



How to Calculate Paired Sample *t*-Test using SPSS Software: From Step-by-Step Processing for Users to the Practical Examples in the Analysis of the Effect of Application Anti-Fire Bamboo Teaching Materials on Student Learning Outcomes

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ABSTRACT

This study aims to demonstrate how to do paired sample *t*-test using SPSS software to analyze the effect of the application of anti-fire bamboo teaching materials on student learning outcomes. SPSS software is a very common statistical software in educational research that can be used to analyze the differences of a variable after being given treatment. One of the variables that can be analyzed is the difference in student learning outcomes. Teaching materials used in learning can cause differences in student learning outcomes. This research uses fire-resistant bamboo as multimedia-based teaching material to study the properties of the material and its changes. The results of the analysis using SPSS software showed that there are significant differences in student learning outcomes after using fire-resistant bamboo as multimedia-based teaching material. Student learning outcomes become improved and these teaching materials make it easier for students to understand the concepts being taught.

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1. INTRODUCTION

In the research process, data analysis is done after all data needed to solve the problems studied have been obtained. Sharpness and accuracy in the use of analytical tools will determine the accuracy of the conclusion (Purwanto et al., 2021), therefore it is necessary to select the appropriate analytical tool for data analysis. Errors in determining the analytical tools can be fatal to the conclusions and this will have an even worse impact on the use and application of the research result.

Statistical software can be used as an analytical tool to prevent errors in data analysis. Researchers need to look at the research objective to choose the right statistical software for performing the data analysis. SPSS is one statistical software that is very common among researchers to analyze statistical data. SPSS is owned by IBM Inc and is also known as Statistical Package for the Social Sciences or Statistical Product and Service. SPSS can be used to perform the following analysis (Purwanto et al., 2021): data transformation, regression analysis, analysis of variance, multivariate analysis of variance, analysis of covariance, *t*-tests, non-parametric tests, time series, design and analysis of experiments, spatial analysis, survival analysis, dimension reduction, reliability, faktor analysis, correspondence analysis, neural network, correlation and others. Therefore, the SPSS statistical software is easily able to perform both parametric and non-parametric comparison analyses (Ong & Puteh, 2017). It also permits the researcher to check the assumptions of the test and this software enables a frequency analysis to be perfectly conducted (Ong & Puteh, 2017).

Before conducting the research, the researcher determines in advance the research objectives and the characteristics to be studied. Likewise, in educational research, researchers determine the target or sample such as students and determine the variables or characteristics of the sample to be studied (Okagbue et al., 2021). One type of variable studied is a quantitative variable. Quantitative variables are numeric variables or are expressed in numbers. Quantitative variables in educational research, for example, are student learning outcomes. Data on student learning outcomes are usually in the form of values that students get before and after learning (Hanif, 2020; Sriyanti et al., 2021). These data require analysis using statistical software to analyze correlations, differences, comparisons, and causal relationships between the learning outcomes data and the learning carried out (Sriyanti et al., 2021).

Several previous studies have shown that analysis using statistical tests makes student learning outcomes can be seen differences and improvements. The research shows that the use of learning models (Lin et al., 2017), learning methods (Kirindi et al., 2020; Yu et al., 2021), teaching materials (Sriyanti et al., 2021), and learning media (Hadisaputra et al., 2019; Hanif, 2020; Khoirudin et al., 2021; Sahronih et al., 2019) in the learning process can improve student learning outcomes. Currently, multimedia-based teaching materials are often used to improve student learning outcomes in science learning such as videos, animations, and applications. Multimedia-based teaching materials can improve knowledge construction, and synthesis skills and build bridges between knowledge in students. Using these teaching materials, it becomes easier for students to understand the science concepts being taught, especially abstract science concepts.

Science learning about the properties of materials and their use is one of the abstract science concepts that require multimedia-based teaching materials because students need to know how the structure and components of the materials can affect the properties of the materials themselves (Savitri & Mudzakir, 2017). However, learning about the properties of materials and their use in schools only comes to identifying the properties of the materials

that are around them without knowing the changes in the properties that occur in the materials.

The use of fire-resistant bamboo can be used as multimedia-based teaching material to explain the properties of materials and changes in properties that occur in materials. Fire-resistant bamboo is bamboo that has been coated with fire-resistant liquid so that it has better strength than ordinary bamboo and is resistant to heat (Ren et al., 2018). By comparing ordinary bamboo and fire-resistant bamboo, students will learn the properties of bamboo materials and the differences in properties between the two different types of bamboo. However, there has been no research related to the use of fire-resistant bamboo as teaching material and its effect on student learning outcomes. Therefore, this research was conducted to examine student learning outcomes after using anti-fire bamboo as material properties teaching material.

2. METHODS

2.1. Teaching Method

The research was carried out using an experimental demonstration method as the learning method. The participants involved in this study were 20 students from one of the junior high schools in Jakarta, consisting of 5 male students and 15 female students. The transfer of anti-fire bamboo teaching material is carried out in several stages including providing a pretest to measure the condition of student motivation before given treatment using video learning. The next stage is presenting the anti-fire bamboo material in the form of a learning video that contains a brief explanation of changes in properties that occur in bamboo due to combustion. Then, the final stage is giving posttest questions to measure the condition of learning motivation after being given the learning video treatment. The pretest and posttest questions contain 20 short answers with true or false answers. The analysis score for answering the statement correctly is 5 while the incorrect answer is given a value of 0. If the student answers all the questions correctly, the maximum score is 100.

2.2. Analysis Method

The learning outcomes are analyzed using Paired *t*-Test statistical calculations. This analysis was conducted to see the differences in student learning outcomes before and after using anti-fire bamboo as multimedia-based teaching material in explaining the nature of the material and its changes. In addition, this analysis was carried out to determine the significance level of the experimental demonstration learning method. SPSS software is used as statistical software to perform paired *t*-tests. The steps in using SPSS software to perform paired sample *t*-test are as follows:

- (i) Open the SPSS software and two windows will appear, namely dataset and output. To process data, simply focus on the dataset window.
- (ii) In the dataset window, three steps must be done, namely preparing the data template, conducting a normality test, and conducting a paired sample *t*-test.
- (iii) To prepare a data template, click the variable view tab. Then fill in Name with variable markers written without spaces. Then, change the Label section with the variable to be tested and change the Measure to scale. After matching the image, click the data view tab.
- (iv) On the data view tab, enter the data obtained during the research
- (v) If all data has been entered, it can be continued to the normality test. The normality test used is the Shapiro-Wilk test. The test starts by pressing analyze, selecting descriptive statistics, and selecting explore.

- (vi) In the explore window, two variables are moved to the dependent list by clicking the arrow
- (vii) If it has been moved to the dependent list, then continue by clicking Plots, then in Window Explore: Plots, tick Normality Plots with tests, click Continue in Window Explore: Plots, and click Ok in Window Explorer. The results of the normality test will appear in the output window.
- (viii) If the data is normally distributed, then the data processing is continued to the paired sample *t*-test. Testing begins by pressing analyze, selecting compare means, and selecting paired sample *t*-test.
- (ix) In the Paired Sample *T*-Test Window, enter variable data 1 into column variable 1 and variable data 2 into variable 2 by clicking on variables and arrows. Next, it is finished by clicking ok. The results of the normality test will appear in the output window.

3. RESULTS AND DISCUSSION

Based on this paper, the process and results of the analysis of student learning outcomes using SPSS software are discussed. The analysis process using SPSS software consists of several stages. These stages are:

- (i) Raw data collection
- (ii) Calculation of average and gain data
- (iii) Normality test using Shapiro-Wilk test
- (iv) Paired sample *t*-test

3.1. Raw Data Collection

The effect of using anti-fire bamboo teaching materials on student learning outcomes can be seen from the comparison of the results of the pretest and posttest conducted. The results of the students' pre-test and post-test are shown in **Table 1**.

Table 1. Pre-test and post-test results.

Student	Pretest	Post-test
1	65	100
2	40	45
3	70	95
4	75	70
5	70	85
6	50	60
7	60	100
8	60	90
9	65	85
10	60	70
11	60	90
12	80	80
13	45	60
14	75	85
15	75	70
16	60	80
17	60	75
18	65	95
19	90	90
20	55	90

3.2. Calculation of Average and Gain Data

The calculation of the average and gain value is carried out to determine student learning outcomes before using anti-fire bamboo teaching material (pre-test) and student learning outcomes after using anti-fire bamboo teaching material (post-test), as well as to see whether there is an increase or not. learning outcomes. The average value is a numerical representation of a group of data that represents the data as a whole. The average value can represent conditions and briefly describe a group of data. The average value can be determined by adding up a group of data and dividing it by the number of data. **Table 2** shows the average pre-test and post-test scores of students. The mean score of the students' pre-test was 64 and the average value of the post-test of students was 80.75.

Table 2. Average and gain data.

Student	Pre test	Post test	Gain
1	65	100	35
2	40	45	5
3	70	95	25
4	75	70	-5
5	70	85	15
6	50	60	10
7	60	100	40
8	60	90	30
9	65	85	20
10	60	70	10
11	60	90	30
12	80	80	0
13	45	60	15
14	75	85	10
15	75	70	-5
16	60	80	20
17	60	75	15
18	65	95	30
19	90	90	0
20	55	90	35
Average	64	80.75	16.75

Gain is the difference between the post-test and pre-test scores. Gain data can be used as data to increase student learning outcomes. Student learning outcomes are said to increase if there is a positive change before and after learning (positive gain). The use of anti-fire bamboo teaching material in learning improves the learning outcomes of 18 out of 20 students because 18 students have positive gain values. However, two students have a negative gain value, which means there is a decrease in learning outcomes for the two students. After knowing the gain value of each student, the normalized gain analysis (*N*-Gain) can be done. This analysis is used to determine the gain criteria obtained. The gain is obtained from the pre-test and post-test score data, which is then processed to calculate the normalized average gain. The average normalized gain is calculated through Equation (1) (Hake, 1998).

$$\langle g \rangle = \frac{\% \langle G \rangle}{\% \langle G \rangle_{max}} = \frac{\% \langle sf \rangle - \% \langle si \rangle}{100 - \% \langle si \rangle} \quad (1)$$

Where $\langle g \rangle$ is the normalized average gain, $\langle G \rangle$ is the actual average gain, $\langle G \rangle_{max}$ is the maximum possible gain, $\% \langle sf \rangle$ is the post-test average percentage, and $\% \langle si \rangle$ is the mean percentage of the pre-test. The normalized gain value criteria are listed in **Table 3**.

Table 3. N-gain value criteria.

Limit	Category
$0.7 < \langle g \rangle$	High
$0.3 \leq \langle g \rangle \leq 0.7$	Medium
$\langle g \rangle < 0.3$	Low

After calculating using Equation (1), it is known that the resulting N -gain value is 0.47 and is in the medium category. This shows that the use of anti-fire bamboo teaching material is quite effective in improving student learning outcomes.

3.3. Normality Test (Shapiro-Wilk Test)

Before the paired sample t -test was performed, the normality test must be carried out first as a condition of whether or not the data obtained can be analyzed by t -test. The normality test chosen was the Shapiro-Wilk test because the amount of data obtained was less than 50.

Table 4 shows the results of the normality test on the data.

Table 4. Normality test results.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
Pre-test Result	0.168	20	0.140	0.971	20	0.770
Post-test Result	0.164	20	0.162	0.932	20	0.171

Table 4 shows the results of the normality test using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Because the number of research data is less than 50, the results to be discussed are the results of the Shapiro-Wilk test. In the results of the Shapiro-Wilk test, there are three data in the form of statistical values, df values, and significance values. The way to get these three data using SPSS is through the following steps.

- Press analyze, select descriptive statistics, and select explore as shown in **Figure 1**.

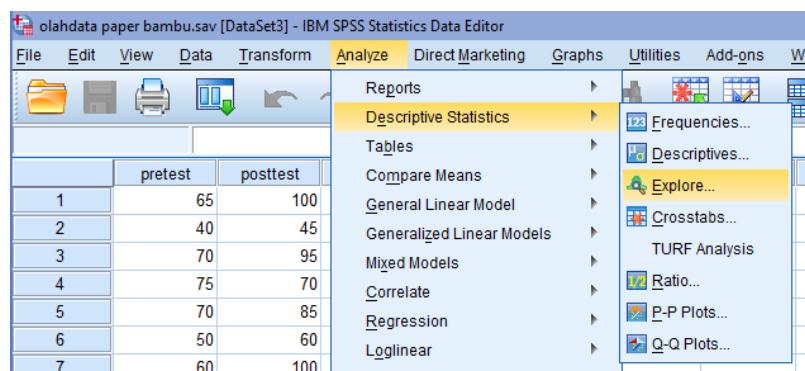
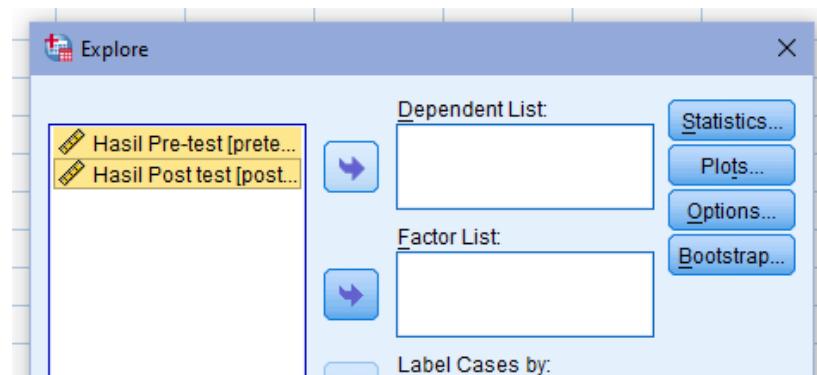
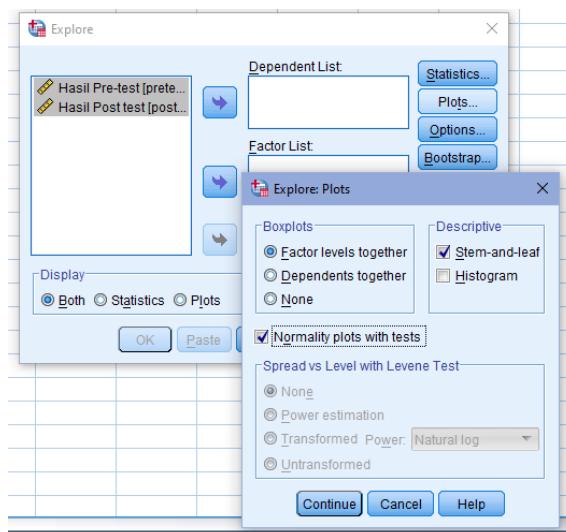


Figure 1. Shapiro-wilk test step 1.

- In the explore window, two variables are moved to the dependent list by clicking the arrow as shown in **Figure 2**.

**Figure 2.** Shapiro-wilk test step 2.

- iii) If it has been moved to the dependent list, then continue with the steps in **Figure 3** by clicking Plots, then in Window Explore: Plots, tick Normality Plots with tests, click Continue in Window Explore: Plots, and click Ok in Window Explorer.

**Figure 3.** Shapiro-wilk test step 3.

The value of df (degree of freedom) in the table of results of the Shapiro-Wilk test is the number of research respondents or the number of students participating in the study, which is as many as 20 people. The statistical value indicates the statistical value or the Shapiro-Wilk coefficient (W). Generally, this value indicates the suitability of the sample data with a normal distribution. The greater the coefficient value, the greater the possibility of conformity between the sample data and the normal distribution and vice versa (Shapiro & Wilk, 1965). The magnitude of the Shapiro-Wilk coefficient is influenced by the size of the sample or in this case the number of students participating in the study. The Shapiro-Wilk coefficient can be determined manually through Equation (2) (Shapiro & Wilk, 1965).

$$W = \sum_{i=1}^n (X_i - \bar{X})^2 \quad (2)$$

Where W is the Shapiro-Wilk coefficient, X_i is number i in data, and \bar{X} is the average of data. The sig value is the significance value or p -value. The significance value can be interpreted as the error value obtained by the researcher from the results of statistical calculations. The significance value determines the normality of the data in the Shapiro-Wilk

test using SPSS. To find out if the data obtained were normally distributed or not, then the significance value of the data was compared with the significance level (α). The level of significance is the maximum error determined by the researcher. If the significance value is greater than the value of α , then the data is normally distributed (the initial hypothesis is accepted) and vice versa (the final hypothesis is rejected). Meanwhile, in the manual Shapiro-Wilk test, the normality of the data is determined by the t value through Equation (3) (Shapiro & Wilk, 1965).

$$T_3 = \frac{1}{W} \left[\sum_{i=1}^k a_i (X_{n-i+1} - X_i) \right]^2 \quad (3)$$

Where T_3 is the Shapiro-Wilk statistical conversion approximation to the normal distribution, W is the Shapiro-Wilk coefficient, X_{n-i+1} is the $n-i+1$ number in data, and X_i is the number i in the data. If the value of T_3 is known, then the range of p -values can be searched using the Shapiro-Wilk table. After that, the range of p -values was compared with the same significance level as in the Shapiro-Wilk test with SPSS.

The results of the Shapiro-Wilk normality test showed that the sample data obtained showed conformity with the normal distribution because it had a fairly high statistical value, namely 0.971 in the pre-test and 0.932 in the post-test. In addition, it is seen that the significance of the pre-test has a value of 0.077 while the post-test has a significance value of 0.17. These two significance values were compared with a significance level of 5% (0.05). Because the decision-making basis for normality exceeds the significance level of 0.05, it can be concluded that the data is normally distributed.

3.4. Paired Sample t-Test

The results of the normality test showed that the data obtained were normally distributed. Therefore, the requirement to perform a sample t-test was met. Paired Samples t-test was conducted by comparing the mean scores of pre-test and post-test. In SPSS software, the steps to perform the Paired Samples t-test are as follows.

- Pressing analyze, selecting compare means, and selecting the paired sample t -test as shown in **Figure 4**.

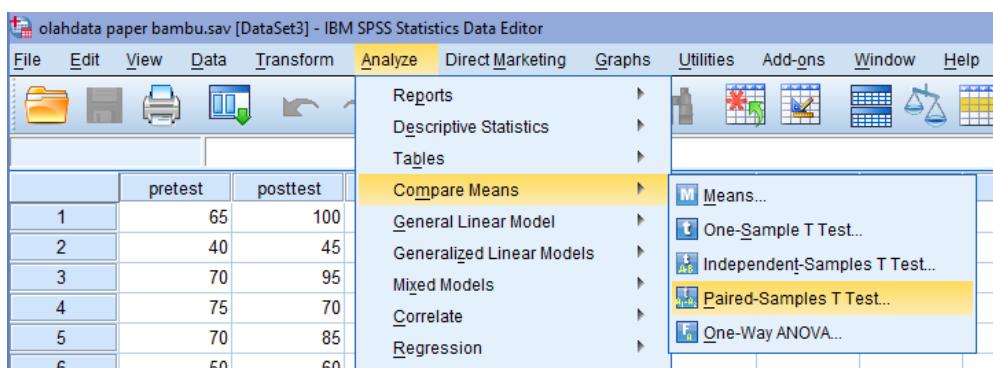
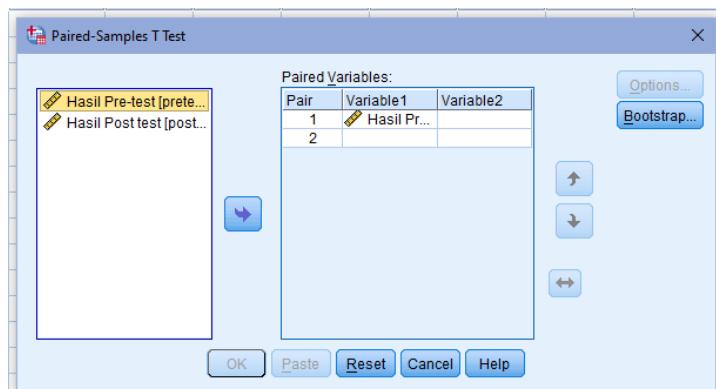


Figure 4. Paired sample t -test step 1.

- In the paired sample t -Test Window , enter variable data 1 into column variable 1 and variable data 2 into variable 2 by clicking on variables and arrows . Next, it is solved by clicking ok. Next to **Figure 5**.

**Figure 5.** Paired Sample *t*-test step 2.

After the Paired Sample *t*-Test was performed, the results of the descriptive analysis of the processed data (paired sample statistics) were obtained in **Table 5**.

Table 5. Paired sample statistics results.

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test Results	64.00	20	11.877	2.656
Post-test Results	80.75	20	14.625	3.270

The mean value shows the average value of the data. This value can be obtained by adding the total value given in the data and then dividing the sum by the sum of the total values. The average value in the pre-test is 64 and the average value in the post-test is 80.75. The average value of the pretest is smaller than the average value of the post-test. This shows that there are differences in student learning outcomes descriptively. The value of *N* indicates the amount of data for each variable. In this study, the value of *N* in the table indicates the number of respondents who participated in the research sample, as many as 20.

The standard deviation informs how much the data varies with the mean value. The greater the value of the standard deviation, the more varied the data (heterogeneous) and vice versa. If the standard deviation value is greater than the mean value, then the mean value is a poor representation of the overall data. Meanwhile, if the standard deviation value is smaller than the mean value, then the mean value is a good representation that can be used as a representation of the entire data. Manually, the standard deviation can be determined through Equation (4).

$$s = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n - 1}} \quad (4)$$

where *s* is the standard deviation, \bar{X} is the average value of data, and *n* is the number of data. The results show that the standard deviation of the pre-test is 11.87 and the post-test is 14.625, which means that the standard deviation of both is smaller than the average value. Therefore, the average value of the pre-test and post-test can represent the overall data well.

The mean standard error ($s_{\bar{x}}$) can be calculated by dividing the standard deviation by the square root of the sample size as Equation (5).

$$s_{\bar{x}} = \frac{s}{\sqrt{n}} \quad (5)$$

where *s* is the standard deviation and *n* is the number of data. The mean standard error is useful for knowing how well the average data from the sample data for each variable can

estimate the population means. If the data is normally distributed (passes the normality test), then the known standard error can explain that the average data from the sample data for each variable can estimate the population average.

Figure 6 shows paired sample t-test results . The average value in **Figure 6** is the average value of the pairwise differences derived from the difference in the mean values . The test results show the average value of the difference is -16.750. The known standard deviation is the sample standard deviation of the pairwise differences . The standard deviation of the difference can be calculated using the equation mentioned before . The test results show the standard deviation of the difference of 13.791. The mean standard error is an estimate of the standard deviation of the sample mean distribution (of differences) for an infinite population . The standard error of the mean difference can be calculated through the equation. It is known that the standard error value of the average test result is 3,084.

Paired Samples Test											
	Paired Differences					t	df	Sig. (2-tailed)			
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference							
				Lower	Upper						
Pair 1 Hasil Pre-test - Hasil Posttest	-16.750	13.791	3.084	-23.204	-10.296	-5.432	19	.000 0.000031			

Figure 6. Paired t-test results.

The upper and lower confidence limits are the confidence limits of the confidence interval for the mean difference . The confidence interval can be determined through Equation (6).

$$\bar{d} \pm t_{\alpha/2} \left(\frac{s_d}{\sqrt{n}} \right) \quad (6)$$

The t value in **Figure 6** is the t value used to build confidence limits. It is based on degrees of freedom and confidence level. The t value can be calculated if the average value of the difference and the standard error value of the average difference is known or through equation (7).

$$t = \frac{\bar{d}}{s_{\bar{x}}} \quad (7)$$

While *df* or degree of freedom is the degree of freedom used to determine the distribution of *T* from, which *t* is formed. The degrees of freedom can be determined by Equation (8).

$$df = n - 1 \quad (8)$$

If the values of *t* and *df* are known, then a decision can be made by comparing the value of the *t* statistic with the *t* table. The basis for decision-making is that if the *t*-statistical value is greater than the *t*-table value, then H_0 is rejected (no significant difference) and H_a is accepted (there is a significant difference), and vice versa. The statistical *t* value of the test results is known to be 5.432. While the *t* table value is 2.903, which is known through the *t* distribution table with a value of *df* is the 19. This shows that the use of anti-fire bamboo as multimedia-based teaching material on material properties and changes has a significant influence on student learning outcomes.

In addition to the *t*-value, significance can also be determined from the significant value or *p*-value in the table. The basis for decision making determines that if the significance (Sig. (2-tailed)) is less than 0.05, the hypothesis of H_0 (no relationship between two paired groups) is rejected and H_a (there is a relationship between two paired groups) is accepted. The results

of the paired samples t-test showed a significance (Sig. (2-tailed)) of 0.000031 so H_0 was rejected and H_a was accepted. Thus, the use of fire-resistant bamboo as multimedia-based teaching material on material properties and changes has a significant influence on student learning outcomes (Lin et al., 2017).

This shows that learning using anti-fire bamboo as multimedia-based teaching material is effectively used in learning activities. During the teaching and learning process, there are several advantages of learning using anti-fire bamboo as a multimedia-based teaching material, including: (1) students more easily understand the lesson learned using anti-fire bamboo teaching materials, (2) the learning material delivered is more memorable, and (3) anti-fire bamboo teaching materials can present something abstract to be able to solve a problem itself. This fire-resistant bamboo teaching material helps students in finding their concepts. In addition, students' interest in learning science has increased, which is indicated by students who feel more motivated to learning.

4. CONCLUSION

Based on the research that has been done, there are differences in student learning outcomes after using anti-fire bamboo as multimedia-based teaching material. Anti-fire bamboo teaching materials have a significant effect on student learning outcomes. This is indicated by an increase in learning outcomes after using fire-resistant bamboo teaching materials. In addition, these teaching materials also make it easier for students to understand the lesson and help students find learning concepts.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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