that work according to thermodynamic principles, examples of such equipment are vehicle engines, heat engines, air conditioners, and so on. Based on this example, the author chose the Project-Based Learning (PjBL) learning model because it is suitable for delivering thermodynamics material to students. This research aims to determine the effect of the Project-Based Learning (PjBL) learning model to improve students' creative thinking skills in thermodynamics material in class XI Science. The results of this analysis include the results of class XI pretest-posttest questions before and after the Project-Based Learning (PjBL) learning model was treated on thermodynamics material.

METHODS

This research aims to determine the improvement and impact of the project-based learning (PjBL) learning model on students' creative thinking skills. The type of research used in this research is quasi-experimental with a pretest-posttest nonequivalent control group design, which is research carried out in two groups, namely the experimental class and the control class. The experimental class is a class that is treated with a project-based learning model while the control class is a conventional learning model (lecture) (Sugiyono, 2013). The population of this study was all class XI Science at SMAN 1 Pandeglang. Next, two classes were selected to be treated with these 2 learning models. The technique for selecting the 2 classes used a purposive sampling technique, this is because the 2 classes were selected by the physics teacher concerned. The classes selected were 30 students from class XI IPA 8 as the experimental class and 31 students from class XI IPA 1 as the control class. Classes XI IPA 8 and XI IPA 1 are treated the same at the beginning of learning, namely the pretest (initial test) and at the end of learning posttest (final test). To see more clearly the research design, see the following Table 1

Table 1. Pretest-Posttest Nonequivalent Control Group Design Research Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Information:

O_1 = Pretest in the experimental class before treatment is given

O_3 = Pretest in the control class before treatment is given
O_2 = Final test (Posttest) in the experimental class that was given treatment
O_4 = Final test (Posttest) in the control class which was not given treatment
X = Learning using the Project-Based Learning learning model

Pretest and posttest data taken are learning outcomes based on indicators of creative thinking abilities. There are 4 indicators of creative thinking, namely fluency, originality, flexibility, and elaboration. The pretest and posttest questions are essay questions totaling 8 questions. The essay question instrument was tested using empirical validation using the AnBuso version 8.0 software application after being tested on class XII Science students who were not the research sample. The supporting instrument to see the improvement and influence of using the project-based learning model is a questionnaire sheet on student responses to the project-based learning model.

After getting the pretest data, the posttest obtained the gain values for the two classes. Gain data is data on the difference in value from the posttest results pretest and posttest. Results from the pretest, posttest, and gain were then tested for normality and homogeneity. If both data have a normal and homo distribution (same variance) then continue using the T-Test (Independent Sample T-Test). Normality, homogeneity, and T-test tests use the help of the SPSS Statistics 26 software application. Normality tests, homogeneity tests, and T-tests use a significance level of 5%. Normality test using Shapiro-Wilk. The homogeneity test was carried out using the Levene test statistics, and the T-test using the Independent Sample T-Test.

Shapiro-Wilk test is carried out with the guideline that if the significance value (sig. value) is less than 0.05 then the data is not normally distributed, conversely, if the significance value (sig. value) is more than 0.05 then the data is normally distributed. The homogeneity test is carried out using the Levene test. The guideline for using the Levene test is that samples can be said to have the same/homogeneous population variance if the calculated probability value is greater than 0.05 ($p > 0.05$). Hypothesis testing in this research uses the Independent Sample T-test. This test uses hypothetical decision-making which is guided by the following decision base, namely H_a means there is a significant difference in creative thinking skills between students who are taught and those who are not taught using the PjBL learning model, while H_0 means there is no significant difference in creative thinking skills. significant between students who received treatment using the PjBL learning model and students who did not receive treatment using the PjBL learning model. For hypothesis decision-making, use acceptance or rejection of the null hypothesis (H_0) namely

(1) H_a is accepted and H_0 is rejected, if the calculated $t_{value} > t_{table}$, or sig. probability value < sig (α) 0,05
(2) H_a is rejected and H_0 is accepted, if the calculated $t_{value} < t_{table}$, or sig. probability value > sig (α) 0,05.

RESULTS AND DISCUSSION

Results

Quantitative data is the result of data from this research. The data obtained are the results of pretest and posttest based on creative thinking indicators. Apart from that, the student response questionnaire supports the results data regarding the project-based learning model on thermodynamics material. The recapitulation of the results from the experimental and control classes on thermodynamics material is in Table 2 below.

Table 2. Recapitulation of Pretest and Posttest Data for Experimental and Control Classes

Class	*Pretest average*	*Posttest average*	N-gain average	Criteria
Experiment	43.1	79.3	0.62	Currently
Control	43.6	59.4	0.27	Low

Based on the recapitulation of pretest and posttest data for the experimental and control classes in Table 2, the results showed that the average pretest and posttest scores in the experimental class and control class were different. The average pretest score in the control class was 43.6 higher than the average pretest score in the experimental class, namely 43.1. However, after receiving different treatments during teaching and learning activities between the experimental class and the control class, each of them showed an increase in creative thinking abilities, namely the average posttest score for the experimental class was 79.3 higher than the average posttest score. control class, namely 59.4. Based on Figure 1, the average N-gain score in the experimental class is 0.62 in the medium criteria. Meanwhile, the control class got an average N-gain score of 0.27. The experimental N-gain score value is greater than the control class N-gain score value. This proves that there is an increase that occurred in the experimental class which used the project-based learning model compared to the increase that occurred in the control class which used the conventional learning model.

After processing the pretest and posttest data, statistical tests are needed in the experimental class and control class in the form of normality tests, homogeneity tests, and hypothesis tests. This is done to prove the influence of the project-based learning (PjBL) learning model on students' creative thinking skills. The Normality Test is carried out to determine the significance of data distribution, and whether the data used is normal or not. The Homogeneity Test aims to find out whether the data used by researchers is homogeneous or not. Hypothesis testing (T-test) is used to determine whether there are differences between before and after using the project-based learning model in the control and experimental classes. Table 3. shows the data from statistical calculations of normality tests using the SPSS version 26 application.

Table 3. Recapitulation of Normality Test Creative Thinking Ability Test Pretest, Posttest and Gain

Tests of Normality	Class	Sig. Shapiro-Wilk	Information
Pretest	Experimental	0.094	Normal Distribution
	Control	0.056	
Posttest	Experimental	0.052	
	Control	0.053	
Gain	Experimental	0.696	
	Control	0.109	

Based on Table 3, we obtained recapitulation data for normality tests from pretest, posttest, and Gains. The basis for decision-making in the Shapiro-Wilk normality test is if the sig. > 0.05 then the data used is normally distributed, conversely, if the value is sig. < 0.05 then the data used is not normally distributed. Based on the data obtained, the pretest, posttest, and Gain data in the experimental class and control class had a significance level of more than 0.05. Based on the data, the pretest significance value (sig.) of the experimental class students' creative thinking ability was 0.094 and the control class was 0.056. The significance value (sig.) of the posttest creative thinking ability of experimental class students was 0.052 and the control class was 0.053. The significance value (sig.) of the gain in creative thinking abilities of students in the experimental class was 0.696 and in the control class was 0.109. This shows that the pretest, posttest, and Gain value data are The experimental and control classes that were normally distributed and met the normality test requirements. The homogeneity test is used as a condition for using hypothesis testing (t-test). Table 4. Shows data from statistical calculations for homogeneity tests using the SPSS version 26 application.

Table 4. Recapitulation of Homogeneity Test for Creative Thinking Ability Test Pretest, Posttest, and Gain

Homogeneity Test	Levene Statistic	Information
Experimental and control class pretest	0.473	homogeneous
Experimental and control class posttest	0.171	
Gain	0.381	

Based on Table 4, we obtained recapitulation data for the homogeneity test from the pretest, posttest, and Gain for the experimental and control classes. Data will be said to be homogeneous if the significance value (sig.) is more than 0.05 (sig. > 0.05) while data is said to be inhomogeneous if the value is less than 0.05 (sig. < 0.05). Based on the data obtained, the pretest data for the experimental and control classes received a sig value. 0.473, posttest data for the experimental and control classes got a sig value. of 0.171 and the data gain gets a sig value. of 0.381. Analysis of the results of pretest, posttest, and Gain data shows that the sig. A value above 0.05 means that the data used in the pretest, posttest, and gain data have a population with the same/homogeneous variation. After carrying out normality and homogeneity tests, and obtaining normal and homogeneous data, a hypothesis test (t-test) is carried out. Hypothesis testing was carried out to determine whether there were/are not differences in creative thinking skills after and before the project-based learning model was implemented. Table 5. Shows a table of hypothesis test results (T-test) before and after project-based learning.

Table 5. Table of Hypothesis Test Results (T-Test)

Independent Samples Test							
		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Gain	Equal variances assumed	.778	.381	6.425	59	.000	20.39355
	Equal variances not assumed			6.405	56.445	.000	20.39355

Table 5. Shows the hypothesis table, based on the results of the table above, the hypothesis results were obtained using the independent samples T-test, the value $t_{calculated}$ = 6.425 and t_{table} = 2.001. Comparison of the $t_{calculated}$ and t_{table} values in the results that have been obtained, so it can be concluded that $t_{calculated} > t_{table}$ (6.425 > 2.001) so H_0 is rejected and H_a is accepted. Apart from that, the significant value (2-tailed) in the table is 0.000. This value shows

that the significant value (2-tailed) is smaller than 0.05 (0.000 < 0.05). Based on these calculations, it can be concluded that there is a significant difference in creative thinking skills between students who are taught and students who are not taught using the Project-Based Learning (PjBL) learning model. This is supported by the results of student questionnaires that received good responses to this project-based learning model.

Discussion

This research was conducted at SMAN 1 Pandeglang to determine the influence of the Project-Based Learning (PjBL) model in improving students' creative thinking skills in physics, especially in thermodynamics. Students' creative thinking abilities at the beginning of the meeting in both classes were relatively low. Therefore, to determine the effect of implementing the project-based learning (PjBL) learning model, the experimental class was treated using the project-based learning model while the control class learning was carried out using the conventional learning model. After treating the learning models in the two different classes, then to see the differences between the two classes, namely by looking at the results of the posttest on creative thinking abilities in the two classes. The posttest results obtained show that there is an influence from the application of the project-based learning model to improve creative thinking abilities. According to research conducted by (Nelson and Tarigan, 2022) the benefits of using the project-based learning model are that it can increase motivation, improve problem-solving abilities, students' skills in working in a group, and improve students' skills in obtaining and searching for information. In this study, it shows that the average posttest score for the experimental class was 79.3 higher than the average score for the control class, namely 59.4. In the posttest scores in the experimental class and control class, the scores for both classes increased, however, the average value of the experimental class got a higher increase compared to the average value of the control class.

Based on the average posttest score, it was stated that the average posttest score for the experimental class increased more than the average posttest score for the control class. This is because in learning using the project-based learning model students are more active in the learning process. By the syntax contained in the project-based learning model, students themselves search for and find projects related to the material being taught by relating it to everyday life. This is the same as research conducted by (Safriana, Ginting, and Khairina, 2022) which said that after using the project-based learning (PjBL) learning model, the average posttest score for the experimental class was higher than the average posttest score for the control class which used the model. conventional learning because in the project-based learning, model there is a syntax that can direct students to understand the problems in the discourse.

Factors that can improve creative thinking skills are student involvement in completing projects carried out by the students themselves to help develop their creative thinking skills. Based on the research results, students appear to be more active and more enthusiastic during the learning process using the project-based learning model compared to students who use conventional learning models. This can be seen from the results of the student response questionnaire that 73.5% of students were in the good category. This is supported by the results of research conducted by (Safriana, Ginting, and Khairina, 2022) which shows that the project-based learning model can improve creative thinking abilities based on the research students consider the project-based learning model to make it easier for them to discover concepts directly, learning using this model can produce products that can improve students' creative thinking abilities. Supported by research conducted by (S. Y. Sari and Dewi, 2018) one of the factors of the project-based learning model is to encourage students, especially students, to maximize their creativity and critical thinking abilities through creative and investigative activities. Research conducted by (Shalihah, Dafik, and Prastiti, 2020) shows that creative thinking skills increase by involving students in problem-solving, for example analyzing questions, finding easy techniques for answering questions, being on time in completing assignments, and answering questions in detail.

According to the results of the data analysis that has been described in the research results, it was found that the average gain value of students' creative thinking abilities before and after learning using the project-based learning model experienced a more significant increase compared to students who did not use the project-based learning model. This can be proven by the average score of the final results in the experimental class of 0.62 in the medium category which is greater than the average score of the final results of the control class of 0.27 in the low category. Based on the N-gain results conducted by researchers, the N-gain results are also supported by research carried out by (Luthvitasari, Putra, and Linuwih, 2013) in whose research students' creative thinking skills received an N-gain value of 0.67 in the medium category and experienced a significant increase before and after the project-based learning model was implemented. These results are supported by the results of relevant studies, which stated (Artini, 2019) if based on the results of the research, the average value of the class using the project-based learning model is statistically greater than the average value of the class using the conventional learning model. This means that there is a comparison of the average scores of students who use the project-based education model with students who use the conventional education model. The creative thinking abilities of students who are taught using a project-based learning model are better than students who do not use a project-based education model. Apart from that, the results of research conducted by (Sukmawijaya, Suhendar, and Juhanda, 2019) show that the project-based learning model can improve the results of creative thinking abilities with an average N-gain value in the control class of 0.47 lower than the average value the average N-gain for the experimental class is 0.71.

The results of the T-test in the research obtained a significant value (2-tailed) of 0.000, this means that there is an influence between students who received the project-based learning model treatment and students who used the conventional model. This matter is supported by research conducted by (S. P. Sari, Manzilatusifa, and Handoko, 2019) based on the results of his research, it was found that there was a comparison of students' creative thinking abilities between the experimental class and the control class, not only that based on the gain formulation in his research which was obtained. increase in students' creative thinking abilities in the experimental class. Research that supports that the project-based learning model can improve creative thinking skills in physics lessons is research conducted by (Umamah and Andi, 2019) showing that the results of the experimental class achieved creative thinking skills that are significantly higher than the control class.

Based on the results of observations of creative thinking skills during the learning process, the findings found were that the results of creative thinking skills showed increased scores in the experimental class. The results of student responses in this research also show good responses from students to the project-based learning model on thermodynamics material. The use of the project-based learning model to improve students' creative thinking skills in this research has limitations, namely limited time during learning. This is to research conducted by (Tyaningsih, 2022) that the research carried out took quite a long time. Several students who immediately responded to work according to the deadline given, but several students worked on the project at the last minute. This will affect the quality of students' work. The results of work that is made wholeheartedly and done for quite a long time compared to student work that is made in a relatively short time will certainly be different. Therefore, researchers try to overcome this by instructing students to prepare materials and projects at home with group work and monitoring can be done online, so that when learning takes place it can save time.

CONCLUSION

Based on the analysis results, the conclusion is that the implementation of the project-based learning (PjBL) model has a significant effect and improvement on creative thinking skills in thermodynamics material. The increased creative thinking abilities can be seen based on the N-gain value and hypothesis testing. The gain and hypothesis test values were obtained from the pretest-posttest after and before the project-based learning (PjBL) learning model was carried out. Learning that uses the project-based learning model experiences significant differences compared to that that uses the conventional model and the increase in creative thinking abilities is at a fairly large level. This is supported by the results of student responses to learning using the project learning model-based learning gets a good response. Based on the results and discussion, it is concluded that the Project-based learning model is effective for use in teaching physics, especially in thermodynamics material at the high school level, particularly in enhancing creative thinking skills.

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