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APPLICATION OF THE PJBL-STEM LEARNING MODEL ON SMOKELESS INCENERATOR DEVICE ON TEMPERATURE, HEAT, AND EXPANSION TO IMPROVE THE COGNITIVE LEARNING OUTCOMES OF STUDENTS OF CLASS VII SMPN 1 TAPUNG HULU

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ABSTRACT

The purpose of this study was to describe student learning outcomes using the PjBL-STEM learning model using smokeless incenerator burner media. Location This research took place at SMPN 1 Tapung Hulu in the Kampar Regency of Riau Province. The research approach utilized was Quasi Experimental Design employing the Posttest Only Non-Equivalent Control Group Design technique. The participants in this research included 176 students. The study involved resulting in a total of 59 participants. The cognitive abilities assessment tool, structured as a posttest, includes 15 multiple-choice questions for data collection. The analysis method used comprised descriptive analysis by determining the average student performance and inferential analysis that involved normality tests, homogeneity tests, and hypothesis testing. The findings from the descriptive analysis show a difference in absorption power between the experiment class and the control class, specifically 72.1% and 63.4%, respectively, indicating that the PjBL-STEM model used on the smokeless waste burner is more effective than the control class. The PjBL models grounded in STEM that utilize smokeless waste burner media can serve as an alternative applicable in the science education process within schools to enhance students' cognitive learning results. The results of the inferential analysis from the Hypothesis Test in this study show that the independent sample T-test yielded at value of 2.653 with a significance (sig. 2-tailed) of 0.010.

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1. INTRODUCTION

Education is one of the factors that can be seen for the quality of a country. Schools are state institutions that can play a role in providing quality human needs in the field of education. Quality humans will improve the quality of a country. Efforts to improve human quality cannot be separated from education (Azhari & Kurniady, 2016). Education plays a very important role in a country because it is the initial foundation for human resource development In accordance with Number 20 of 2003, in the Law of the Republic of Indonesia, concerning in the National Education System, which can be concluded that the function of National Education is to develop the ability to live well from intelligence to the ability to live and form the character and civilization of a dignified nation based on faith and become democratic and responsible citizens. To achieve the goals of national education, it must be in line with the development and progress of science and technology that exist now. (Hidayat, Ag, & Pd, nd, 2019)

Arranging the efficient curriculum and education system, managing education management, improving the quality of teaching staff, and implementing information technology in education are some of the steps taken by the government to improve the quality of education. The Independent Curriculum is expected to be able to improve the quality of education in Indonesia and students' interest in learning, because the Independent Curriculum offers a more effective concept, so that students have enough time to understand the concept and strengthen their competence. Teachers have the right to choose various learning tools so that the learning process can be adjusted to the needs and interests of students. (Ministry of Education, Culture, Research and Technology, 2022). Teaching materials consist of resources that are organized methodically and showcase the skills students need to acquire. For instance, textbooks, lesson kits, modules, audio instructional materials, handouts of LKPD, and so on.

Science learning requires students to be able to understand concepts, demonstrate scientific attitudes, ask questions and make observations about the natural environment and be able to present simple reports of observation data (Ministry of Education and Culture, 2016). Science has different characteristics from other subjects, concepts, principles, laws and theories in science are products obtained through a systematic and planned process starting from curiosity about natural phenomena. Asking as a form of curiosity is continued by formulating problems, hypothesizing, designing and conducting experiments, collecting data and concluding until a solution is obtained to the problems that have been formulated. By carrying out learning activities with appropriate teaching materials, the right models and methods in a class can increase student motivation and learning outcomes.

A teacher must master what is called pedagogy. Pedagogical competence refers to a teacher's skill in overseeing the learning experience of students. Management of the educational process definitely involves execution, assessment, and personality growth of learners (Wahyudi, 2012). Numerous students struggle to grasp the concept of science due to the traditional teaching methods employed by instructors, which render the learning experience monotonous and ultimately hinder effective learning. Numerous students struggle to answer the provided questions, particularly when grasping concepts that involve calculations. This situation results in the quality of learning outcomes in science content being below acceptable standards. One solution that can overcome this problem is that teachers must be innovative and creative in developing variations of learning models that suit students' needs. It is hoped that the variations made to learning methods will make students interested in studying science and understand the concepts of the methods usually used so that they can improve students' cognitive learning outcomes. Therefore, one strategy that can be used to improve high-level thinking skills is to use a learning model that is not teacher-centered but must be student-centered.

Learning should be a vehicle for mastering concepts that are useful for solving problems in everyday life. STEM-based education represents an interdisciplinary method combining Science, Technology, Engineering, and Mathematics, where these four components work together harmoniously to address real-world issues through problem-based learning. (Torlakson, 2014). Project Based Learning (PjBL) is an educational approach that focuses on addressing real-life problems encountered daily through hands-on learning experiences within the community. PjBL can likewise be viewed as project-oriented learning, experiential education, or genuine learning grounded in real-world issues. Project Based Learning (PjBL) is a modern educational approach focused on students (student centered) and positions teachers as motivators and guides, allowing students the chance to work independently to build their knowledge (wardani, 2018).

Based on the survey and interviews obtained, grade VII students of SMPN 1 Tapung Hulu regarding student perceptions of science learning in schools that almost all grade VII students lack understanding of science concepts, this is because in the learning process carried out by teachers using conventional learning methods makes learning monotonous so that learning is not optimal. During the learning that took place at SMPN 1 Tapung Hulu in the 2023/2024 academic year in the previous material, students were less able to solve the questions given, especially in understanding the concept of calculation. This condition causes learning outcomes in science material to be less than satisfactory. This can be seen from the daily science test scores of grade VIII students of SMPN 1 Tapung Hulu in the attached data, the average class score is 30.862 to 42, far below the KKM. In class A only 5 people have a score of 60 and above and in class D there are 4 people who have a score of 60 and above. It can be seen that the cognitive learning outcomes of vulnerable students are still low and lack skills in real learning practices. The variety in learning methods and facility utilization has resulted in low student motivation and learning outcomes. Although the facilities are quite good and complete with tools and materials, they are rarely used in the science laboratory for direct learning. Based on the survey data, researchers are interested in integrating STEM with the PjBL method as an effort to increase learning interest and thus improve student learning outcomes.

It is important to note that STEM integrates four elements, including technology. The use of technology in the 21st century is closely related to scientific advancement. The use of technology in education can be an option for teachers in implementing learning. Technology-based media is not limited to software and virtual media, but can also take the form of technological objects that exist in human life. One example of technology-based media is the smokeless incinerator, which can burn waste without smoke. This was created by humans to facilitate waste processing while minimizing environmental pollution (Yanti *et al*. 2024). The smokeless incinerator can be used as a learning medium for students at SMPN 1 Tapung Hulu because this tool is available there as one solution for utilizing technology as a learning medium by teachers to explain the concepts of temperature, heat, and expansion that occur during the combustion process.

This research has been conducted by several previous researchers. One of the researchers used the STEM-integrated PjBL learning model using E-LKPD as a learning medium conducted by Melania Sandri Ayuni, et al. (2022), the results of the study showed a significant difference between scientific reasoning abilities and student learning outcomes. Based on the description above, researchers are interested in using the same learning model, namely STEM-integrated PjBL with a smokeless incinerator as a learning medium. The research to be conducted is entitled "Application Of The PjBL-STEM Learning Model on Smokeless Incenerator Device on Temperature, Heat, and Expansion to Improve the Cognitive Learning Outcomes of Students of Class VII SMPN 1 Tapung Hulu".

2. METHOD

This study was carried out at SMPN 1 Tapung Hulu, Kampar Regency, Riau Province. The research employed a *Quasi Experimental Design* utilizing the *Posttest Only Non-Equivalent Control Group Design* approach in Table 1 below:

Table 1. Research Design

Group	Treatment	Posttest
Experiment	X1	O1
Control	-	O2

Source: (Sugiyono, 2021:132)

Where, x1 is learning using STEM-PjBL media using smokeless waste burners, o1 is posttest results of the experimen class, o2 is posttest result of control class.

The study research population comprised 143 students in grade VII phase D. The sample included 59 students, where class VII D had 29 students as the experimental group, while class VII A included 30 students as the control group. Based on table 1, both classes of students were given treatment, namely the learning process using the STEM-PjBL Approach using smokeless waste incinerator media. After the treatment was completed, the students were then given a final test (post-test) to see if there was an increase in student learning outcomes after being given treatment. When giving the posttest, both classes were given the same number of questions and time. The results of the two classes were used as data which were later compared using statistical analysis.

This research was conducted descriptively and inferentially. The intended descriptive analysis is the students' absorption capacity calculated based on the benchmark assessment, with the formula:

$$\text{Hasil Belajar Kognitif} = \frac{Jumlah\ Jawaban\ Benar}{Jumlah\ Soal} \times 100 \quad (1)$$

The values obtained are then grouped into four categories, namely very good, good, quite good, and less good. The categorization of students' absorption power can be seen in table 2.

Table 2. Student Absorption Capacity Categories

Category	Score Interval
Very good	85 -100
Good	70 - 84
Little good	50 - 69
Not good	0 - 49

Source: (Ministry of National Education, 2006).

Inferential analysis was performed following descriptive analysis. Inferential analysis was employed to identify the differences in learning outcomes between students utilizing PjBL-STEM media smokeless waste burners in the experimental group and those in the control group using traditional learning models, via hypothesis testing. The study employed inferential data analysis, utilizing the Kolmogorov-Smirnov test technique for the normality assessment, facilitated by SPSS. Furthermore, in this study, the homogeneity test was conducted on secondary data in the form of daily test scores obtained from Science Teacher data at SMP Negeri 1 Tapung Hulu using the Levene technique with the help of SPSS. Then a hypothesis test was conducted to test the truth based on the data obtained from the research sample. If the data obtained is normal, then the technique used for the hypothesis test in quantitative data analysis uses the independent sample t-test technique. The hypothesis test (T test) with this technique determines whether there is a significant difference in the cognitive learning outcomes of students in the experimental and control classes.

3. RESULTS AND DISCUSSION

The study aimed at enhancing students' cognitive learning outcomes by utilizing the PjBL-STEM model with smokeless waste incinerator media for the topics of temperature, heat, and expansion in class VII at SMPN 1 Tapung Hulu includes three variables: independent variables, dependent variables, and control variables. The independent variable is the use of the PjBL-STEM model with smokeless waste incinerator media, whereas the dependent variable is the cognitive learning outcomes of the students, and the control variables include the same teacher and teaching materials. This study uses the PjBL-STEM learning model with smokeless waste incinerator media, where children create STEM-based projects based on this smokeless waste incineration technology to understand the concept of temperature, heat, and expansion. The step of the project implementation schedule are as follows in Table 3 below:

Table 3. Step of the project implementation schedule.

Meet	Syntax / Step
Meeting 1	• Problem introduction The introduction of the problem here is done by opening the learning with a question that is related to the material, such as "How is the smokeless waste incinerator related to the material on temperature, heat, and expansion?", and is carried out at the first meeting • Project planning Project design here students are directed to find out what a waste incinerator is first. How it works and collect relevant information. Students discuss making a project plan including division of tasks, preparation of tools, materials, media, and sources needed. This project design is carried out at the first meeting before making the project. The following are the results of the project planning that have been made by students in Figure 1 below.

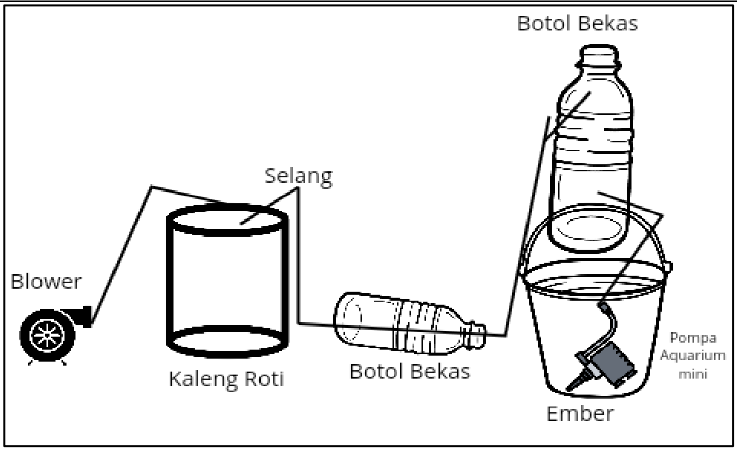

Figure 1. Product design sketch

- Project scheduling
  It took 5 meetings to complete the material on temperature, heat, and expansion with this model.

Meeting 2

- Project implementation and mentoring.
  Project implementation and mentoring is done after designing the project. Carrying out this activity is accompanied by a teacher as a mentor for the project.
- Testing project results
  Students try the tool and present it in front of the class. It can be seen in picture 2 below.

Meeting 3

Figure 2. Product results

- Evaluation
  The teacher evaluates the product and together with the students concludes the project results to understand the temperature material.

Meeting 4 The project product is used for heat.

Meeting 5 Project products are used to explain expansion.

3.1. Descriptive analysis

This descriptive analysis includes the absorption power and effectiveness of learning. Data for this descriptive analysis were obtained from the cognitive learning outcomes of students in the experimental class and control class in the form of final learning outcome scores (posttest). Science learning outcomes on the material of temperature, heat and expansion were analyzed through the average absorption power and effectiveness of learning using the calculations in equation 1. Student learning outcome data can be seen in table 3 below:

Table 4. Students' absorption of material on temperature, heat and expansion

No	Value Interval (%)	Category	Experimental Class		Control Class	
			Amount Student	Percentage (%)	Amount Student	Percentage (%)
1.	85 < M ≤ 100	Very good	6	20.6	3	10
2.	70 < M ≤ 85	Good	7	24.1	2	6.6
3.	50 < M ≤ 70	Pretty good	15	44.8	17	56.7
4.	M < 50	Not enough	1	10.5	8	26.7
Average %				72.1		63.4
Category				Good		Pretty good

Based on table 3, it can be seen that the absorption power between the experimental class and the control class is different. The average absorption power of students in the experimental class that applies the STEM integrated PjBL learning model on the waste incinerator is higher than the control class that applies conventional learning, with a difference between the two classes of 8.7. In accordance with the average absorption power obtained in table 3, the effectiveness of learning through the application of the PjBL-STEM learning model with smokeless waste incinerator media is effectively used compared to the control class using the conventional method.

The indicators of students' cognitive learning outcomes based on Bloom's taxonomy test indicators consist of six indicators, namely C1-C6 (Winarti & Istiyono, 2020: 22-24). The explanation of students' cognitive learning outcomes for each indicator is as follows:

1) Remembering (C1)

Remembering is an effort to retrieve knowledge from past memories, both newly acquired and old knowledge (Gunawan & Palupi, 2016:105). The distribution of cognitive ability posttest questions is spread across 2 questions for the cognitive level of remembering, namely questions number 2, 4, and 6. In question number 2, students are asked to understand the concept of temperature by explaining the meaning of temperature, for question number 4 students are asked to be able to determine the comparison between temperature scales, then number 6 students can explain heat transfer, one of which is through radiation.

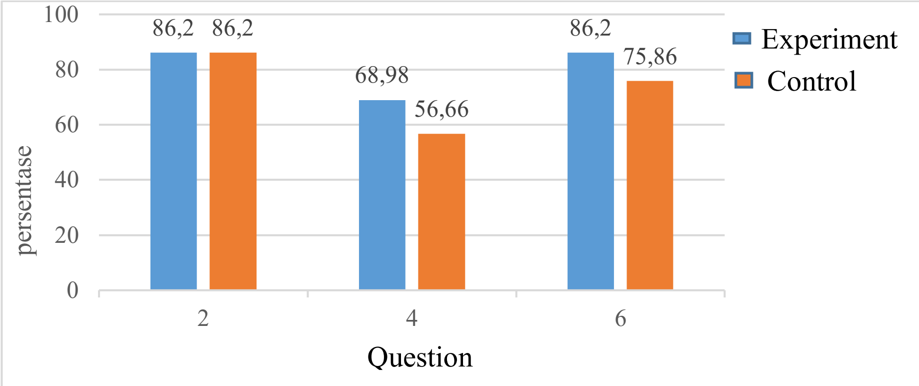

Figure 3. Percentage Distribution of Cognitive Results C1

In Figure 3, questions that have the same correct level between the two classes can occur due to many factors in problem solving when experimenting. Overall, better absorption was obtained in the experimental class compared to the control class for question indicator C1. The ability to remember students in the experimental class tends to be higher than the ability to remember students in the control class. This is because learning with PjBL-STEM does not require students to memorize, but to observe and carry out activities directly to find information independently and relate it to the concept of temperature and heat with smokeless waste incinerator media. This is in line with research (Jaka Afriana, 2022) which reveals that learning with PjBL-STEM does not require students to memorize but to find information independently by producing a product.

2) Question indicator C2 (Comprehension)

Understanding is building a meaning or an understanding that causes someone to know what is being communicated and can connect what is being communicated without connecting it to anything else (Gunawan & Palupi, 2016:106).

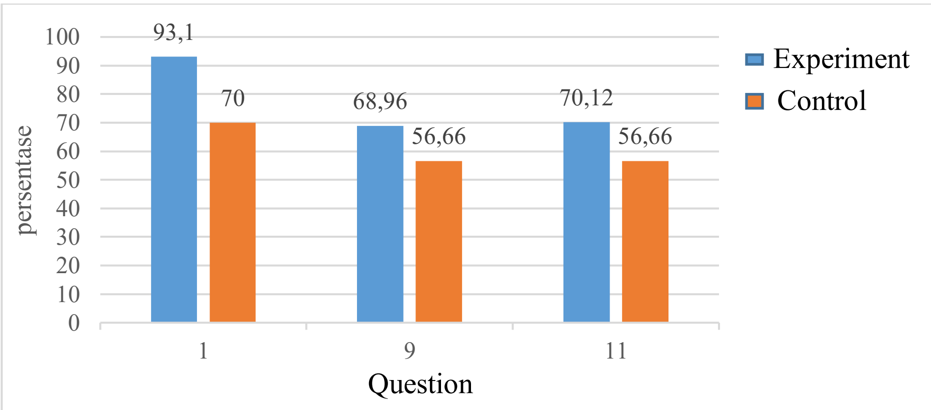

Figure 4. Percentage Distribution of Cognitive Results C2

In Figure 4, it can occur due to differences in teaching methods, in question no. 1, the indicator is that students can find out about temperature measuring instruments. In the experimental class, temperature measuring instruments are directly introduced and how to use them when the project to make a simple smokeless waste burner is taking place, while the control class only uses book references so that there are differences in learning outcomes. In question number 9, the experiment class has a higher absorption score compared to the control class. The experiment class has a value of 68.96, while the control class has a value of 56.66; for item number 9, students are instructed to provide examples of heat transfer in daily life shown with images.

This is in line with (Maulana, 2020) who also conducted research using PjBL-STEM which had higher cognitive learning outcomes in the experiment class than the control class, this was because both classes had learning experiences in different ways. Number 11 students were asked to be able to explain the concept of expansion, the absorption score of the experiment class was higher than the control class. Overall, better absorption was obtained in the experiment class compared to the control class for the C2 question indicator.

3) Question indicator C3 (Application)

Applying or implementing refers to the cognitive process of utilizing a procedure in conducting an experiment or solving a problem. Applying means using formulas, equations, formulas, methods, and principles in a particular context (Gunawan & Palupi, 2016:106-107).

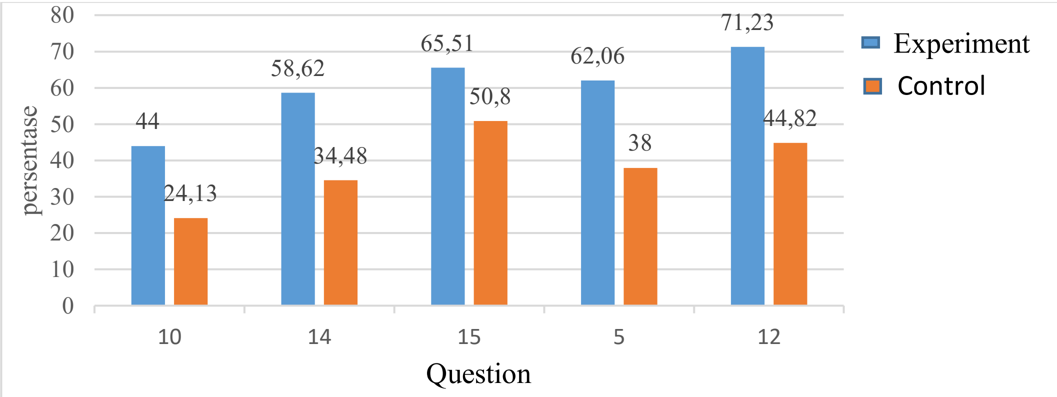

Figure 5. Percentage Distribution of Cognitive Results C3

Figure 5 shows that for the distribution of questions number 5, 10, 12, and 14. Number 5 students are asked to calculate the temperature conversion from Celsius to Kelvin. Number 10 students are asked to calculate the amount of heat, and have a higher absorption score for the experimental class than the control class. In number 12 students are asked to be able to provide examples of expansion from the available options. The same thing also happened in number 14 students were asked to calculate the temperature conversion and number 15 also with an experimental value of 65.51 and a control class value of 50.8. In general, the cognitive outcome value for C3 is very dominant by the experimental class, higher than the control class. This could happen because of the difference in teaching methods for the class. For the experimental class, the method taught directly and understanding the concept assisted by the module and LKPD PjBL-STEM model with smokeless waste burner media is more interesting for students so that it can direct students to complete the temperature conversion accompanied by an explanation to understand the concept of temperature conversion.

This is in line with research (Didelmi, A., 2023) which uses PjBL-STEM-based media to attract interest and direct students to solve problems so that it can influence critical thinking and student learning outcomes. Then, students in the experimental class also tend to be more active during learning so that it can be one of the significant differences between the values of the experimental class and the control class. In addition, individual factors and different abilities of each child can affect learning outcomes.

4) Question indicator C4 (Analyze)

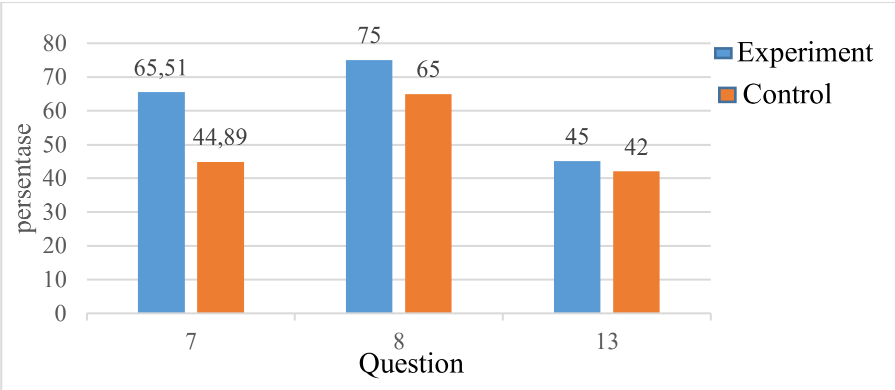

Figure 6. Percentage Distribution of Cognitive Results C4

Figur 6 analyzing is the process of solving a problem by separating each part of the problem and looking for the relationship between each part to find out the relationship between the parts that cause a problem (Gunawan & Palupi, 2016:107). Figure 6 shows the distribution of results for questions 7, 8, and 13. Number 7 students are asked to analyze the relationship between temperature and heat, the absorption score of the experiment (give the treatment) class is higher. For question number 8 students are asked to understand measuring instruments and their applications in everyday life by analyzing the questions provided, the absorption score of the experimental class is higher than the control class. The large number of students in the experimental class who answered correctly was because students had been trained to analyze from the beginning to solve problems of applying measuring instruments in experimental activities starting from how to use several types of thermometer temperature measuring instruments to the use of thermometers in everyday life. This is in line with (khoiriyyah, 2018) who uses STEM to improve critical thinking so that they can solve problems and states that STEM can improve critical thinking and analytical skills to solve a problem.

5) C5 Indicator

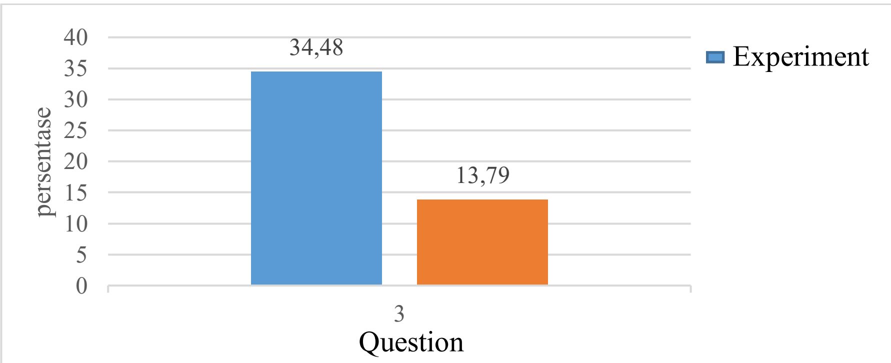

Figure 7. Percentage Distribution of Cognitive Results C5

Figure 7 shows that for question number 3, students are asked to be able to understand measuring the difference in temperature of objects. The distribution score of the experimental class's cognitive results is higher than the control class. There is only 1 question for the C5 domain, in this question a narrative is presented for two different quantities, then students are asked to conclude the correct statement. This difference in cognitive score occurs because in addition to the difference in teaching methods, in this question the indicator is that students can understand the concept of measuring the difference in temperature of objects by being given two different temperature measurements with different units. In the experimental class, the temperature measuring instrument was directly introduced and how to use it when making a simple smokeless waste burner, while the control class only had an explanation based on the book. However, the level of difficulty for students to understand the question is still high for this C5 question, indicated by the level of absorption, which is still in the low category for both classes. This is in line with the opinion of (Wardani, 2018) namely integrated STEM learning through technology as a medium, students can be encouraged to apply knowledge and understand directly, not just understand it at all times.

3.2. Inferential Analysis

In addition to using descriptive analysis, this study also uses inferential analysis to determine the effectiveness of learning to improve students' cognitive learning outcomes at SMPN 1 Tapung Hulu as a reference for making final decisions. Before hypothesis testing is carried out, a normality test and a homogeneity test must first be carried out as a requirement in data processing. The normality test is carried out with the aim of determining whether the data is normally distributed or not using the Kolmogorov-Smirnov test on the posttest value, it is obtained that the significance value of the Kolmogorov-Smirnov normality test is 0.200 for class VII D and 0.140 for class VI A. For the homogeneity test, both classes are homogeneous with a significance value of 0.327 so that the data is homogeneous. After that, a hypothesis test is carried out as in the table 5 below.

Table 5. Results of Independent 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	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Students' Cognitive Learning Outcomes	variance assumed	1,441	,235	2,653	57	,010	12,09,37	4,559	2,968	21,225
	Equal variances not assumed			2,648	55,547	,011	12,097	4,559	2,943	21,251

The Table 5 once the tests for normality and homogeneity are completed, the next step will involve conducting a hypothesis test. In this research, the hypothesis test employs an independent sample T-test. This hypothesis test was conducted to assess if there was a notable difference in the enhancement of cognitive learning outcomes between the experimental group using the STEM-integrated PjBL method with the smokeless waste burner and the control group employing the traditional method. The conditions for the T test are that the data should be normally distributed and homogeneous (though it's not a strict requirement). According to the findings from the SPSS 23 output of the Test presented in table 4, a \t value of 2.653 was achieved with a significance (sig.2-tailed) of 0.010.The criteria for conclusions in this study based on inferential analysis are:

1. If significant at $p \geq 0.05$, H0 is accepted. In other words, there is no significant difference in student learning outcomes between the treatment and untreatment classes.
2. If significant at $p < 0.05$, H0 is rejected, meaning there is a significant difference in student learning outcomes between the treatment and untreatment classes.

Based on the results of the Independent Sample T-test analysis, it can be concluded that there is a significant increase in cognitive learning outcomes between the experiment class using the PjBL-STEM method on the topic of smokeless waste burning and the control class applying traditional teaching methods. This is indicated by a significance value of 0.01 which is smaller.than 0.05, so H0 is rejected, which means there is a significant difference in student learning outcomes between classes that utilize PjBL-STEM learning media on the topic of smokeless waste burning and classes that apply conventional learning methods on the topic of temperature, heat, and expansion,

4. CONCLUSION

According to the research findings from class VII at SMPN 1 Tapung Hulu, the cognitive learning results of students in the experimental class, which utilized the STEM Integrated PjBL model with a Smokeless Waste Incinerator on Temperature, Heat, and Expansion Material, are superior to those in the control class that followed conventional learning methods. This is shown by the average cognitive learning results of students in the experimental group, which is 72.11 in the good category, whereas the control group is 63.4. A notable distinction exists in the cognitive learning results between the experiment and the control class following the application of the PjBL-STEM model on the Smokeless Waste Incinerator, indicating that the STEM Integrated PjBL learning model is effective in enhancing students' cognitive learning outcomes, particularly regarding temperature, heat, and expansion topics for class VII at SMPN 1 Tapung Hulu.

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