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How to Calculate Statistics for Significant Difference Test Using SPSS: Understanding Students Comprehension on the Concept of Steam Engines as Power Plant

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ABSTRACT

A significant difference test is used to evaluate certain treatments on the sample in two different observation periods. One of the commonly used software is SPSS which is used to analyze data which helps researchers in calculating data so that it can be completed quickly. However, there are still many students and researchers who are not experts in calculating data using SPSS software, especially significant difference tests. This article aims to provide a step-by-step guide in calculating data using SPSS for statistical requirements and significant difference tests. To understand the calculations well using SPSS, we demonstrate the requirements tests (i.e., normality and homogeneity tests), parametric significant difference tests (i.e., One Sample t-test, Paired sample t-test, and Independent Sample t-test), and non-parametric (i.e., Wilcoxon test and Mann-Whitney test). We also added and demonstrated the steps for calculating data in the field of education with the variables analyzed being differences in student learning outcomes. We used the data when delivering the steam engine concept to students, showing how statistical calculation can understand students' comprehension. Bibliometric analysis regarding statistics was also added. This paper can be used as a guide in carrying out statistical tests using SPSS software.

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1. INTRODUCTION

Statistics is a branch of science that is the backbone of data processing and analysis. In the modern information age, where data has become more abundant and diverse, statistics plays an increasingly important role in uncovering patterns, trends, and meanings from that data (Wan, 2021). One type of statistic that is frequently and widely used is the difference test statistic (Morris *et al*., 2019; Afifah *et al*., 2022). Using different test statistics allows researchers to explore and understand significant differences between different data groups, variables, or populations (Savalei & Rhemtulla, 2013). In the worlds of science, health, and business, an accurate understanding of these differences is the foundation for informed decision-making, the development of new theories, and the improvement of existing practices and processes (Cvitanovic *et al*., 2015). Different test statistics have wide applications in various scientific disciplines, from social sciences, and economics, to health sciences and natural sciences (Mishra *et al*., 2019). Research and statistical analysis of difference tests can provide valuable insight into the phenomena we observe, such as the effect of medical intervention on a group of patients, a comparison of educational outcomes between two schools, or the impact of a marketing strategy on product sales (Vinje et al., 2021).

Difference test statistics are not just about numbers and formulas. It also involves interpreting data, understanding context, and being able to identify the essence of statistical findings (Arican & Kuzu, 2020). That is why the use of different test statistics has become a hot topic in research (see **Figure 1**), confirmed by the bibliometric analysis from the Scopus database, reaching 50,675 documents between 1894 and 2023, taken on 27 October 2023 (using keywords "different test statistics". Detailed information for further bibliometric analysis is reported in previous studies (Al Husaeni & Nandiyanto, 2022).

To test the data, it is important to use appropriate analytical instruments. The use and standards of research results will be more negatively impacted by errors in selecting analytical instruments, which can have a negative impact on drawing conclusions. Data analysis errors can be avoided with the help of statistical software (Hayat, 2022).

Year ↓	Documents ↑
2023	2046
2022	2788
2021	2616
2020	2497
2019	2587
2018	3014
2017	3011
2016	2697
2015	2795
2014	2388

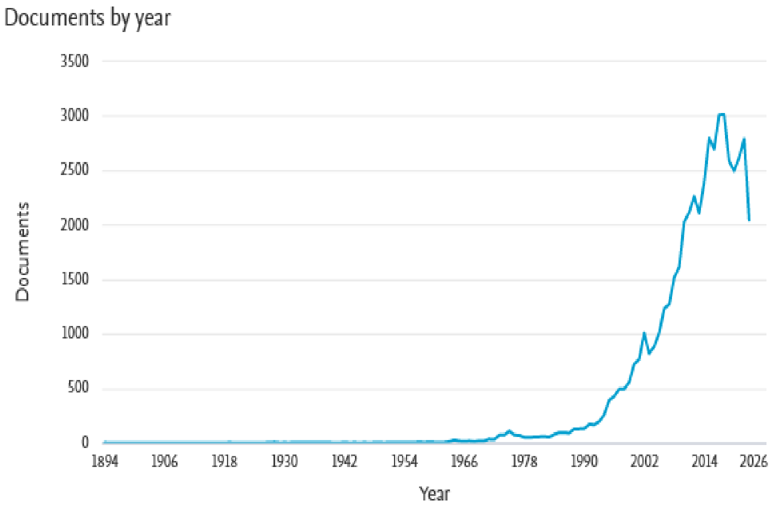

Figure 1. The bibliometric analysis from the Scopus database, taken on 27 October 2023.

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IBM SPSS (Statistical Package for the Social Sciences) is statistical software used for statistical data analysis. Some of the main uses of SPSS software are statistical analysis, data manipulation, data visualization, big data processing, prediction and processing models, decisions and action taking, as well as research and publication (Nwogwugwu & Ovat, 2021). Apart from that, it is necessary to pay attention when carrying out statistical analysis, first carrying out the required tests, namely the normality test (to determine whether the population variance is the same or not) and the homogeneity test (to determine whether the distribution of research data is normal or not). The test results of the requirements are used to determine further analysis, namely parametric and non-parametric tests (Orcan, 2020). The difference between the two tests is based on the assumption that the data is normally distributed or not. When choosing between parametric and nonparametric tests, it is important to understand the data characteristics and the research question (Delacre *et al*., 2019).

Several previous studies have illustrated the statistical effectiveness of difference tests in revealing significant differences in various contexts. For example, in the field of education, research conducted by Nandiyanto et al. (2022); Nandiyanto et al. (2020); Ragadhita et al. (2023); Afifah et al. (2022) used different test statistics to compare student learning achievements between two different learning methods. In the health sector, research conducted by Sun et al. (2021) used different test statistics to evaluate the effects of various treatments on patients with certain medical conditions. Additionally, in the context of the business run by Soni (2022), different test statistics are used to compare the performance of different products or marketing strategies in measuring their impact on sales. These studies demonstrate the extent to which difference test statistics can provide valuable insights to support informed decision-making.

Even though there have been many studies discussing the use and application of different test statistics, there is still no research discussing step-by-step statistical tests using SPSS. Apart from that, there are still students and researchers who are not yet experts in calculating data using SPSS, especially significance difference tests. Therefore, this article was created with the aim of providing a step-by-step guide in calculating data using SPSS software to test statistical requirements and test for significant differences. Apart from that, this article discussed basic statistical concepts regarding test requirements (i.e. Normality and Homogeneity tests) as well as parametric significant difference tests (i.e. One Sample t-test, Paired Samples t-test, and Independent Samples t-test) and non-parametric (i.e. Mann-Whitney test and Wilcoxon test). In this article, real cases were also presented in the use of different test statistics in the educational sector using the SPSS application. Differences in learning outcomes are caused by the use of experimental demonstration methods in teaching steam engines as a teaching aid, which were used to help students understand heat and renewable energy. This article can provide a strong basic understanding of statistics and can be a useful reference source for anyone interested in understanding more about the role of statistics, especially difference tests in processing, analyzing, and interpreting data in various contexts.

2. THEORETICAL FRAMEWORK

2.1. Steam engine

A steam engine is an external combustion engine that uses air or gas as its working fluid and works based on thermodynamic circulation principles. Steam engines are commonly used as pump engines, power-generating engines, and solar-powered engines. Steam engines utilize temperature differences, pressure changes, and changes in the volume of working fluid

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in a closed system. This engine could be an alternative driving engine that can use renewable energy sources as an answer to the fuel oil crisis that is currently hitting the world (Herrero *et al*., 2023).

In theory, the combustion of a steam engine occurs outside, producing heat from the fuel which is not directly converted into motion, but first through a conducting medium and then converted into mechanical energy. Mechanical energy can be converted into electrical energy if it is connected to an electric generator dynamo. This machine was created because it can convert solar thermal energy, which is abundant in nature, into rotary motion energy to drive a generator and convert it into electrical energy (Malele & Ramaboka, 2020).

Steam engine design is carried out by first determining the output power to be produced, expansion temperature, and compression temperature. From these values, the method continues with calculations to determine the dimensions and materials used in the components. The basic principle of this machine is to get pressure by expanding gas when it is cooled. In a Stirling engine, varying pressure is generated by the shifting piston which alternately works between the cold parts of the cylinder (Brit & Cowling, 2017).

3. METHOD

3.1. Design Procedure

The data collected consists of literature and field studies. Data obtained from the literature review is used as an example, to demonstrate step-by-step carrying out test requirements (Normality and Homogeneity test), significance difference tests parametric (i.e. One Sample t-test, Paired Samples t-test, and Independent Samples t-test) and non-parametric statistics (i.e. Mann-Whitney test and Wilcoxon test). The flow diagram for calculating significant different test data is shown in **Figure 2.** **Figure 3** presents the different uses of statistically significant differences based on the data obtained

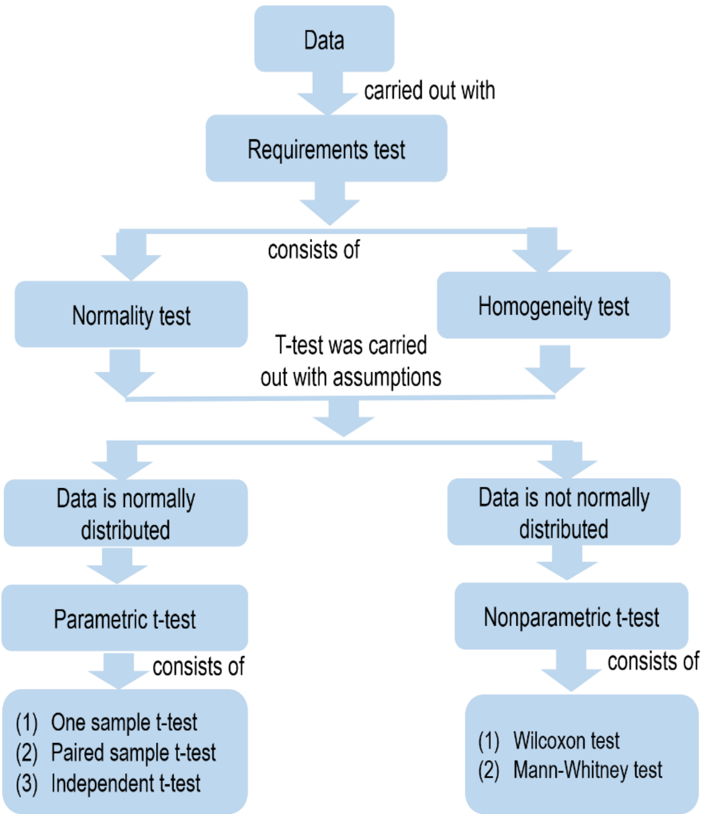

Figure 2. Statistical flow chart of significant difference test.

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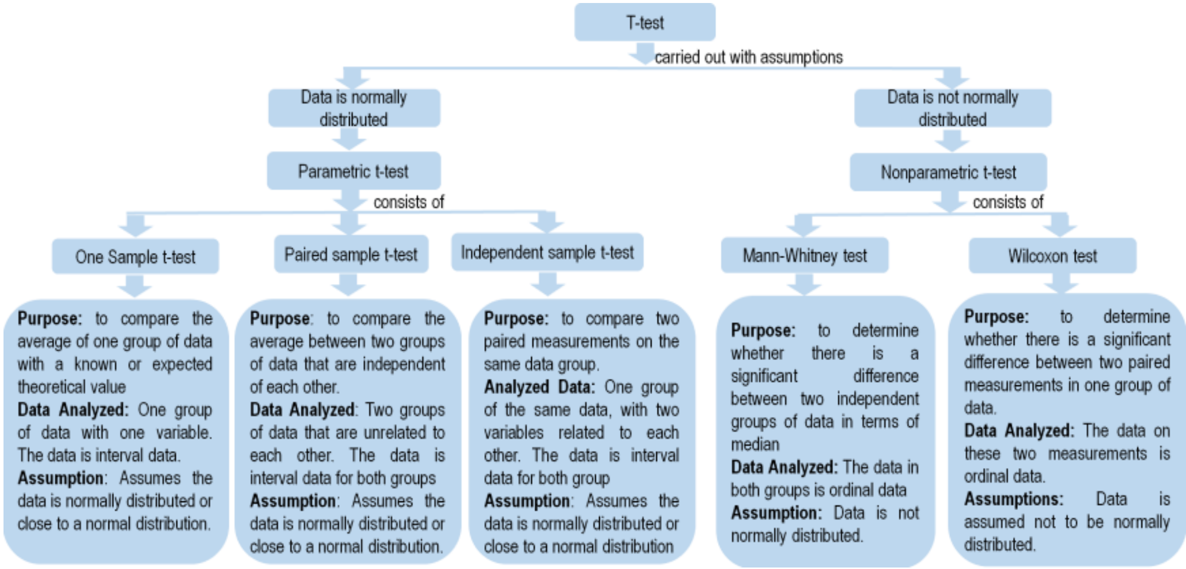

Figure 3. The different uses of statistically significant differences based on the data obtained.

Meanwhile, data in the field was obtained directly. The subjects used were Junior Islamic School class IX students, around Kebumen, Central Java. A total of 60 students were divided into two classes, namely the control class and the conventional class. The design used is a pretest-posttest control group design. The two classes are given different treatment. In the control class, this is done by giving an initial test (pretest) before being given treatment, after being given treatment (i.e. learning video), and a final test (posttest). Whereas, the experimental class was carried out by giving an initial test (pretest) before being given treatment, after being given treatment only in the form of material, and a final test (posttest). Learning outcomes in the form of pretest and posttest are used to analyze differences in students' understanding of the concept of the steam engine as a power plant using conventional methods and experimental demonstration videos.

3.2. Calculation Steps Using SPSS

Furthermore, the data collected is then calculated using SPSS version 26. The selection of data processing features using SPSS is adjusted to the processing objectives and what data you want to conclude. In this article, significant difference tests are calculated using SPSS which consists of test requirements (i.e. Normality test and Homogeneity test), parametric difference test (One Sample t-test, Paired Sample t-test, and Independent Sample t-test), and non-parametric test (i.e. Wilcoxon test and Mann-Whitney test).

The description of the basic steps in calculating and processing data using SPSS version 26 software is as follows:

1) Open the SPSS application. Click Windows then search "IBM SPSS Statistics". After that, click "Open IBM SPSS Statistics" (See **Figure 4**).
2) Furthermore, on the home page, click New Dataset to open a new worksheet (See **Figure 5**).
3) After clicking "New File", there are two worksheets, namely input data and output data (see **Figures 6 and 7**). In data input, there are two worksheets, namely "Data View" and "Variable View". Data View is used to display SPSS worksheets to display the contents of the input data. Meanwhile, "Variable View" is used to edit and view data variables on the worksheet.

Figure 4. Open the IBM SPSS Statistics.

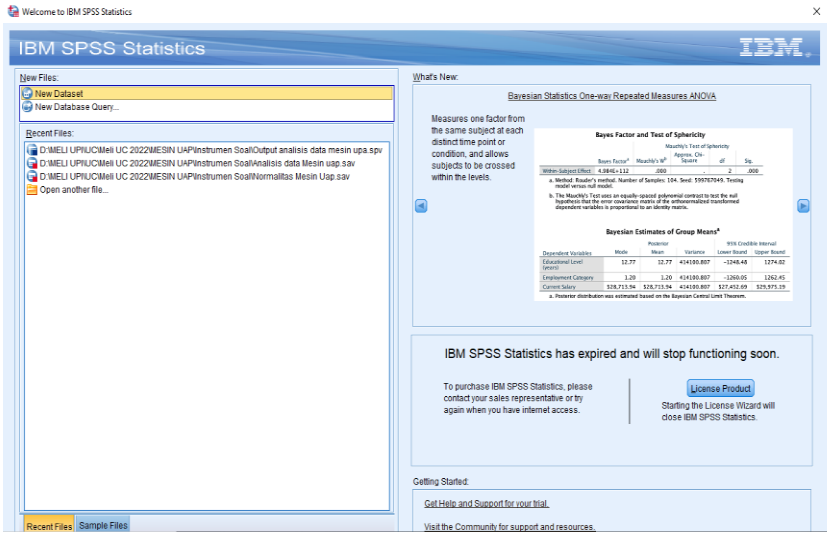

Figure 5. The initial appearance of SPSS.

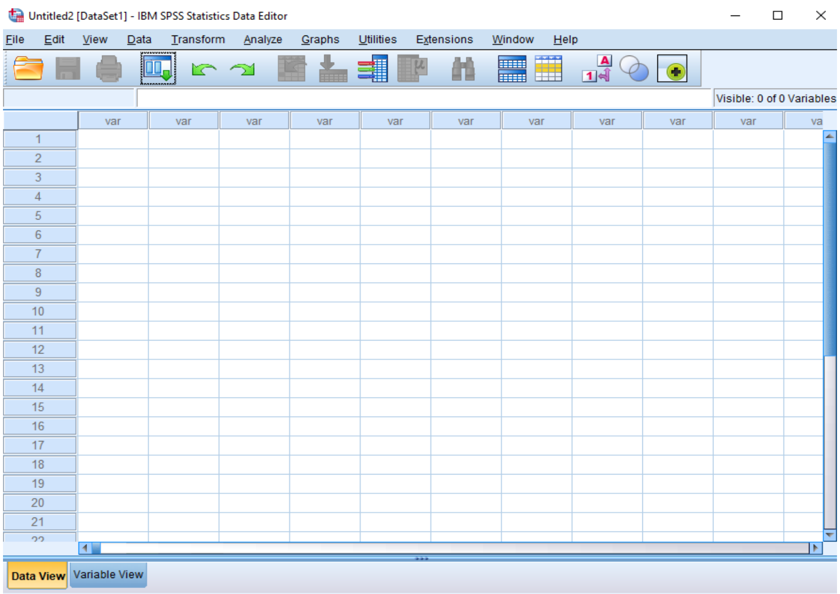

Figure 6. Data input display in SPSS.

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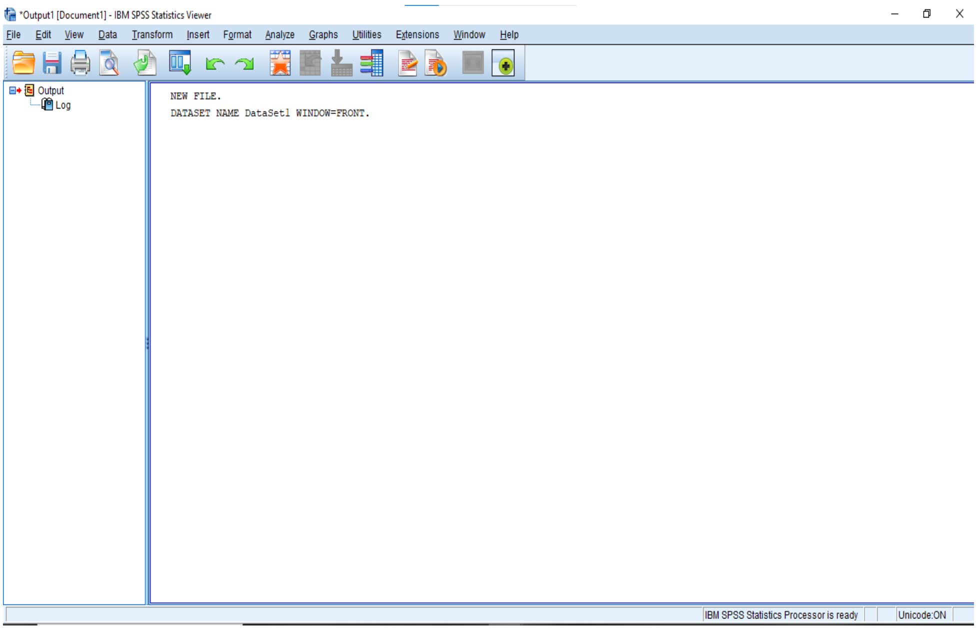

Figure 7. Data output display in SPSS.

4) After the SPSS software has been successfully opened. First, create a variable. On the data input worksheet, click Variable View in the lower left corner column, and then the Variable View worksheet will appear as shown in **Figure 8**. When entering variables, there are several aspects you must pay attention to, namely as follows:
   (i) The variable name entered must begin with a letter and not be capitalized
   (ii) The data type selected must be adjusted to the type of data being analyzed, for example selecting (character) then selecting "String" in the type column. Apart from that, the data type when entering variable data must be adjusted to the data type, be it numeric, ordinal, or the scale contained in the "Measure" column.
   (iii) The number of decimals used must be adjusted to the data entered.

For example, the value of class IX students' understanding ability in the science of energy and heat material is presented in **Figure 9**.

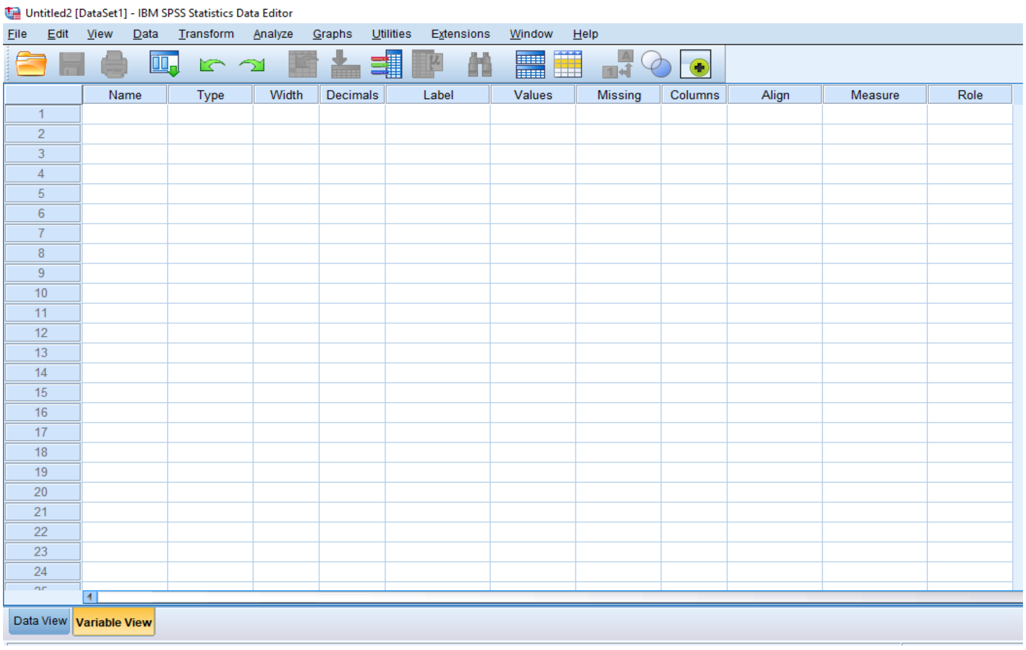

Figure 8. Variable view worksheet displays in SPSS.

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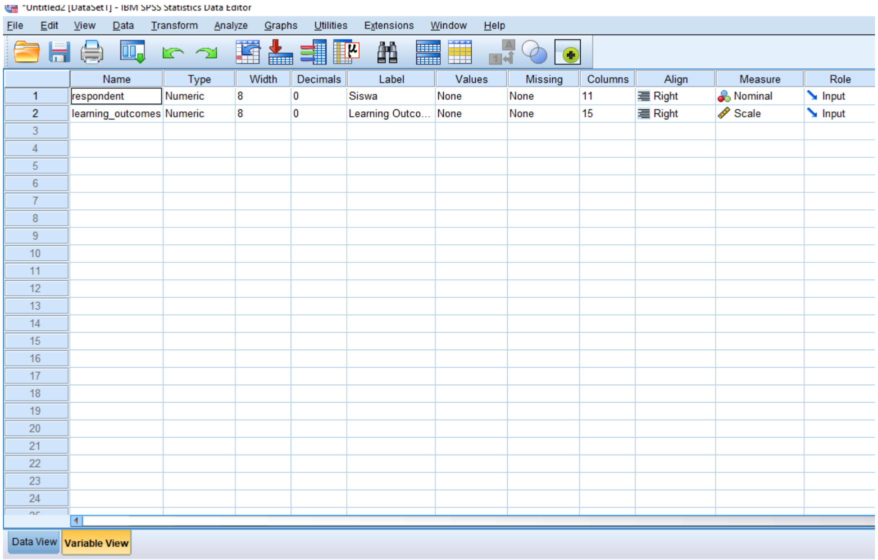

Figure 9. Display of variable view data input results with SPSS.

5) The next step is to input data. Click "Data View" in the bottom left corner. To enter data, it must be adjusted to the available variable columns (See **Figure 10**).

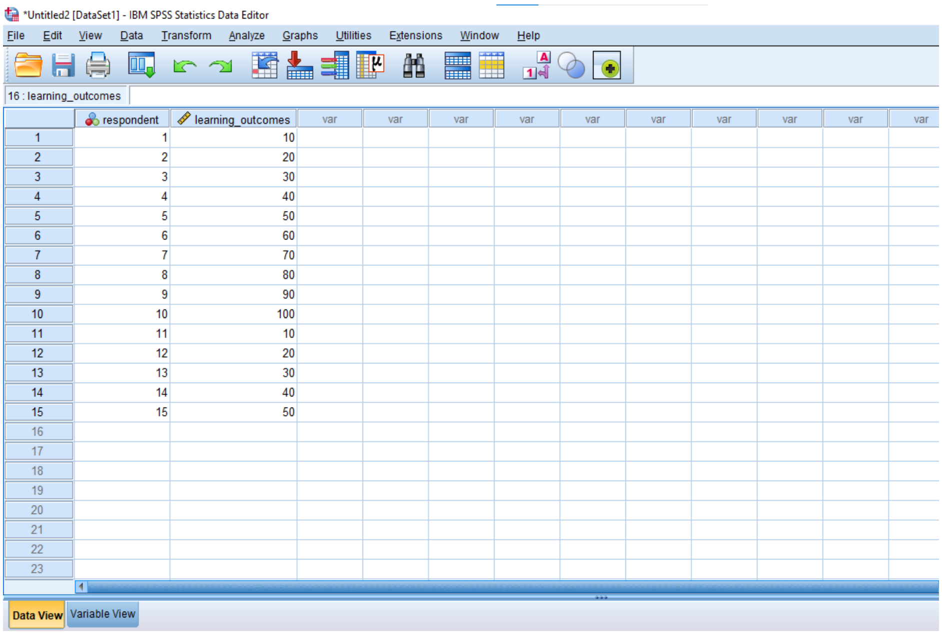

Figure 10. Display of data input results with SPSS.

6) After entering all the data into the variable column, then, we use data processing features in SPSS such as the normality test, homogeneity test, parametric t-test, and non-parametric t-test.

4. RESULTS AND DISCUSSION

4.1. Example of processing data with requirements testing

Before data calculation and analysis were carried out, a requirements test was first carried out. Prerequisite testing is a basic concept for determining which test statistics are required, and whether the test uses parametric or non-parametric statistics. The prerequisite tests consist of a normality test and a homogeneity test. Below is a detailed explanation of the normality test and homogeneity test:

4.1.1 Normality test

The normality test is a test carried out to check whether our research data comes from a population with a normal distribution. This test needs to be carried out because all parametric statistical calculations assume the normality of distribution. Normal data has the characteristic that the mean, median, and mode have the same value (Mishra *et al.,* 2019).

In testing the normality test, data is said to be normally distributed if the significance value is more than 0.05 (sig. > 0.05). The basis for decision-making in the Kolmogorov-Smirnov Normality test is (Knief & Forstmeier, 2021),

(i) If the significance value (Sig.) is greater than 0.05, then the research data is normally distributed.
(ii) On the other hand, if the significance value (Sig.) is smaller than 0.05, then the research data is not normally distributed.

In this article, the normality tests that will be discussed are Kolmogorov-Smirnov and Shapiro-Wilk.

4.1.1.1. Kolmogorov-Smirnov

The Kolmogorov-Smirnov Normality test is a test carried out to determine the distribution of random and specific data in a population. Based on tests carried out by the National Institute of Standards and Technology (), the Kolmogorov-Smirnov test is suitable for data sizes of 20 - 1000. However, in research in general, the Kolmogorov-Smirnov test is still used for data samples with a size of more than 1000 samples (20 ≤ N ≤ 1000). Therefore, it is recommended to use the Kolmogorov-Smirnov test for data above 50 samples (Usman, 2016).

For example, citing the data provided from research conducted by Zakaria et al. (2020), we have 60 respondents' data consisting of data on Motivation (X) and Mathematics Learning Achievement (Y) as shown **in Table 1**. In this context, we carry out a normality test Kolmogorov-Smirnov on the Unstandardized Residual (RES_1) value for the regression equation for the influence of learning motivation on learning achievement. We carried out the Kolmogorov-Smirnov normality test with the help of the SPSS version 26 statistical application.

Table 1. Example of Kolmogorov-Smirnov test research data (results are not normal).

Respondent	Motivation (X)	Achievement (Y)
1	75	80
2	60	75
3	65	75
4	75	90
5	65	85
6	80	85
7	75	95
8	80	95
9	65	80
10	80	90
11	60	75
12	75	95
13	80	95
14	65	80
15	80	90
16	60	75
17	67	75
18	75	80

Table 1. (Continue) Example of Kolmogorov-Smirnov test research data (results are not normal).

Respondent	Motivation (X)	Achievement (Y)
19	60	75
20	65	75
21	75	90
22	65	85
23	80	85
24	75	95
25	80	95
26	65	80
27	80	90
28	60	75
29	67	75
30	75	80
31	60	75
32	65	75
33	75	90
34	65	85
35	80	85
36	75	95
37	80	95
38	65	80
39	80	90
40	60	75
41	67	75
42	75	95
43	80	95
44	65	80
45	80	90
46	60	75
47	67	75
48	75	80
49	60	75
50	65	75
51	75	90
52	65	85
53	80	85
54	75	95
55	80	95
56	65	80
57	80	90
58	60	75
59	67	75
60	75	80

The steps for carrying out the Kolmogorov-Smirnov normality test (using data in **Table 1** with results that are not Normal) with SPSS are as follows:

1) Prepare the data to be tested.
2) Open the SPSS application as shown in **Figure 11**.
3) Then, click Display Variables in the bottom left corner. Next, in the "Name" column, write Motivation in row 1 and Achievement in row 2. In the “Decimals” column change it from

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2 to 0 for Learning Motivation and Learning Achievement. After that, change the "Measure" column for the motivation and achievement variables from unknown to scale (See **Figure 12**).

4) After that, click the "Data View" menu in the lower left corner. After that, enter the data on the motivation and learning achievements of the respondents that have been prepared previously (as can be seen in **Figure 13**).
5) The next step is to calculate or generate the unstandardized residual value (RES_1) to test its normality. RES_1 is the difference between the observed value and the predicted value, and absolute is an absolute value. The way to display the RES_1 value is by clicking the "Analyze" menu on the SPSS toolbar, then clicking "Regression" on the dropdown button then selecting Linear (see **Figure 14**).
6) Thereafter, the Linear Regression windows page will appear as shown in **Figure 15**. In the Linear Regression dialog box, enter the Learning Achievement (Y) variable in the Dependent box and the Learning Motivation (X) variable in the Independent box. Move it using the arrow buttons provided in the dialog box. Once finished, click "Save".

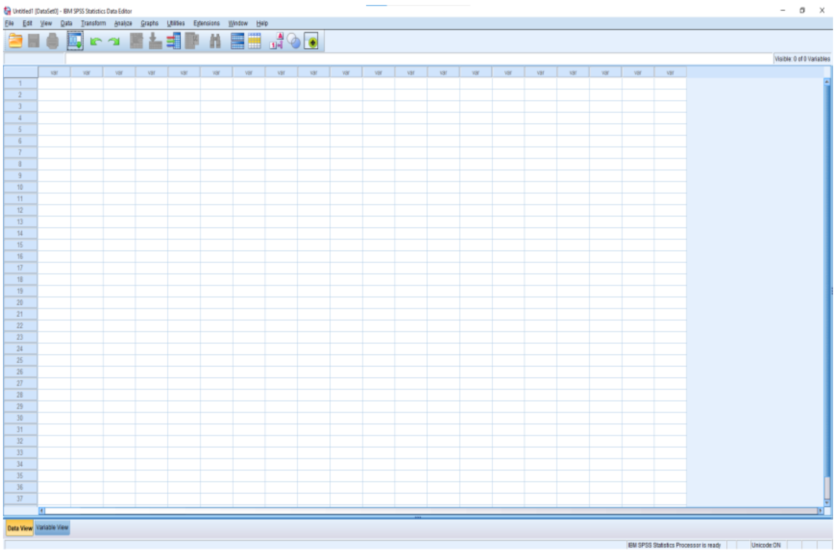

Figure 11. SPSS home page.

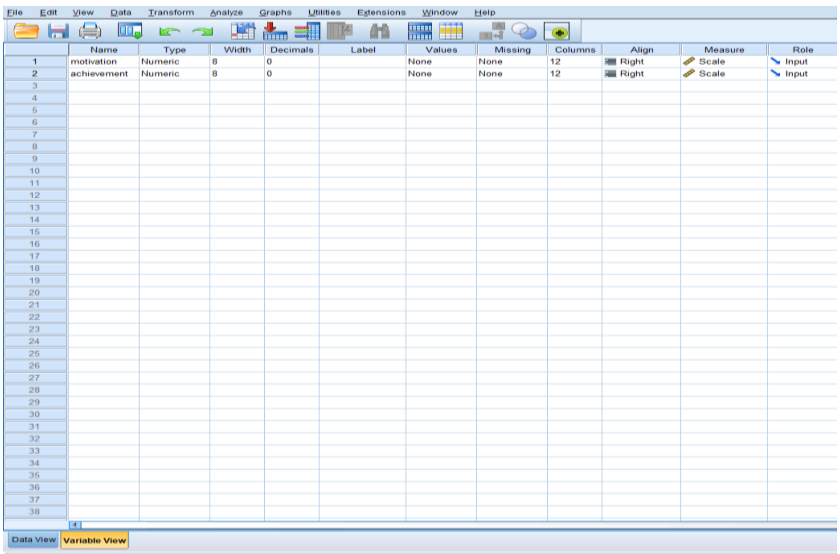

Figure 12. Display the "Variable View" worksheet settings in Kolmogorov-Smirnov Test with SPSS.

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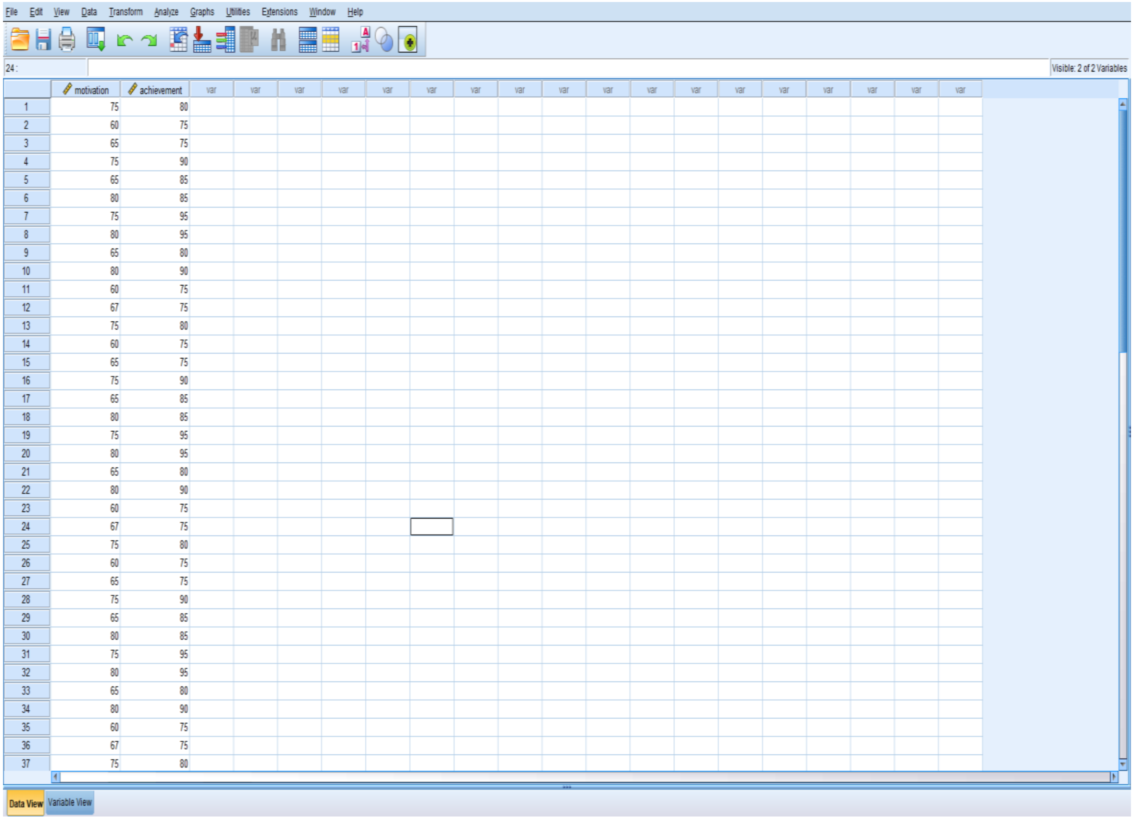

Figure 13. Display the "Data View" worksheet settings in a Kolmogorov-Smirnov Test with SPSS.

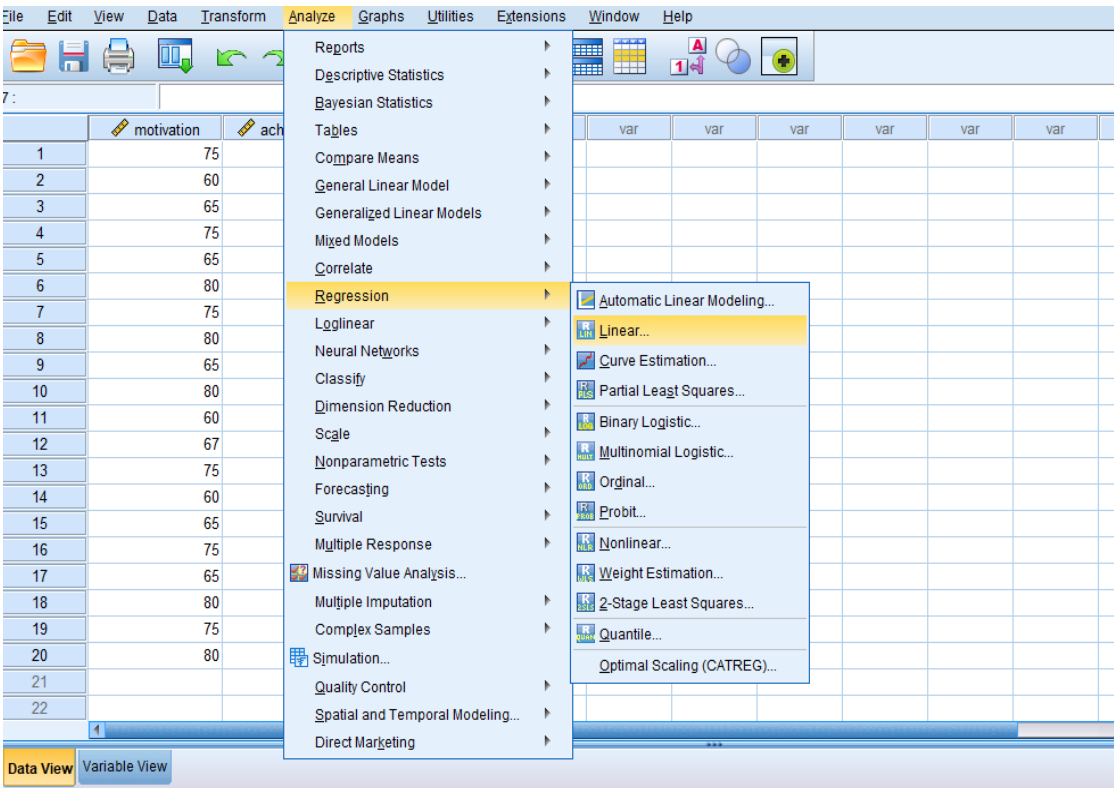

Figure 14. The settings display the unstandardized residual (RES_1) value for the Kolmogorov-Smirnov Test with SPSS.

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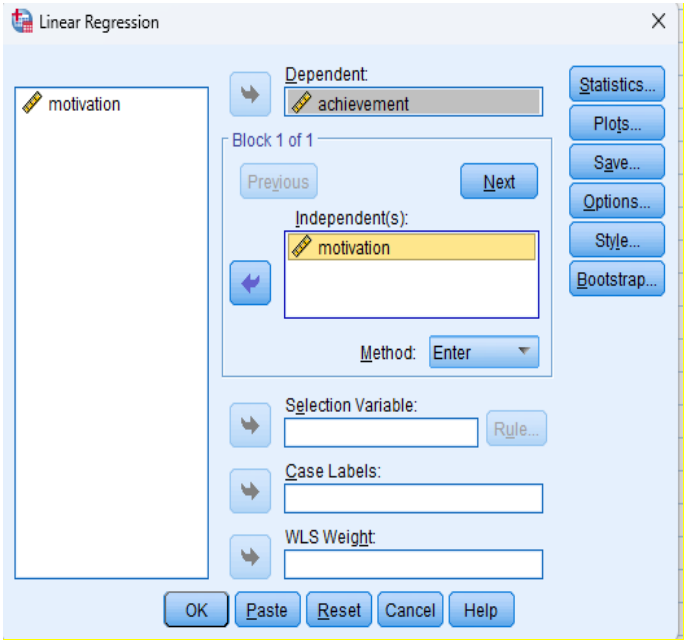

Figure 15. Linear regression settings for the Kolmogorov-Smirnov Test with SPSS.

7) After clicking "Save" in the Linear Regression dialog box, a new dialog box will appear with the title "Linear Regression: Save" as shown in **Figure 16**. In the "Linear Regression: Save" dialog box, the "Residuals" section check or select the option Unstandardised, then click the “Continue” button.

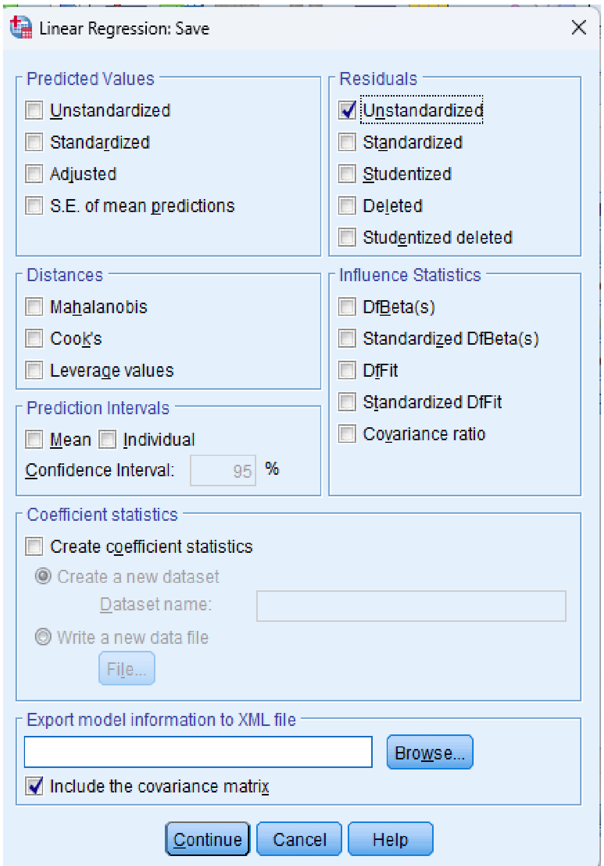

Figure 16. Settings in the linear regression dialog box: Save Kolmogorov-Smirnov Test with SPSS.

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8) After that, you will be directed back to the "Linear Regression" dialog box, then click the "OK" button (see **Figure 17**).

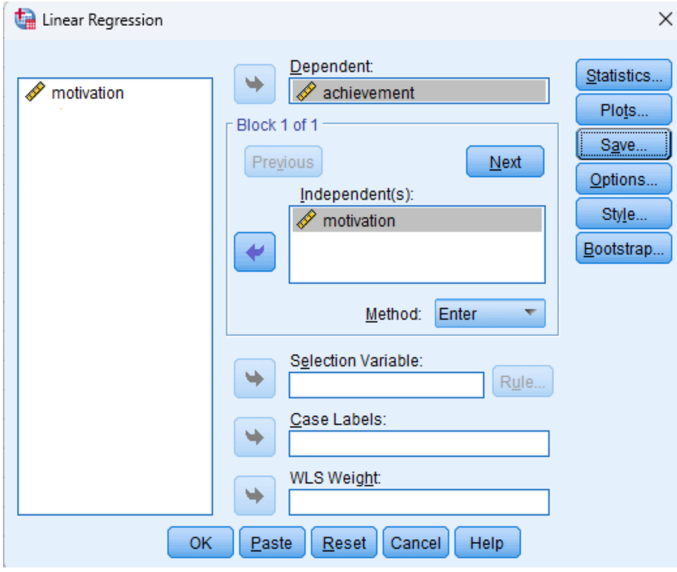

Figure 17. Click "OK" on the Linear Regression Dialog Box.

9) After you click "OK" in the linear regression dialog box, a new variable will appear on the data view page with the name RES_1, as shown in **Figure 18**.

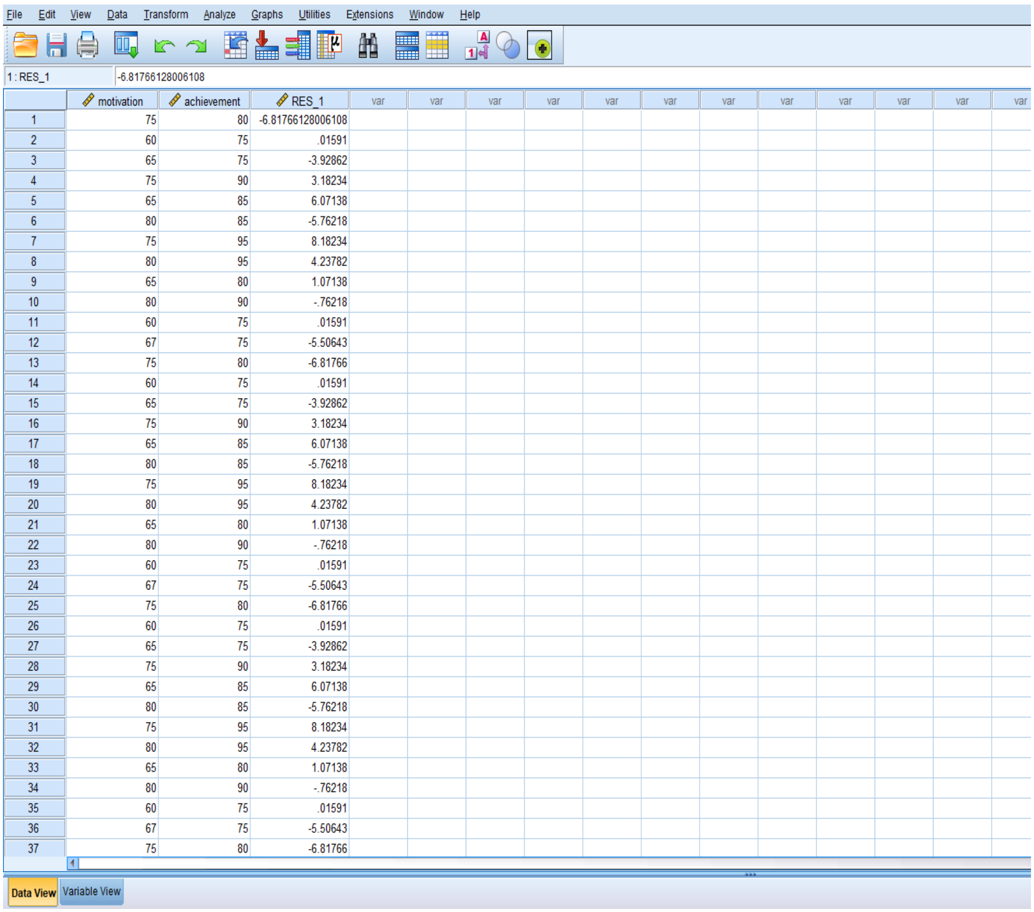

Figure 18. Worksheet display "Data View": Occurrence of variable RES_1.

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10) If you open the output window in SPSS, the regression results will be displayed as shown in **Figure 19**. At this stage, the Kolmogorov-Smirnov test has not been completed.

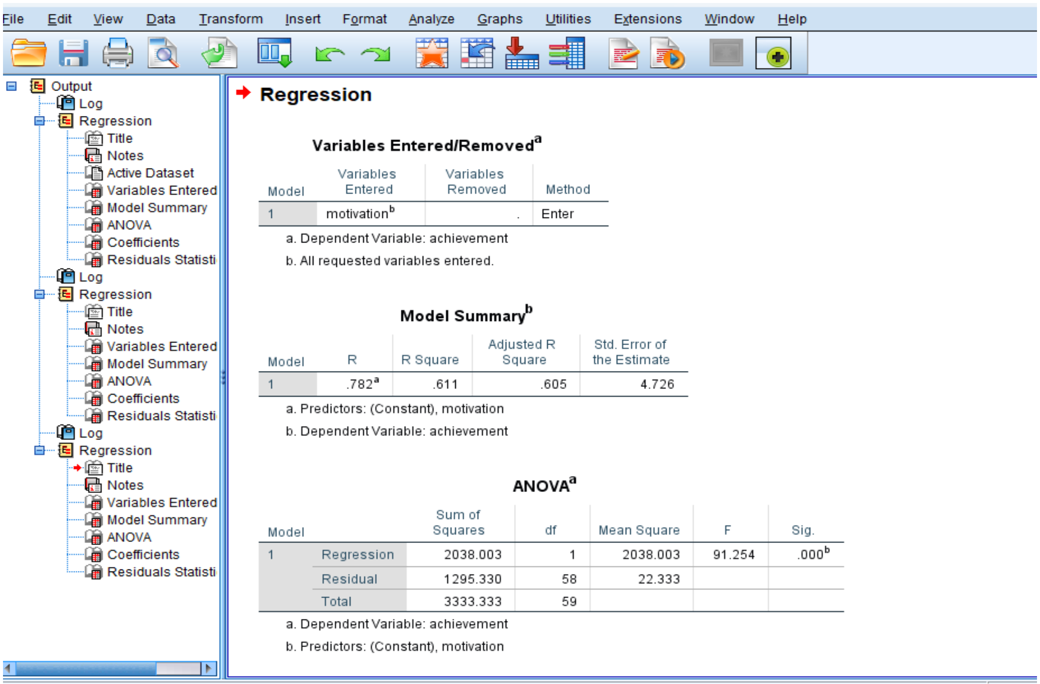

Figure 19. Regression calculation results in SPSS windows output.

11) The next step is the Kolmogorov-Smirnov normality test. The way to test normality using this method in SPSS is to select the "Analyze" menu on the top toolbar, then select "Nonparametric Tests" and click "Legacy Dialogs". Then select “1-Sample K-S” in the Legacy Dialogs submenu (see **Figure 20**).

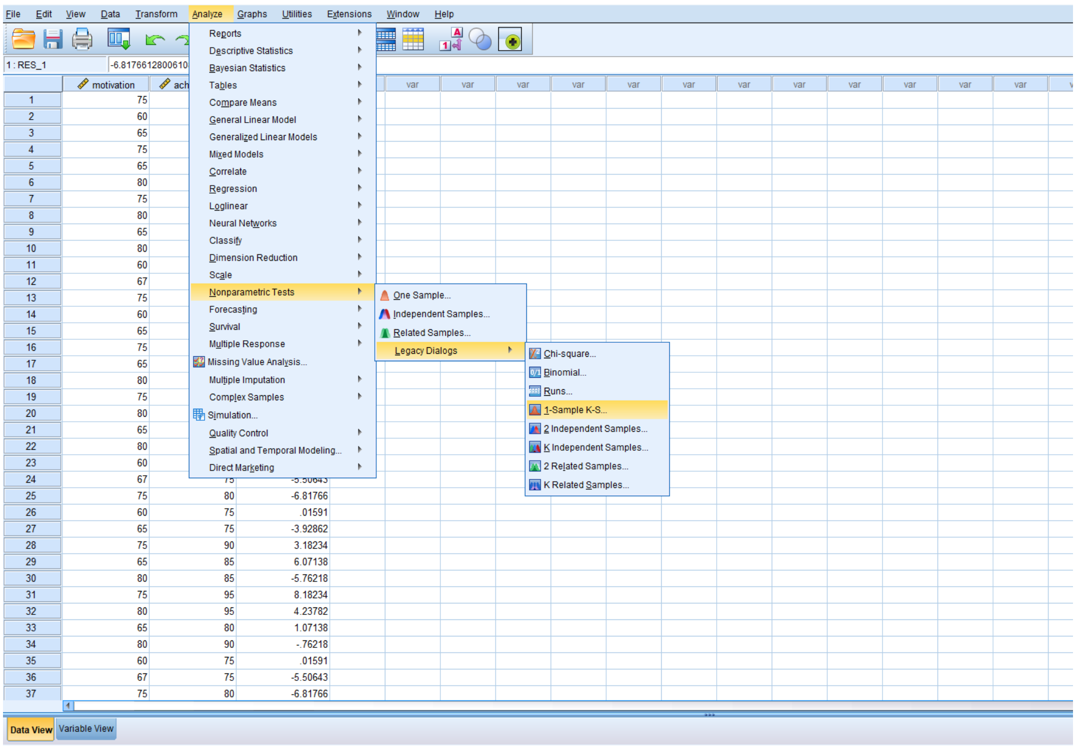

Figure 20. Menu selection method for the Kolmogorov-Smirnov Test in SPSS.

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12) After that, the "One-Sample Kolmogorov-Smirnov Test" dialog box will appear on the monitor screen (see **Figure 21**). Next, you enter the variable "Unstandardized Residuals" into the “Test Variable List” box. In the "Test Distribution" section, activate or check the "Normal" option, then click "OK" (see **Figure 22**).

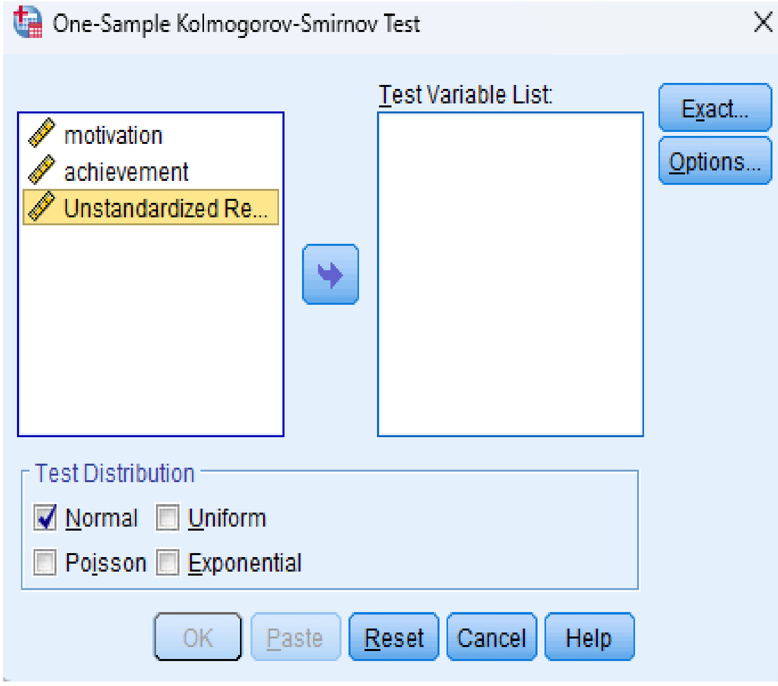

Figure 21. Kolmogorov-Smirnov Test one sample box dialogue.

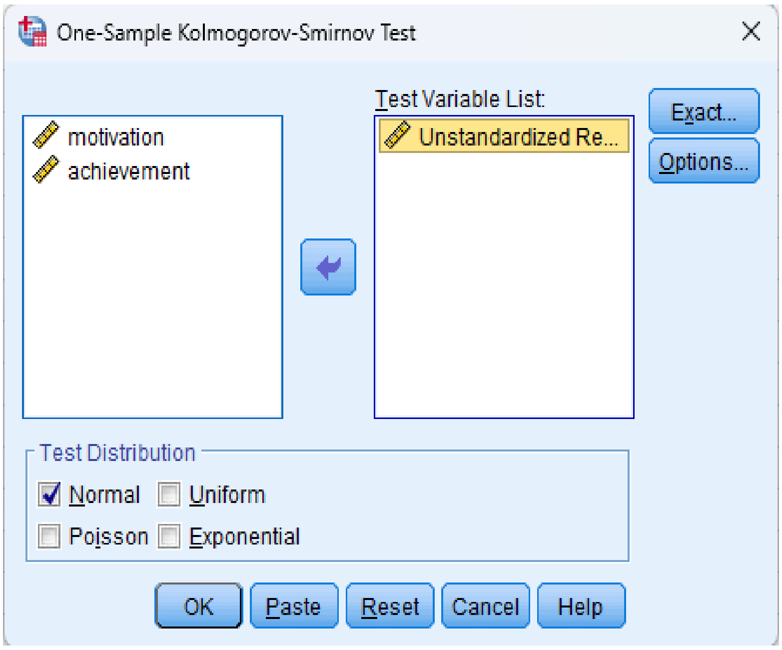

Figure 22. Settings in the One-Sample Kolmogorov-Smirnov Test dialog box.

13) After the calculation is complete, the SPSS window output appears. **Figure 23** shows the output results of the Kolmogorov-Smirnov Test with SPSS.

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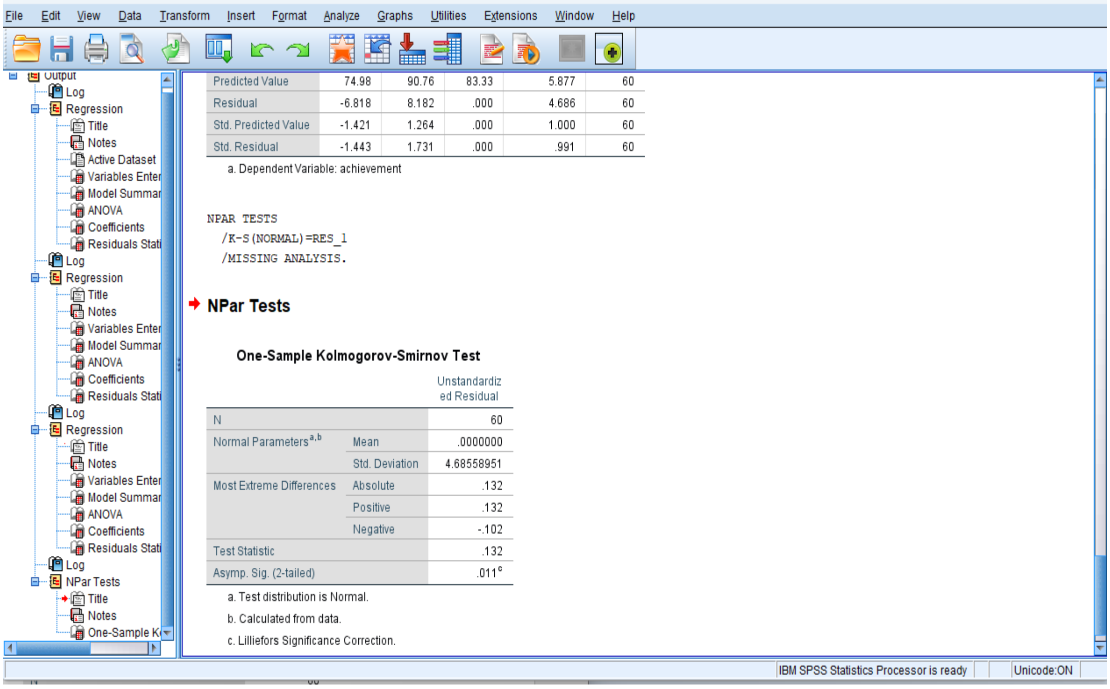

Figure 23. Windows output Kolmogorov-Smirnov Test results with SPSS

Figure 24 shows the results of the Kolmogorov-Smirnov Test calculation using SPSS. Based on these results, it is known that the significance value of Asymp. signature. (2-tailed) of 0.011 > 0.000.

NPar Tests

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		60
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	4.68558951
Most Extreme Differences	Absolute	.132
	Positive	.132
	Negative	-.102
Test Statistic		.132
Asymp. Sig. (2-tailed)		.011[c]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

Figure 24. Kolmogorov-Smirnov Test calculation results: Example of abnormal data with SPSS

Based on the SPSS output table, it is known that the Asymp.Sig (2-tailed) significance value is 0.011 < 0.050. This follows the basic decision-making of the Kolmogorov-Smirnov normality test in **Figure 24**, the data is not normally distributed. Thus, the assumptions or requirements for normality in the regression model are not met. Examples of data with normal Kolmogorov-Smirnov test results are shown in **Table 2**.

Table 2. Example of Kolmogorov-Smirnov test research data (results are normal).

Respondent	Motivation (X)	Achievement (Y)	RES_1
1	75	80	-6.81766
2	60	75	.01591
3	65	75	-3.92862
4	75	90	3.18234
5	65	85	6.07138
6	80	85	-5.76218
7	75	95	8.18234
8	80	95	4.23782
9	65	80	1.07138
10	80	90	-.76218
11	60	75	.01591
12	75	95	-5.50643
13	80	95	-6.81766
14	65	80	.01591
15	80	90	-3.92862
16	60	75	3.18234
17	67	75	6.07138
18	75	80	-5.76218
19	60	75	8.18234
20	65	75	4.23782

Figure 25 shows the results of data calculations in Table 2 using the Kolmogorov-Smirnov test. Based on the SPSS output table, it is known that the Asymp.Sig (2-tailed) significance value of 0.200 is greater than 0.050. thus, following the basis for decision-making in the Kolmogorov-Smirnov normality test, it can be concluded that the data is normally distributed. Thus, the normality assumptions or requirements in the regression model have been met.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		20
Normal Parameters[a,b]	Mean	.2590660
	Std. Deviation	5.05100308
Most Extreme Differences	Absolute	.146
	Positive	.146
	Negative	-.119
Test Statistic		.146
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Figure 25. Kolmogorov-Smirnov Test calculation results: Example of normal data with SPSS

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p- ISSN 2528-1410 e- ISSN 2527-8045

4.1.1.2. Shapiro-Wilk

The Shapiro-Wilk Normality Test is carried out to determine whether the distribution is normally distributed. The Shapiro-Wilk test is used for limited data sizes, namely samples of less than 50 to produce precise and accurate decisions (Killic, 2016).

To provide an understanding of the Shapiro-Wilk normality test, an example is presented by citing data from research conducted by Hairida (2016), we have 30 respondents' data consisting of pretest and posttest data which is shown in Table 3. In this context, we carry out the Shapiro normality test -Wilk to determine the differences in the influence of class VII junior high school student's knowledge of electricity. Here, we carry out the Shapiro-Wilk normality test with the help of the SPSS version 26 statistical application.

Table 3. Example of Shapiro-Wilk Test research data (results are normal).

No	Pretest	Posttest
1	56	87
2	72	92
3	67	87
4	58	82
5	70	89
6	68	86
7	76	90
8	70	86
9	69	80
10	58	85
11	65	90
12	70	83
13	75	80
14	67	87
15	72	82
16	74	80
17	76	83
18	68	82
19	62	89
20	70	85
21	61	92
22	77	85
23	56	87
24	72	92
25	67	87
26	58	82
27	70	89
28	68	86
29	76	90
30	70	86

The following are the steps for carrying out the Shapiro-Wilk normality test with SPSS software as follows:

1) Prepare the data to be tested.
2) Open the SPSS application and prepare a new SPSS program worksheet shown in **Figure 26**.
3) Next, click on the bottom left corner of "Variable View". Then, in the "Name" column, enter the pretest and posttest variables in rows 1 and 2, respectively. In the “Decimals”

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column, change it from 2 to 0. After that, in the column, the "Measure" pretest and posttest variables were changed from unknown to scale (See **Figure 27**).

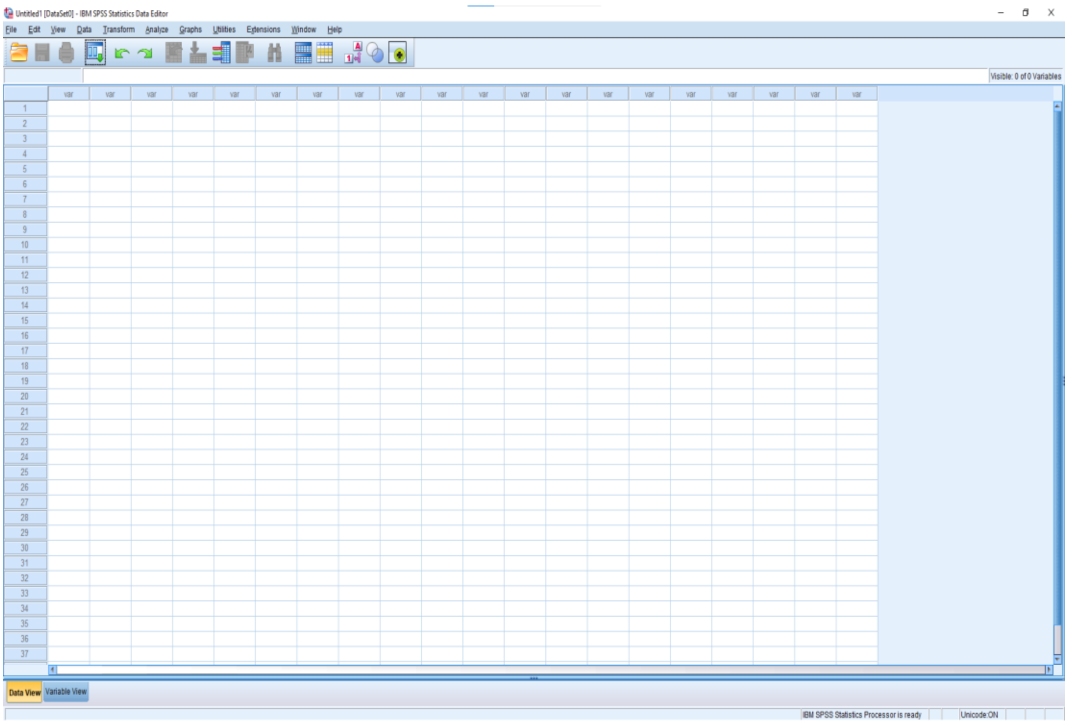

Figure 25. SPSS worksheet home page.

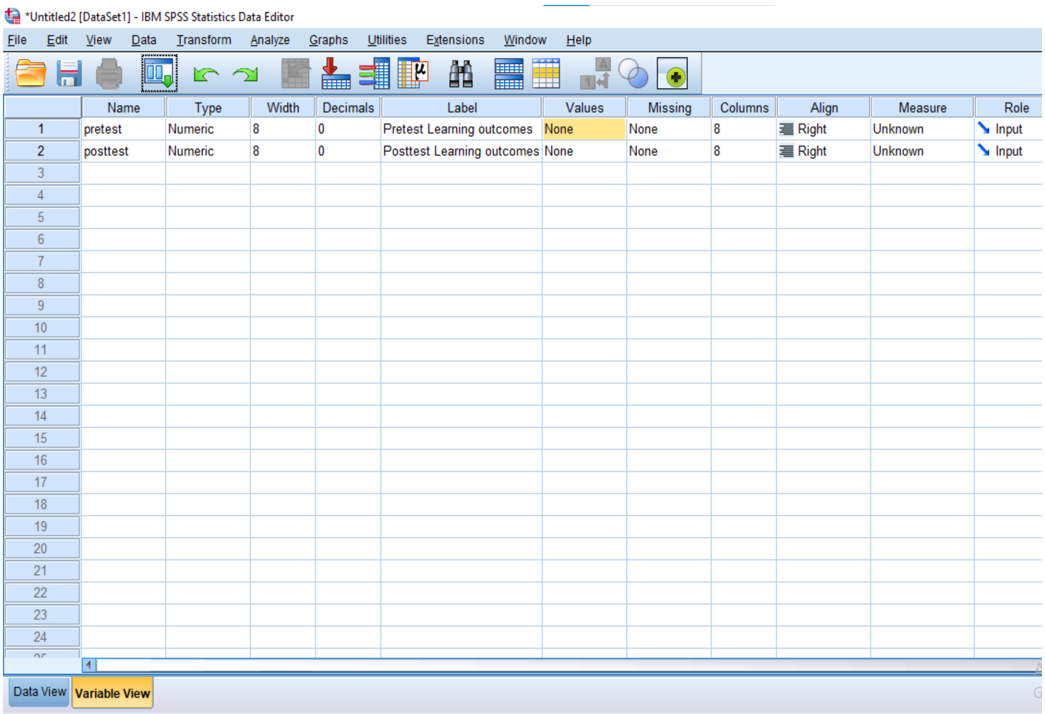

Figure 27. Display the “Variable View” worksheet settings in Shapiro-Wilk Test with SPSS.

4) After that, click "Data View" in the lower left corner and enter the pretest and posttest data as shown in **Figure 28**.

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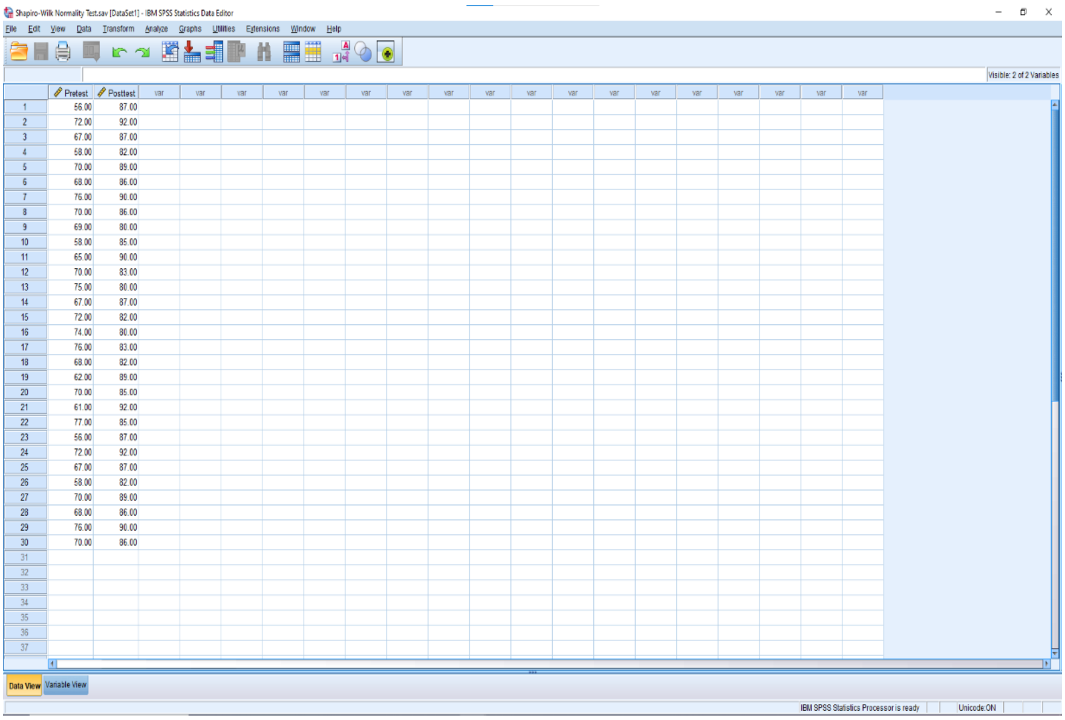

Figure 28. Display the “Variable View” worksheet settings in Shapiro-Wilk Test with SPSS.

5) The next step is to calculate the normality test using Shapiro-Wilk test. Starting by clicking on the SPSS main menu, selecting the "Analyze” then, selecting the “Descriptive statistics” submenu then clicking "Explore" (See **Figure 29**).

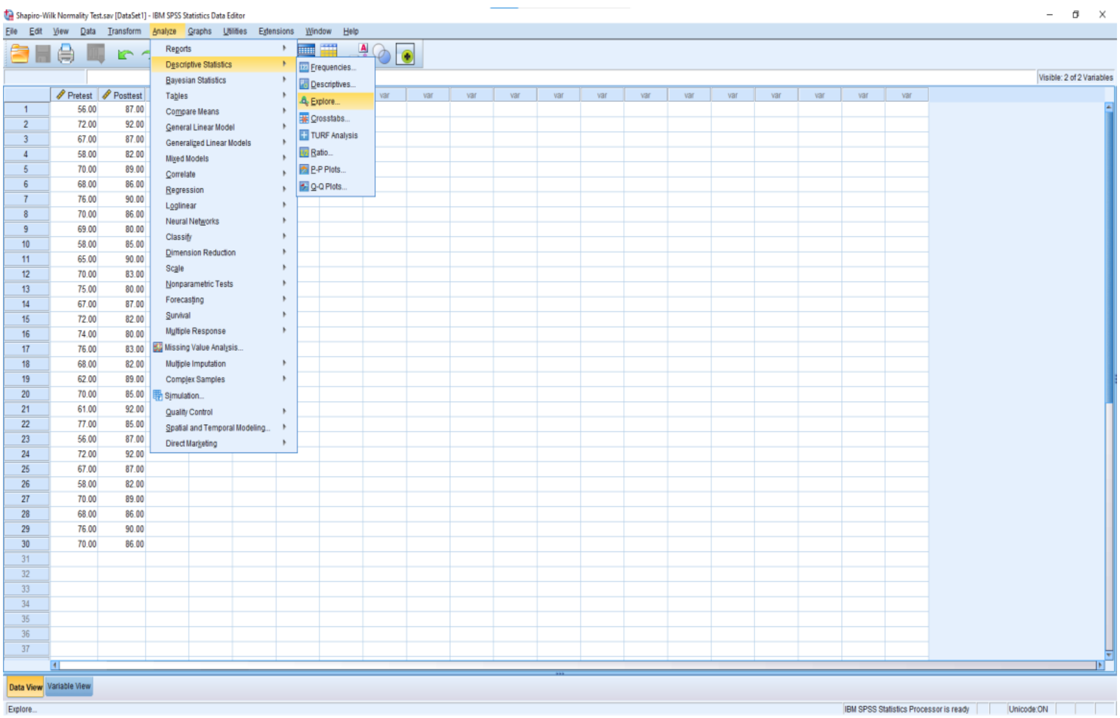

Figure 29. Settings for calculating the Shapiro-Wilk normality test with SPSS.

6) After that, the Shapiro-Wilk normality test worksheet page will appear as in **Figure 30**. In the "Explore" normality test dialog, move the pretest and posttest variables to the

"Dependent List" contact using the button provided. After that, the Shapiro-Wilk normality test worksheet page will appear as in **Figure 30**.

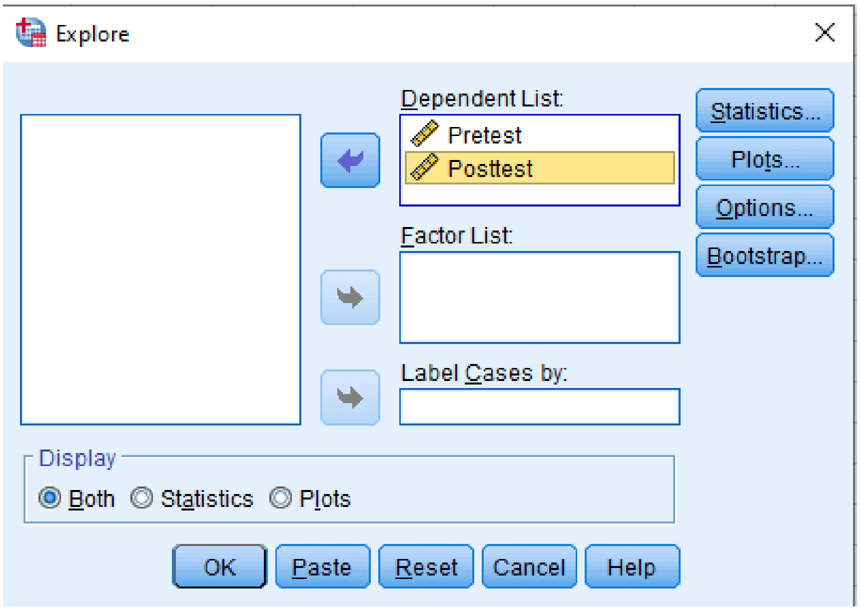

Figure 30. Explore settings on the Shapiro-Wilk normality test with SPSS.

7) Next, you click "Plots" and then a dialogue "Explore: Plots" box appears. Then, check "Normality plots with test", then click "Continue" (See **Figure 31**).

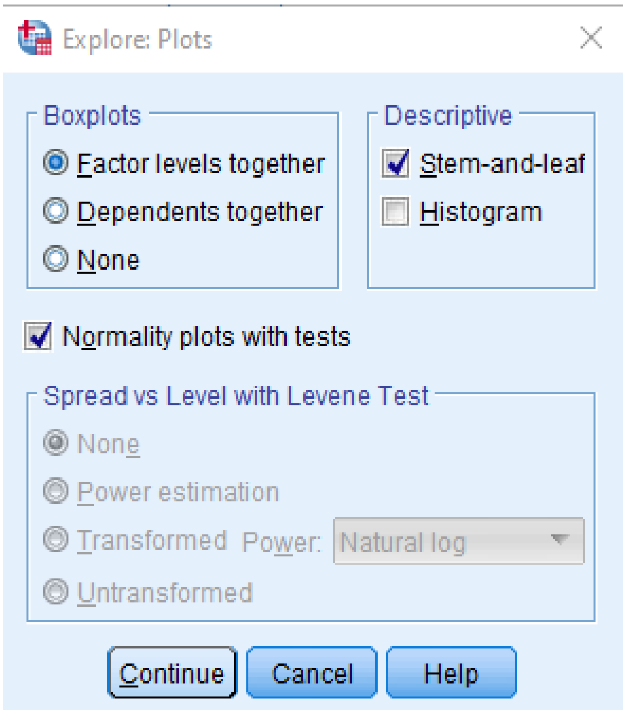

Figure 31. Explore Plot settings in the Shapiro-Wilk normality test with SPSS.

8) After that, you will be directed back to the "Explore" dialog box then click the "OK" button (See **Figure 32**).

DOI: https://doi.org/10.17509/ijost.v9i1.64035
p- ISSN 2528-1410 e- ISSN 2527-8045

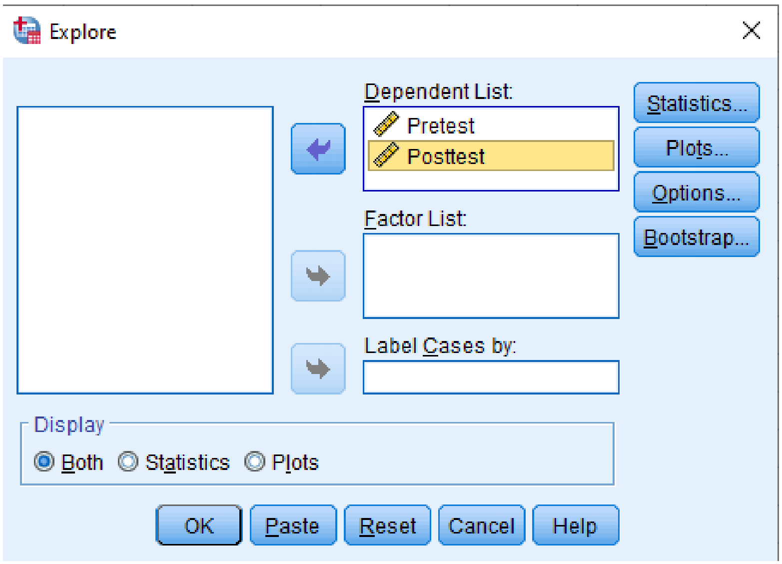

Figure 32. Explore plot settings: Click "OK" on the Shapiro-Wilk normality test with SPSS.

9) After that, you can open the SPSS output window. **Figure 33** shows the output results from the Shapiro-Wilk Test with SPSS.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.174	30	.022	.919	30	.026
Posttest	.100	30	.200*	.949	30	.160

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 33. Shapiro-Wilk Test Results Output Page with SPSS.

Figure 33 shows the results of the Shapiro-Wilk test calculations with SPSS. Based on these results, it is known that the significance value (Sig.) of the Shapiro-Wilk test for the pretest and posttest values is 0.026 and 0.160, respectively. From the output results with a pretest significance value of 0.026 > 0.050 and a posttest of 0.160 > 0.050, it can be concluded that the data is normally distributed.

4.1.2. Homogeneity Test

The homogeneity test is a statistical test procedure that aims to show that two or more groups of data samples taken from a population have the same variance. A brief definition of the homogeneity test is testing whether the variances of two or more distributions are the same (Dogan *et al.*, 2020).

As with the normality test, the homogeneity test is used as a reference material for determining decisions on subsequent statistical tests. The basis or guidelines for decision-making in the homogeneity test are as follows (Agus *et al.*, 2021):

(i) If the significance value or Sig. < 0.05, then it is said that the variance of two or more population data groups is not the same or not homogeneous.

(ii) If the significance value or Sig. > 0.05, then it is said that the variance of two or more population data groups is the same or homogeneous.

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In this article, the homogeneity tests discussed are ANOVA and Levene Test. Below is a description of the steps for the ANOVA and Levene homogeneity tests.

4.1.2.1. ANOVA

Analysis of Variance (ANOVA) is a statistical analysis that determines the mean differences between groups. The group in question can mean a group or type of treatment. ANOVA itself is a statistical test procedure that is similar to the t-test, but ANOVA can test differences in more than two groups. This is different from the independent sample t-test which can only test the difference in the means of two groups (Ustaoglu *et al.,* 2020).

ANOVA is used as an analytical tool to test research hypotheses to assess whether there are differences in means between groups. The final result of the ANOVA analysis is the F test value or calculated F. The basis for decision-making for the ANOVA homogeneity test carried out by comparing the F table and calculated F is as follows:

(i) If the calculated F value > F table, then H1 is accepted or H0 is rejected, which means there is a difference in the averages for all groups.

(ii) On the other hand, if F count < F table then H1 is rejected or H0 is accepted, which means there is no difference in averages in all groups.

The data presented in this article is quoted from research conducted by Paul & Jefferson (2019). We present a homogeneity test on the learning outcomes of class A and B students (See **Table 4**). In this context, we test homogeneity using ANOVA.

Table 4. Example of ANOVA homogeneity test research data (not homogeneous results).

No	Science learning outcomes	
	Class A	Class B
1	65	40
2	70	50
3	75	65
4	70	70
5	70	75
6	69	78
7	60	74
8	70	78
9	70	72
10	75	82
11	80	80
12	72	84
13	70	85
14	76	78
15	68	72
16	70	82
17	70	80
18	61	84
19	77	85
20	70	85
21	60	78
22	70	80
23	80	85
24	70	80
25	70	85
26	68	80

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Table 4. (Continue) Example of ANOVA homogeneity test research data (not homogeneous results).

No	Science learning outcomes	
	Class A	**Class A**
27	75	75
28	76	76
29	65	78
30	60	78

Below we explain the steps for the ANOVA homogeneity test using the SPSS application:

1) Open the SPSS application, then click in the lower left corner "View Variables". After clicking, the next step is to fill in the properties of the research variable as seen in **Figure 34**. To create a variable, write Class A and Class B in rows 1 and 2. In the "Decimal" column, change it from 2 to 0. After that, the "Measure" columns for Class variables A and Class B change from unknown to scale.

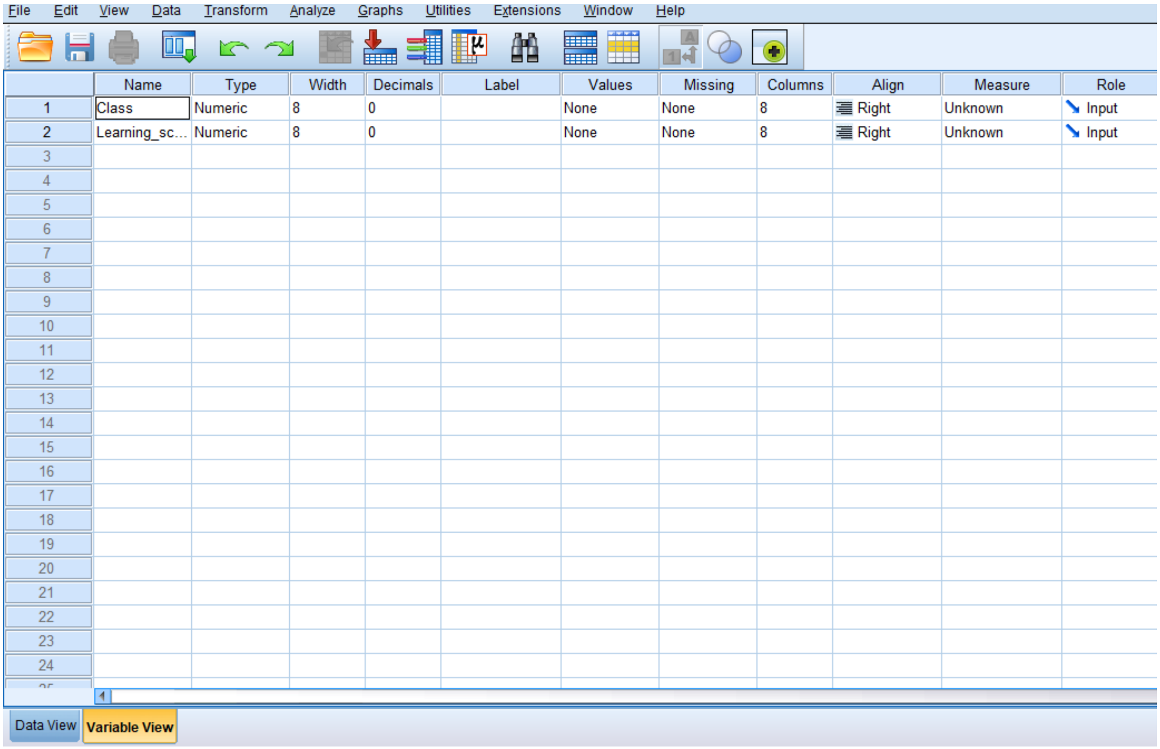

Figure 34. Display the "Data View" worksheet settings in ANOVA Test with SPSS.

2) To fill in the variables in the "Values" section, click the "None" column until the "Value Label" dialog box appears, in the "Value" box, enter number 1, in the "Label" box, enter Class A, then click Add. Then, fill in the "Value" box again with the number 2, and in the "Label" box write Class B, then click Add. If you have successfully filled in the variable properties correctly, the next step is to click the "OK" button. If the process of filling in all variable properties is carried out correctly, the display in SPSS will look like **Figure 35**.
3) After that, you click "Data View" and then enter the Class data into the Class box, and the learning results data into the Learning box. Then, you can carry out the analysis process by going to the "Analyze" menu, then clicking "Compare Means", and the next step is clicking "One Way ANOVA" as shown in **Figure 36**.

DOI: https://doi.org/10.17509/ijost.v9i1.64035
p- ISSN 2528-1410 e- ISSN 2527-8045

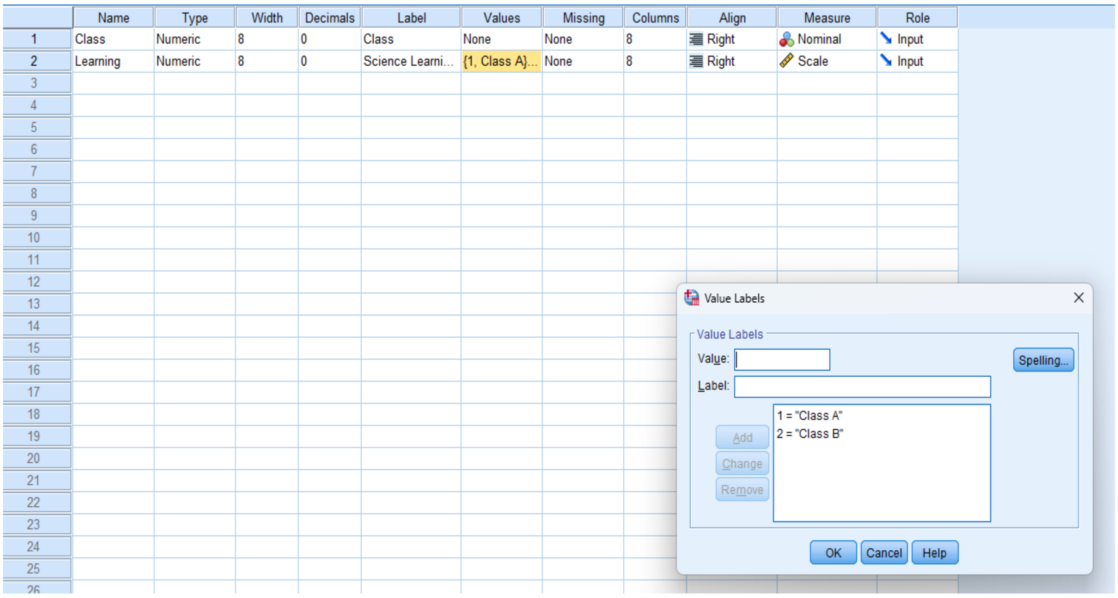

Figure 35. Variable view worksheet settings: Value labels ANOVA Homogeneity Test with SPSS.

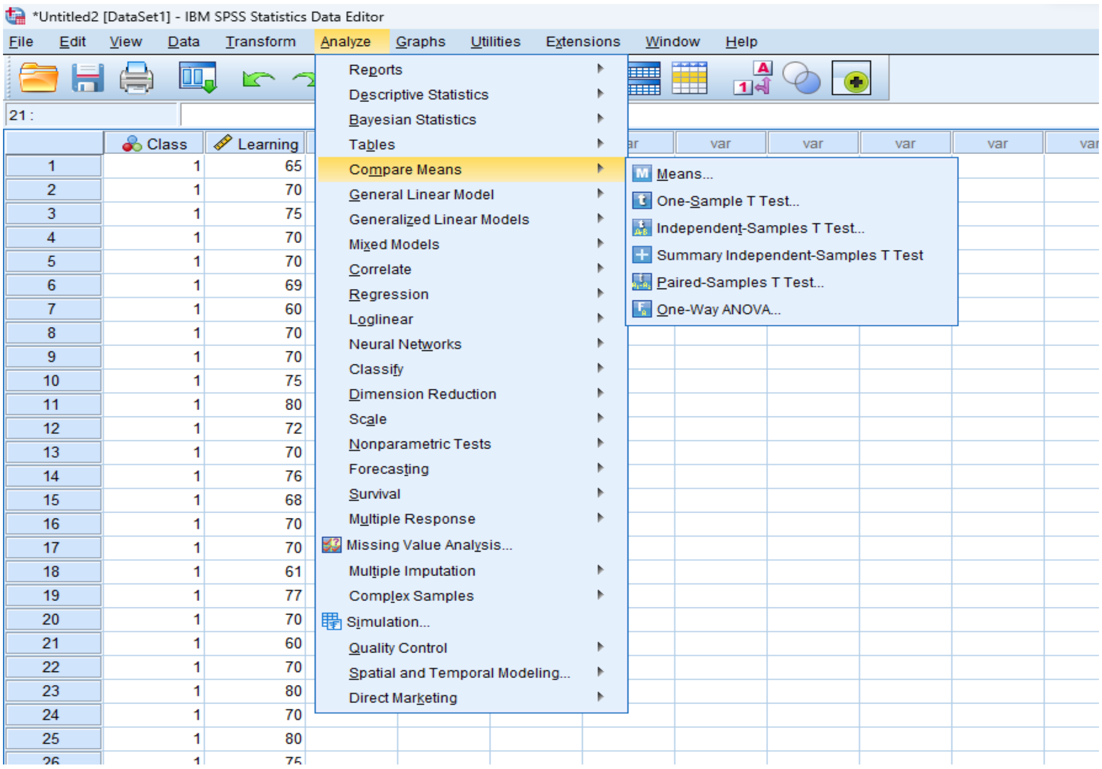

Figure 36. Settings for calculating the ANOVA homogeneity test with SPSS.

4) After you have completed step 3, a box will appear with the name "One-Way ANOVA". Next, enter the variable "Science Learning Outcomes" into the "Dependent List" box and enter "Class" into the "Factor" box, then click options as shown in **Figure 37**.
5) After clicking options, you will be directed to the "One-Way ANOVA: Options" dialog box, in the "Statistics" section, put a tick for descriptive and Homogeneity of variance test, then click continue as shown in **Figure 38**.

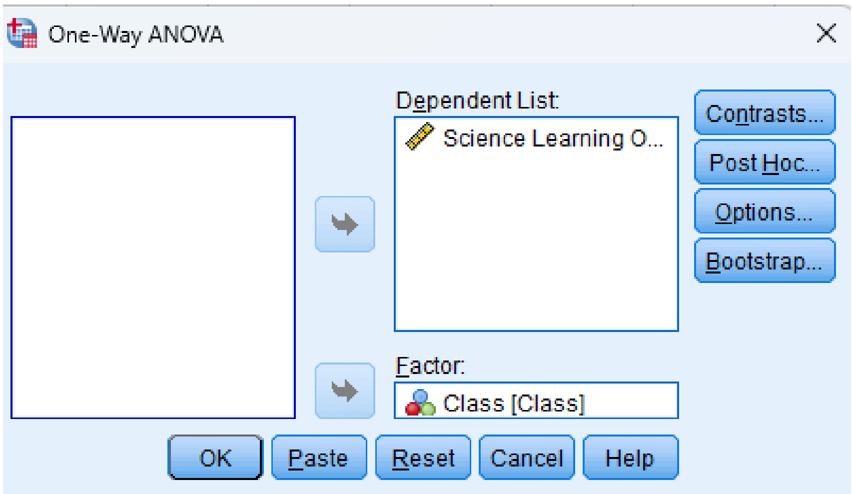

Figure 37. One-Way ANOVA Setup.

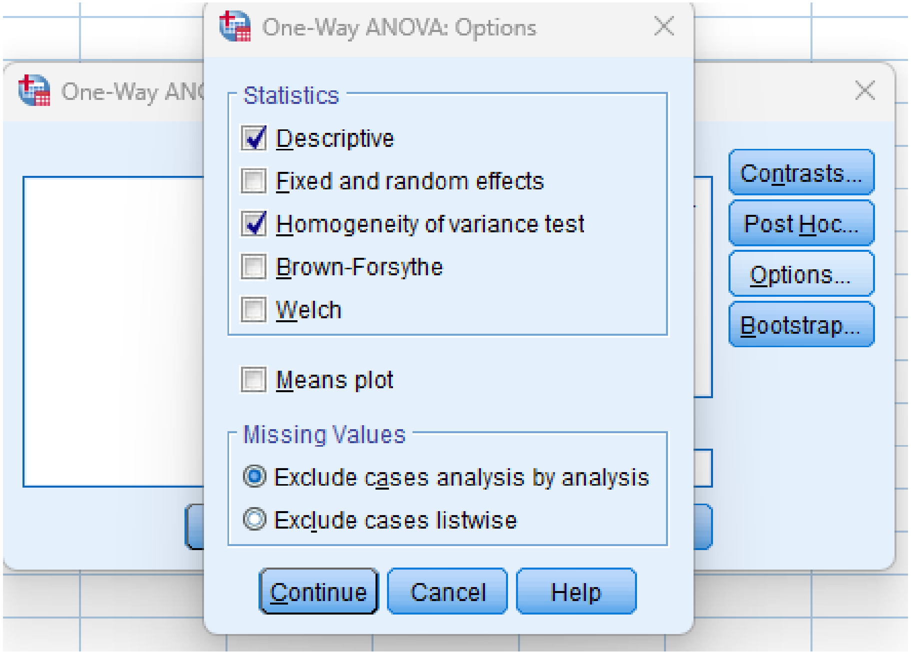

Figure 38. One-Way ANOVA Settings: Statics.

6) Click “OK” to end the command. After carrying out stage 5, the SPSS output display will appear as shown in **Figure 39**.

ANOVA

Science Learning Outcomes

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	504.600	1	504.600	7.967	.007
Within Groups	3673.333	58	63.333		
Total	4177.933	59			

Figure 39. Output page for ANOVA homogeneity test results with SPSS.

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Based on **Figure 39**, the significance value (Sig.) of the data used is 0.007. Meanwhile, the F table value is 7.967. From the output results with a significance value (Sig.) of 0.007 > 0.050, it can be concluded that the data used is not homogeneous. Meanwhile, the output results of the F value and F table value are 7.967 > 3.130, thus it can be concluded that the pretest and posttest value data have different average values.

4.1.2.2 Levene Test

Levene's test is a method of testing the homogeneity of almost equal variants. Levene's test is carried out by looking for the difference between each data and the group average. Levene's test is better used if the amount of data between groups is the same. Levene's test means that data does not have to be normally distributed, but must be continuous. As an example of research conducted by Ananda & Atmojo (2022), we present a homogeneity test on chemistry learning outcomes data for students in classes A and B. Details of student learning outcomes data are presented in **Table 5**.

Table 5. Example of Levene homogeneity test data (homogeneous results).

No	Chemistry learning outcomes	
	Class A	Class B
1	65	40
2	70	50
3	75	65
4	70	70
5	70	75
6	69	78
7	60	74
8	70	78
9	70	72
10	75	82
11	80	80
12	72	84
13	70	85
14	76	78
15	68	72
16	70	82
17	70	80
18	61	84
19	77	85
20	70	85
21	60	78
22	70	80
23	80	85
24	70	80
25	70	85
26	68	80
29	75	75
30	76	76

More clearly, the steps for carrying out the Levene test using SPSS are as follows:

1) Open the SPSS application, then click in the lower left corner "Variable View". Then, in the "Name" column, Class and Learning Outcomes are written in rows 1 and 2. Next, the “Decimals” column is changed from 2 to 0. After that, in the “Measure” column for the

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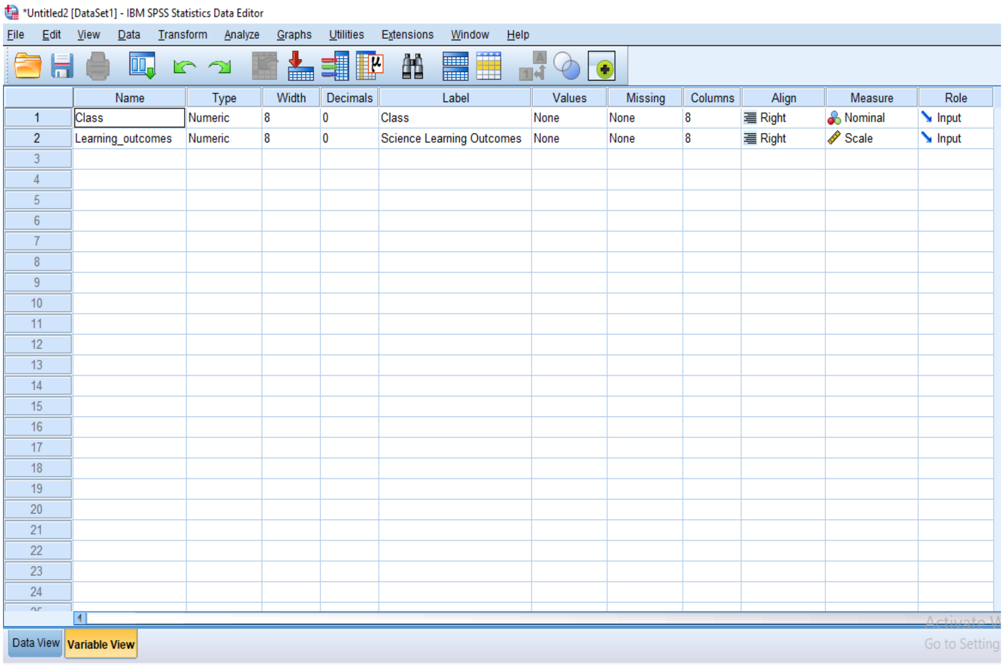
Class variable, it is changed from unknown to nominal and the Learning Outcomes variable is changed to scale (See **Figure 40**).



Gambar 40. Variable settings view homogeneity test: Levene Test with SPSS.

2) After that, to fill in the variables in the "Values" section, click the "None" column, and the "Value Label" dialog box will appear, in the "Value" box, fill in number 1, and in the "Label" box, fill in Class A then click "Add". hen, fill in the "Value" box again with the number 2, and in the "Label" box write Class B, then click Add. If filling in the variable properties has been successfully done correctly, the next step is to click the "OK" button. If the process of filling in all variable properties is carried out correctly, the display in SPSS will appear as in **Figure 41**.

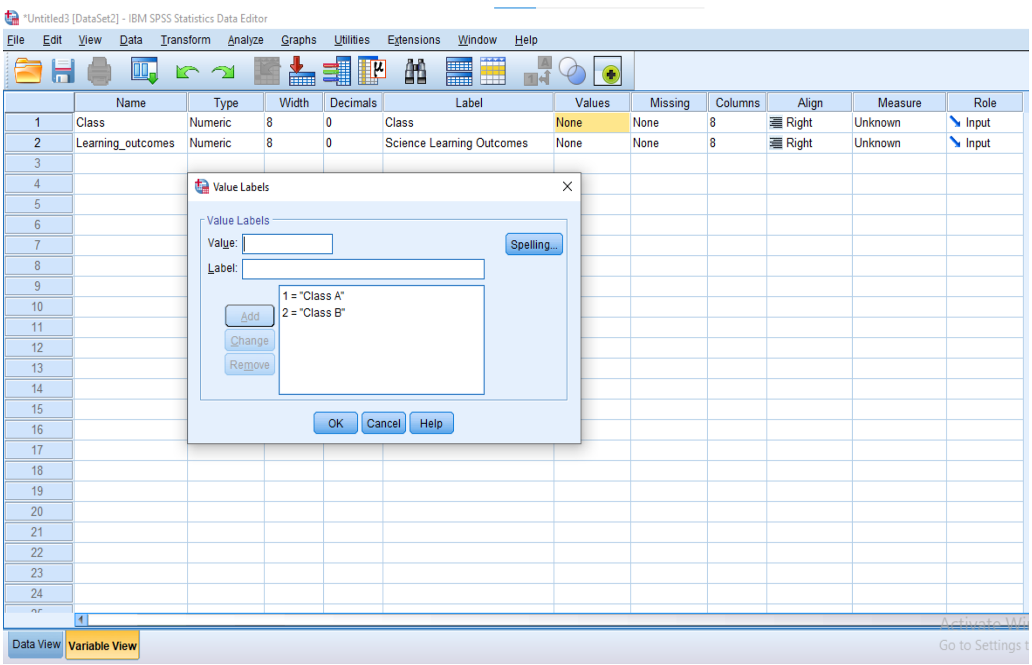


Figure 41. Setting variable values in the Levene Test.

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p- ISSN 2528-1410 e- ISSN 2527-8045

3) The next step is to calculate the homogeneity test using the Levene test. Start by clicking the SPSS main menu, then selecting the "Analyze" menu. After that, click the Descriptive statistics submenu then click "Explore" (See **Figure 42**).

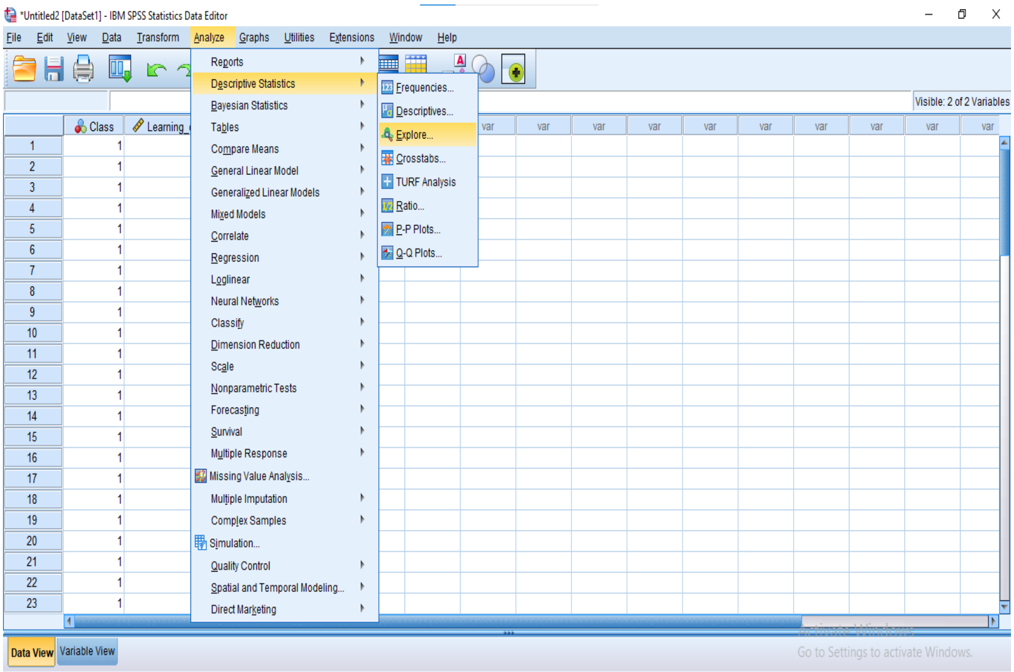

Figure 42. Settings for calculating homogeneity tests with SPSS.

4) After you have completed step 3, you will be directed to a box called "Explore". Next, move the "Chemistry Learning Outcomes" variable to the "Dependent List" box and move the "Class" variable to the "Factor" box, then click options as shown in **Figure 43.**

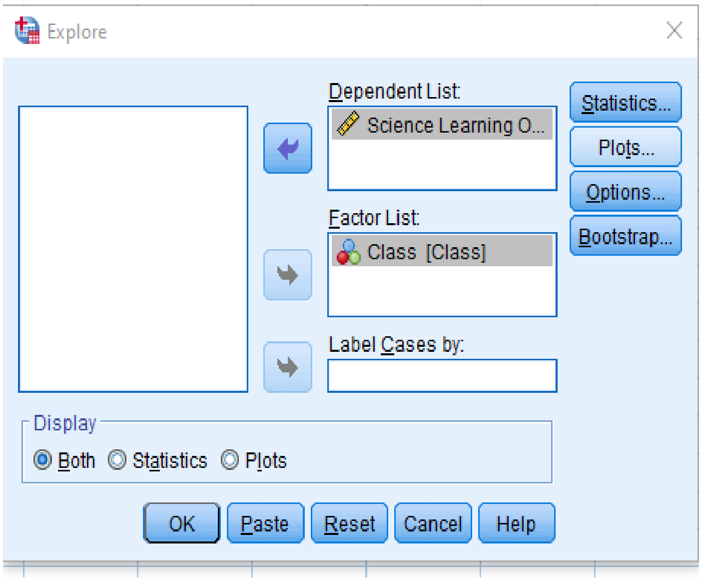

Figure 43. Settings for calculating the Levene test of homogeneity with SPSS.

5) After you have completed step 4. The next step is to click "Plots", a dialog box will appear then in the Boxplots box click "Factor level Together" and in the "Descriptive" box check "stem-and-leaf". After that, in the Speard vs level with the Levene test box, click “power estimation” and click “Continue” as shown in **Figure 44**.

DOI: https://doi.org/10.17509/ijost.v9i1.64035
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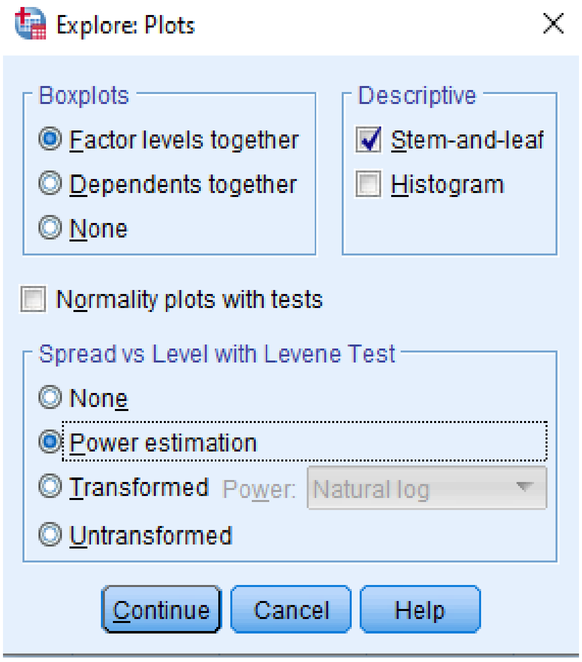

Figure 44. Settings for calculating homogeneity tests. Click "Continue" in the explore plots the Levene test box with SPSS.

6) To end the command, click "OK" and the SPSS output display will appear as shown in **Figure 45**.

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Science Learning Outcomes	Based on Mean	1.734	1	58	.193
	Based on Median	.883	1	58	.351
	Based on Median and with adjusted df	.883	1	41.682	.353
	Based on trimmed mean	.933	1	58	.338

Figure 45. Output page for Levene test homogeneity test results with SPSS.

Based on **Figure 45**, the significance value (Sig.) of the data obtained is 0.933. The output results with a significance value (Sig.) of 0.933 > 0.05, meaning that the data used is homogeneous which indicates that the average value of class A and class B is the same.

4.3. Example of How to Calculate Normally Distributed Data (Parametric Statistics) to Test the Difference in Significance

4.3.1. One Sample t-test

The one-sample t-test is generally used to compare the average of the sample being studied with the average of the existing population. The one-sample t-test can be used to test hypotheses in the form of descriptive statistics if the research data is on an interval or ratio scale. The One Sample t-test is a comparison test to assess the difference between a certain value and the average of a population group. The one-sample t-test is also called the student t-test or one-sample t-test because the t-test here uses one sample. One-sample t-test is a part of parametric statistics. Therefore, the basic assumption that must be met is that the research data is normally distributed (McGovern *et al*., 2020).

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For example, citing data from De Winter (2019), the data sample was taken with the assumption that the "Average science ability score of vocational school students in Bandung City is more than 75”. To prove this, we chose 30 students in the city of Bandung with their National Science National Examination scores. **Table 6** shows an example of one sample t-test data for 30 students.

Table 6. Example of One Sample t-test data (the results are different).

No	Average learning outcomes
1	72
2	67
3	58
4	70
5	68
6	76
7	70
8	69
9	58
10	65
11	70
12	75
13	67
14	72
15	74
16	76
17	68
18	62
19	70
20	61
21	77
22	56
23	72
24	67
25	58
26	70
29	68
30	76

The steps for the one-sample t-test with SPSS based on the data in **Table 6** are as follows:

1) Open the SPSS program, in this study, SPSS version 26 was used. Click "Variable View", then enter the variable name such as in **Figure 46**. To create a variable, enter the average_ outcomes in the "Name" column. In the decimal column, change it from to 0. After that, change the "Measure" column from the unknown to scale.
2) Next, click "Data View" in the lower left corner. After the data view page is visible, enter the data on the average value of learning outcomes of 30 respondents which has been prepared previously (See **Figure 47**).
3) When carrying out a one-sample t-test using SPSS version 26, the first point that needs to be done is to test the normality of the data. The method for testing data normality is the same as the previous demonstration in the previous discussion regarding normality testing. The normality test results from the average learning outcome data for 30 students are shown in **Figure 48**. Based on the results in **Figure 48**, the Shapiro-Wilk Sig value is 0.064 > 0.05. Thus, it can be concluded that the average data on learning

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outcomes for 30 students is normally distributed. Thus, the assumption of normality in the one-sample t-test has been fulfilled.

4) After that, you will carry out the One Sample t-test. The way to do this is to click the "Analyze" menu on the toolbar, then select “Compare Means” in the dropdown menu and click “One Sample T-Test...” (See **Figure 49**).
5) The next step is the "One-Sample T-Test" dialog box (See **Figure 50**).

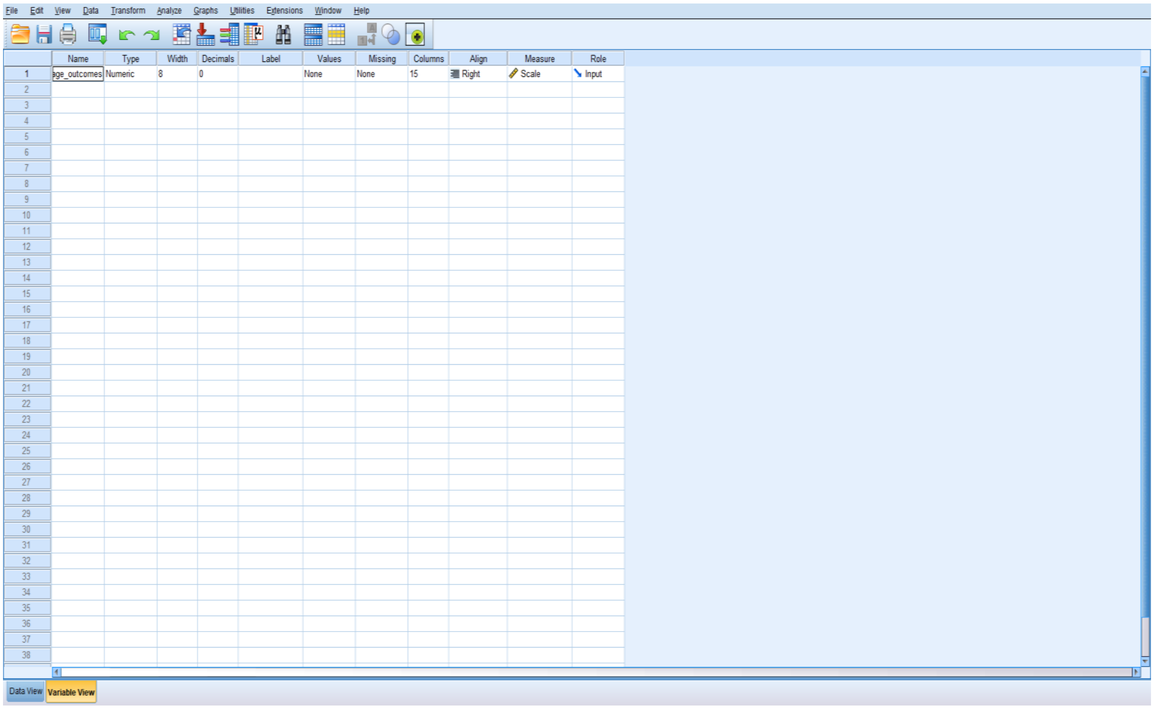

Figure 46. Display the “Data View” worksheet settings in the one sample t-test with SPSS.

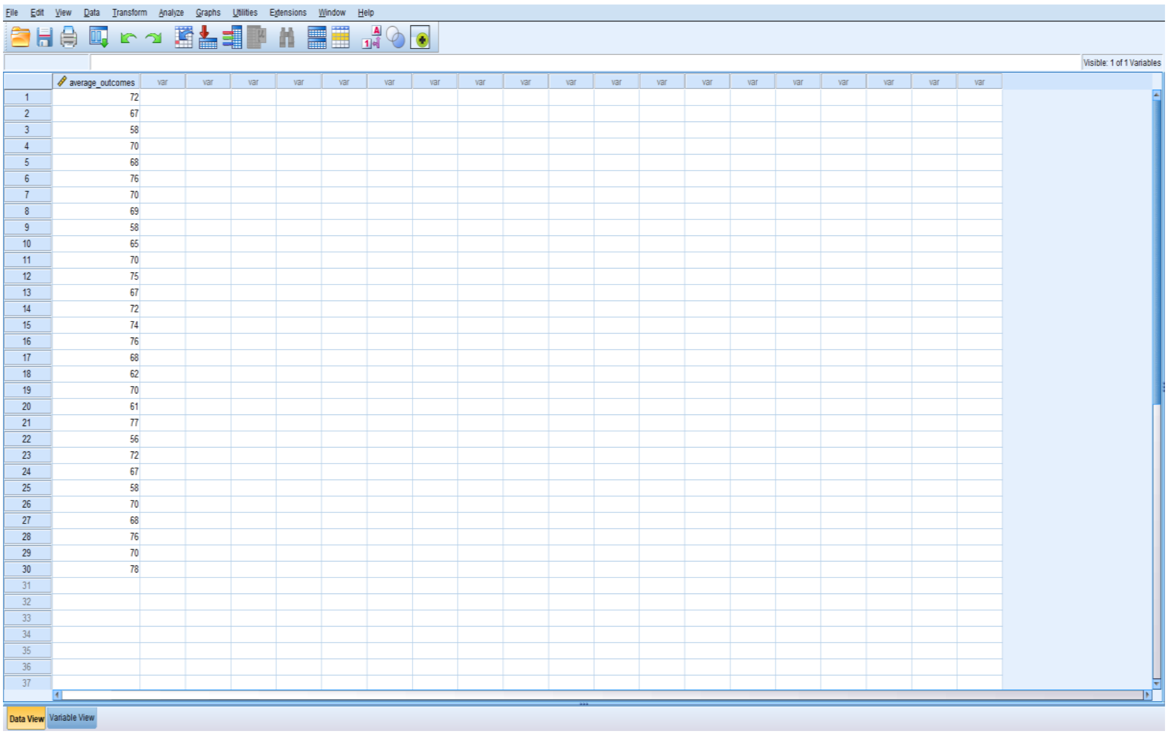

Figure 47. Display the “Data View” worksheet settings in the one sample t-test with SPSS.

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p- ISSN 2528-1410 e- ISSN 2527-8045

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
average_outcomes	.158	30	.054	.934	30	.064

a. Lilliefors Significance Correction

Figure 48. Normality test results in the independent sample t-test

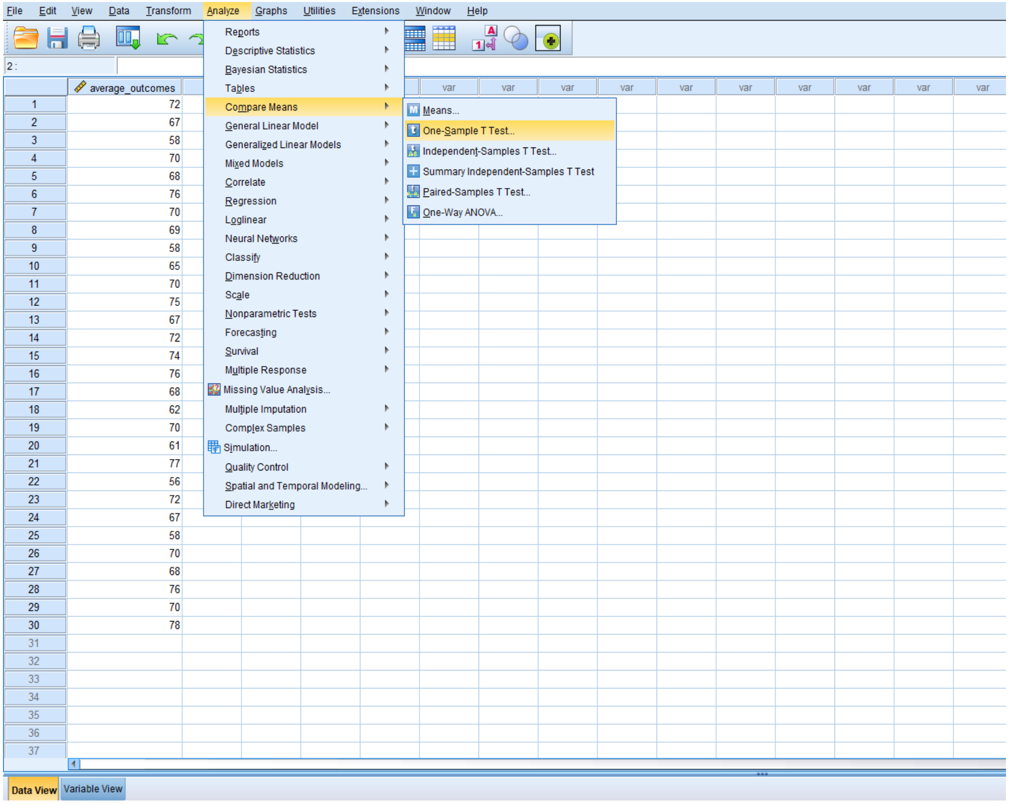

Figure 49. Settings for calculating the One Sample t-test with SPSS.

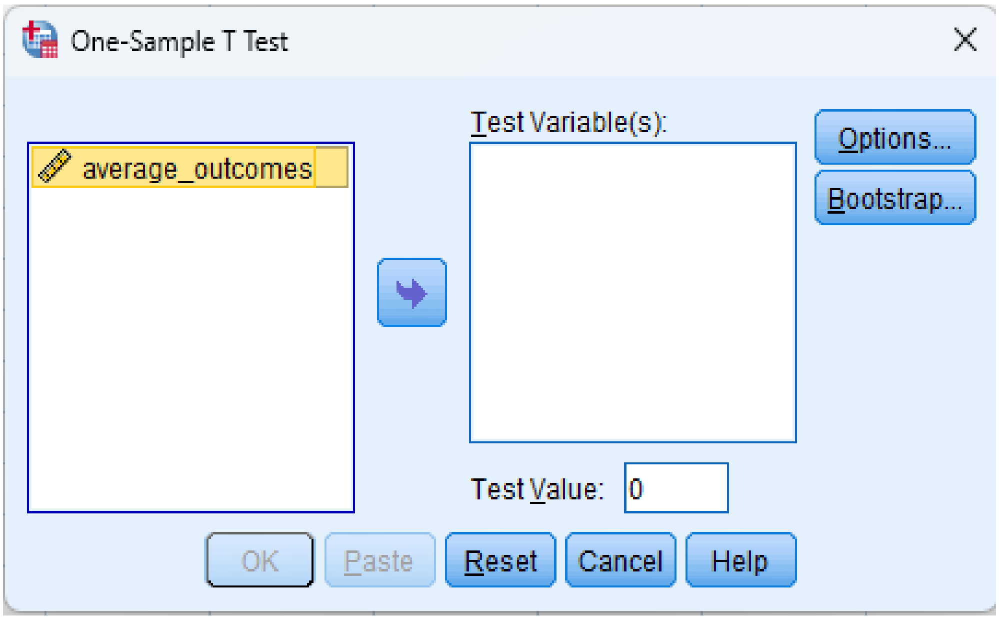

Figure 50. One-Sample T-test dialog box.

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6) In the "One-Sample T Test" dialog box, you must enter the learning outcome variable [Results] into the Test Variable(s) box, in the "Test Value" box type 75. The value 75 is entered in the test value field because in research We want to compare the average score of student learning outcomes with a score of 75. Then in the final step, click the "OK" button. (See **Figure 51**).

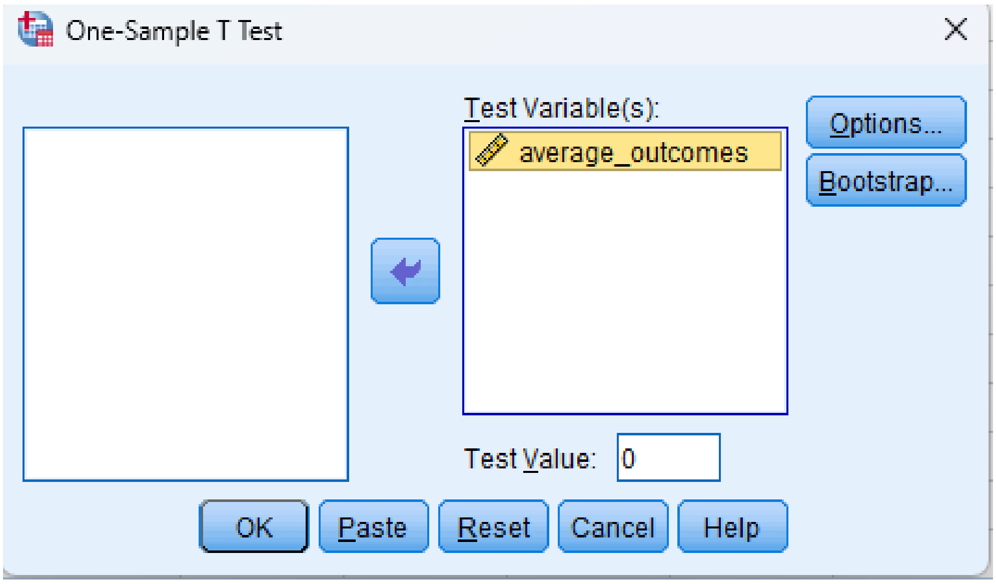

Figure 51. Settings for the "One-Sample T-Test" dialog box in the one sample t-test with SPSS.

7) After that, the SPSS Output windows page will appear as shown in **Figure 52**. **Figure 52** shows the descriptive statistical values and the One-Sample test results table. Based on the results, it is known that N = 30 means the number of samples used was 30 students. Mean = 68.67, meaning the calculated average value is 68.67. Std. Deviation or standard deviation has a Std value. Deviation of 6.042 and Std. The Mean Error is 1.103. Thus, the results of the One Sample Test show that the calculated t-value is -0.706. The df (degree of freedom) value is 29. The Sig. value. (2-tailed) or significance value with a two-sided test of 0.00.

T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
average_outcomes	30	68.67	6.042	1.103

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
average_outcomes	62.248	29	.000	68.667	66.41	70.92

Figure 52. Output results of the One Sample t-test with SPSS.

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If we formulate the research hypothesis in the one sample t-test as follows:
H0 = The average science ability score of vocational school students in Bandung City is equal to 75.
H1 = The average value of science ability of vocational school students in Bandung City is more than 75. The basis for decision-making for the One Sample T Test is
(i) If the Sig. (2-tailed) < 0.05, then H0 is rejected
(ii) If the Sig. value, (2-tailed) > 0.05, then H0 is accepted.

Based on the "One-Sample Test" output table in **Figure 52**, it is known that the Sig value, (2-tailed) is 0.00 > 0.05, so following the basis for decision-making above it can be concluded that H0 is accepted. Thus, it can be interpreted that the average science ability score for vocational school students in Bandung City is greater than 75.

4.3.2 Independent sample t-test

The independent sample t-test is a comparative test or difference test to find out whether there is a significant difference in the mean between 2 independent groups with interval/ratio data. The two independent groups referred to here are two unpaired groups, meaning that the data sources come from different subjects. Some assumptions must be met in the independent t-test namely (Obafemi, 2019),
(i) Interval or ratio data scale
(ii) Independent or unpaired data groups, data per group is normally distributed
(iii) The data per group does not have outliers, and the variance between groups is the same or homogeneous.

To help with comprehension, we've included a sample set of data below that includes 60 respondents split into two groups: the control class and the experimental class. According to research by Susanti and Rustam (2018), the information offered refers to the mathematics learning results of class VIII students (see **Table 7**).

Table 7. Example of Independent t-test Data (results are not different)

Mathematics learning outcomes		
Class	**Pretest**	**Posttest**
Control	70	80
Control	60	90
Control	60	90
Control	35	70
Control	90	65
Control	90	95
Control	70	80
Control	65	70
Control	55	70
Control	40	85
Control	50	70
Control	80	65
Control	60	70
Control	80	80
Control	50	75
Control	50	80
Control	90	70
Control	75	85
Control	60	80
Control	75	90
Control	70	80

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Table 7 (Continue). Example of Independent t-test Data (results are not different).

	Mathematics learning outcomes	
Class	**Class**	**Class**
Control	75	90
Control	84	70
Control	85	95
Control	88	85
Control	85	70
Control	88	65
Control	60	100
Control	50	95
Control	50	90
Experiment	50	95
Experiment	40	92
Experiment	75	85
Experiment	50	85
Experiment	45	88
Experiment	55	90
Experiment	70	87
Experiment	65	83
Experiment	55	89
Experiment	60	85
Experiment	50	70
Experiment	40	82
Experiment	60	88
Experiment	50	89
Experiment	50	75
Experiment	50	80
Experiment	40	70
Experiment	75	85
Experiment	50	80
Experiment	45	90
Experiment	55	95
Experiment	70	55
Experiment	65	90
Experiment	55	93
Experiment	60	85
Experiment	50	70
Experiment	40	65
Experiment	60	70
Experiment	50	80
Experiment	50	75

The steps for carrying out an independent t-test using SPSS:

1) Open the SPSS application. Once the SPSS worksheet is open, click the bottom left corner "Variable view". Then in the "Name" column enter the Class, Pretest, and Posttest variables. Then, in the "Measure" column the pretest and posttest variables from the unknown to scale, the Class variable from the unknown to nominal. In the "Decimals" column it is changed from 2 to 0 (See **Figure 53**).

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p- ISSN 2528-1410 e- ISSN 2527-8045

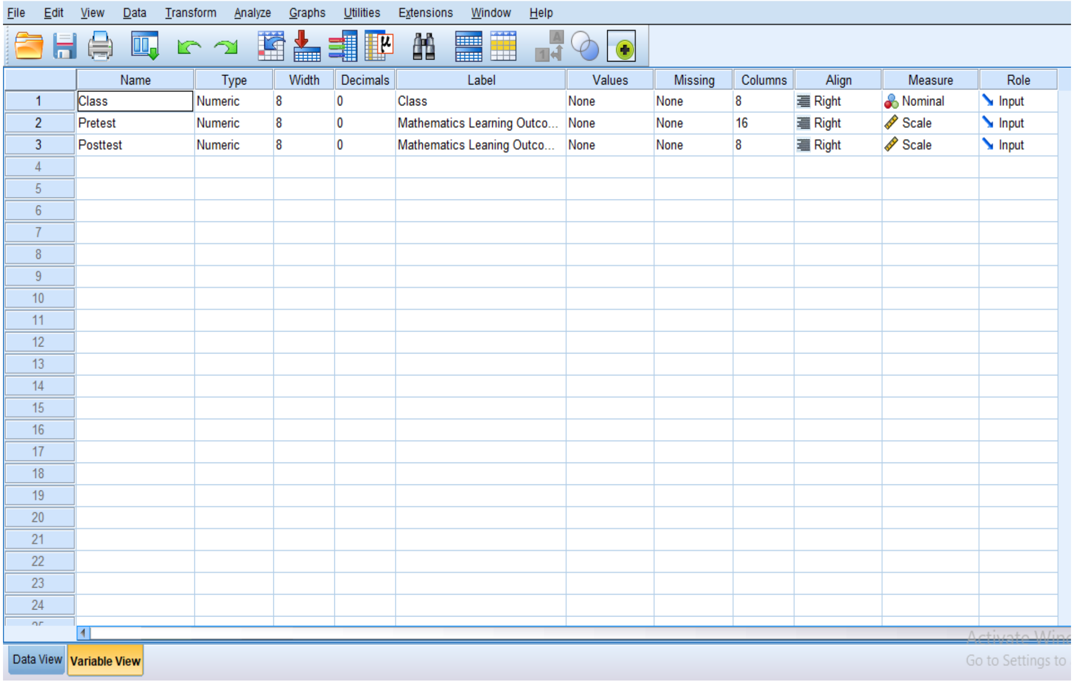

Figure 53. Display the “Variable View” worksheet settings in an independent samples t-test with SPSS.

2) Next, fill in the variables in the Values section by clicking the “None” column until the Value label dialog appears. Then, in the "Value" box, enter number 1. In the "Label" box, enter Class Control, then click Add. Then, fill in the "Value" box again with the number 2, and in the "Label" box write Class Experiment, then click Add. If you have successfully filled in the variable properties correctly, the next step is to click the "OK" button. If the process of filling in all variable properties was carried out correctly, the display in SPSS will appear as in **Figure 54**. If the value label has been filled in, results will appear as in **Figure 55**.

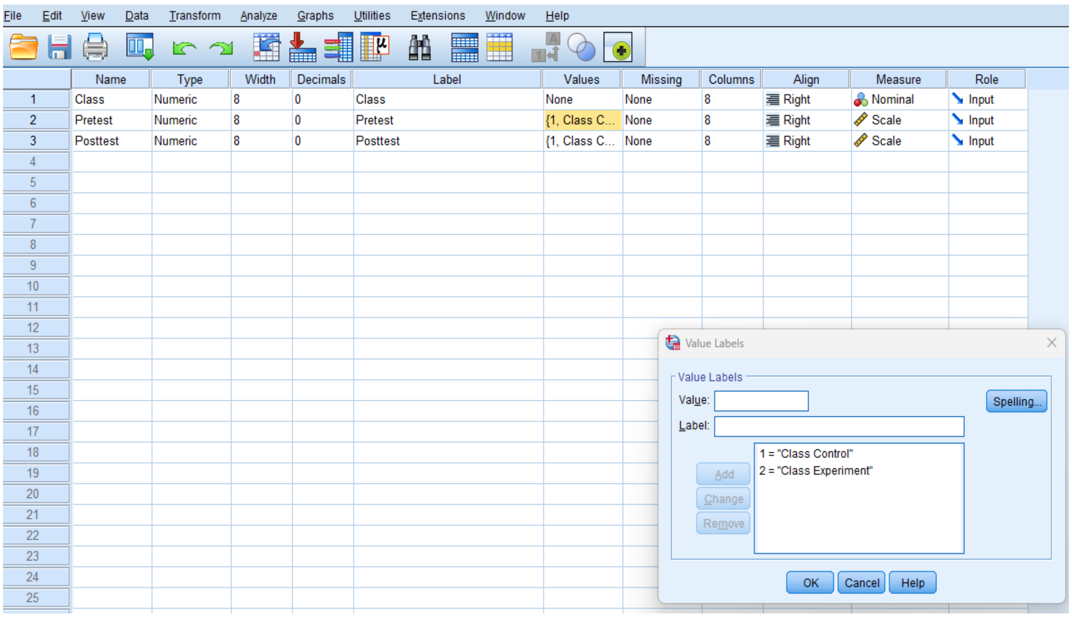

Figure 54. Display the “Variable View” worksheet settings in an independent samples t-test with SPSS.

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	Class	Pretest	Posttest	var	var	var	var	var	var	var
1	1	50	55							
2	1	45	55							
3	1	70	55							
4	1	50	70							
5	1	40	65							
6	1	65	70							
7	1	60	80							
8	1	65	70							
9	1	30	70							
10	1	40	85							
11	1	50	70							
12	1	40	65							
13	1	60	70							
14	1	35	80							
15	1	40	75							
16	1	60	80							
17	1	70	70							
18	1	75	85							
19	1	50	55							
20	1	45	55							
21	1	55	60							
22	1	70	55							
23	1	65	70							
24	1	55	60							
25	1	60	85							
26	1	50	70							
27	1	40	65							
28	1	60	70							
29	1	50	80							
30	2	50	75							
31	2	50	80							
32	2	40	70							
33	2	75	85							
34	2	50	55							
35	2	45	55							
36	2	55	60							
37	2	70	55							

Figure 55. Data input results in the independent sample t-test with SPSS.

3) Before carrying out an independent sample t-test using SPSS version 26, the first point that needs to be done is to test the normality of the data. The method for testing data normality is the same as previously explained in the previous chapter regarding normality testing. After that, the output results will appear as shown in **Figure 56**. Based on **Figure 56**, the output results of the pretest and posttest Shapiro-Wilk normality tests each have a significance value above 0.05. This shows that the data is normally distributed.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	class	Statistic	df	Sig.	Statistic	df	Sig.
pretest	class control	.165	30	.036	.955	30	.231
	class experiment	.150	30	.084	.938	30	.080
posttest	class control	.135	30	.174	.955	30	.233
	class experiment	.119	30	.200*	.972	30	.598

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 56. Normality test results in the independent sample t-test.

4) After the data is normally distributed, an independent sample t-test can be carried out. The way to do this is to click the "Analyze" menu on the toolbar, then select Compare Means in the dropdown menu and click "Independent-Samples T-test" as shown in **Figure 57**.

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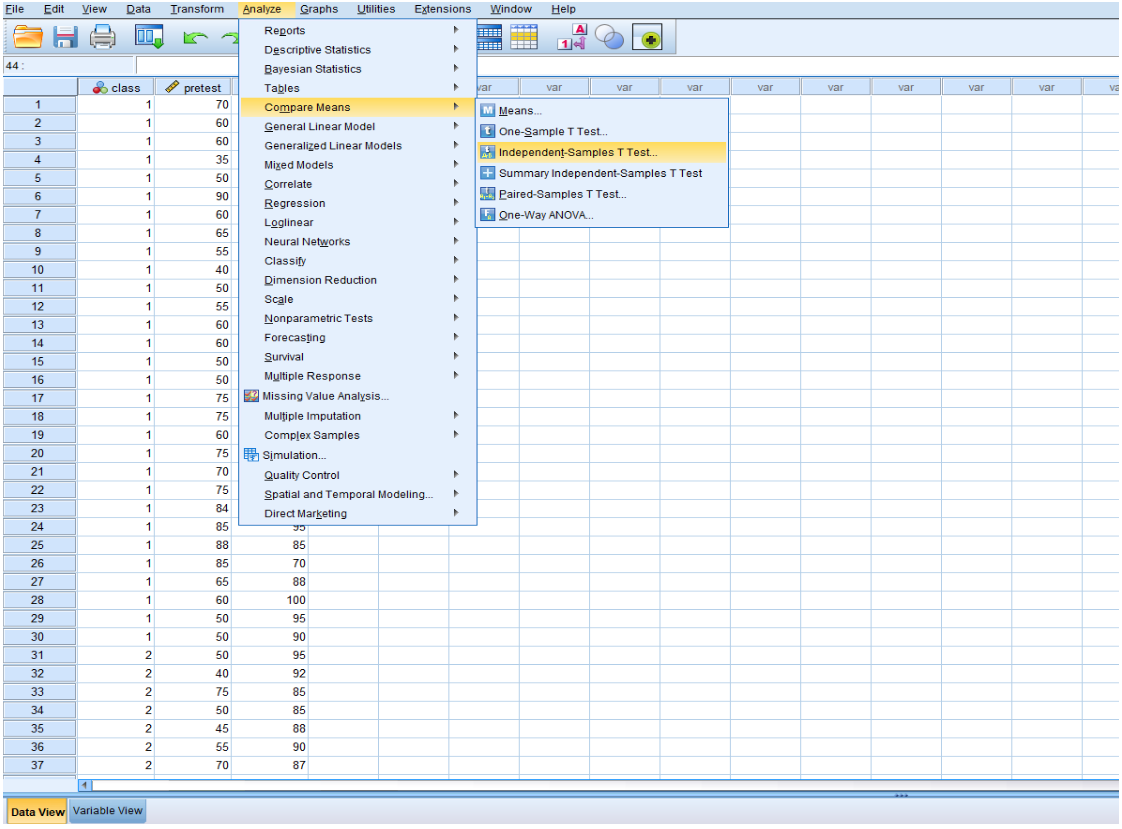

Figure 57. Menu access steps for independent sample t-test with SPSS.

5) After clicking "Independent-Samples T Test" a display will appear as shown in **Figure 58**. Enter the pretest and posttest results in the Variable test column then in the variable grouping column select "Class (? ?). If so, click Define Group (see **Figure 59)**. In "define group" select "use specified values" with Group 1 filled with the number 1 and group 2 filled with the number 2. After that click "Continue" and to to give the final command-click “OK”.

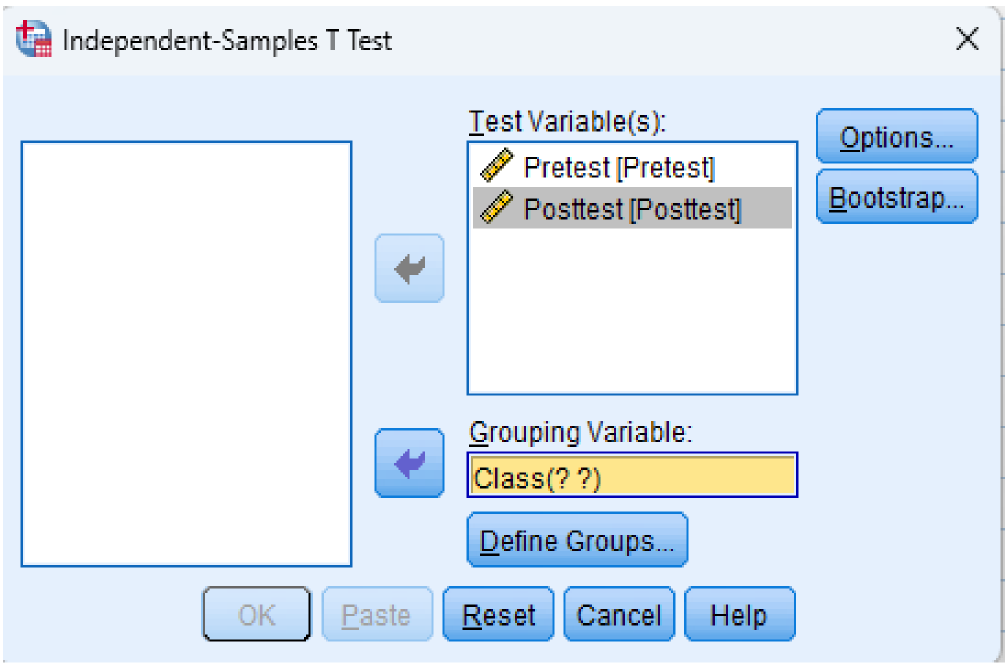

Figure 58. Independent-Samples T Test in Boxes.

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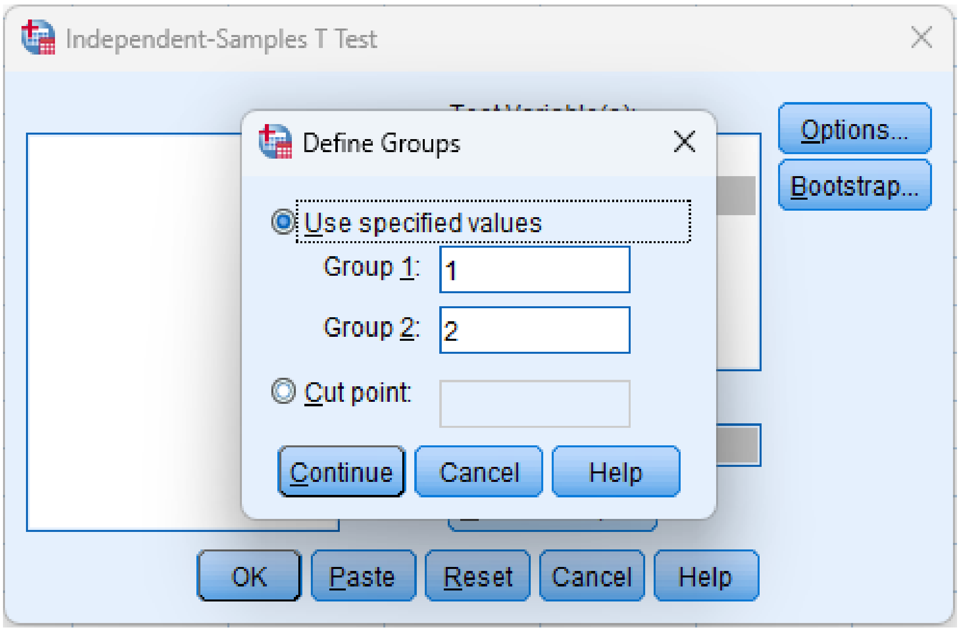

Figure 59. Settings for the "Independent-Samples T-test: Define Groups" dialog box in the independent sample t-test with SPSS**.**

6) After clicking "OK" in step 5, the SPSS calculation results display will appear in the form of a t-test calculation table (see **Figure 60**). Based on **Figure 60**, there significance value (2-tailed) of the pretest data (2-tailed) is 0.640, while the significance value (2-tailed) of the posttest data is 0.598.

T-Test

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Pretest	1	29	53.28	11.823	2.195
	2	30	53.17	14.941	2.728
Posttest	1	29	68.79	9.788	1.818
	2	30	69.33	10.400	1.899

Independent Samples Test

		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
Pretest	Equal variances assumed	.221	.640	.031	57	.975	.109	3.516	-6.931	7.149
	Equal variances not assumed			.031	54.885	.975	.109	3.502	-6.909	7.127
Posttest	Equal variances assumed	.284	.596	-.205	57	.838	-.540	2.631	-5.809	4.729
	Equal variances not assumed			-.206	56.961	.838	-.540	2.629	-5.804	4.723

Figure 60. Output results of independent sample t-test test data calculations.

Here, we formulate the research hypothesis in an independent sample test as follows:
H0 = There is no difference in the average value of mathematics ability of class VIII students between control and experiment
H1 = There is a difference in the mathematics abilities of class VIII students between control and experiment. The basis for decision-making for the Independent t-test is

1. If the Sig. (2-tailed) < 0.05, then H0 is rejected
2. On the contrary, Sig. (2-tailed) > 0.05, then H0 is accepted.

Based on the output of the "Independent t-test" table in **Figure 60**, it is known that the Sig (2-tailed) pretest 0.640 > 0.05 and posttest values 0.596 > 0.050, respectively, by the basis for decision making above it can be concluded that H0 is accepted. Thus, it can be interpreted

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p- ISSN 2528-1410 e- ISSN 2527-8045

that There is no difference in the average value of mathematics ability of class VIII students between control and experiment.

4.3.3 Paired sample t-test

A paired t-test is a parametric test that can be used on two different statistics from two paired samples. The paired sample t-test generally takes the form of interval or ratio scale data (quantitative data). Paired samples are the same subjects, but experience different treatments. This different test model is used to analyze the research model before and after. The conditions for the paired sample t-test are (Alfajri *et al*., 2023):

1. The data owned by the subject is interval or ratio data
2. Both groups of paired data are normally distributed

As an example, we present a research demonstration of the steps of a paired samples t-test from a study conducted by Alvi & Yerimadesi (2022). The data described is the result of class XI students learning acid-base material through the use project-based learning method (see **Table 8**).

Table 8. Example of research data Paired Sample t-test (the results are different).

Respondent	Pretest	Posttest
1	50	85
2	40	75
3	75	85
4	50	80
5	45	75
6	55	88
7	70	85
8	65	79
9	65	85
10	60	85
11	50	88
12	60	90
13	60	95
14	50	80
15	60	80
16	50	80
17	65	90
18	75	85
19	65	90
20	50	85
21	70	95
22	70	88
23	65	70
24	55	90
25	60	85
26	50	70
27	75	100
28	60	70
29	70	90
30	60	75

The steps for the paired sample t-test using SPSS are explained as follows:

1) Start the SPSS program. Open the SPSS worksheet and select "Variable view" in the lower left-hand corner. Then, insert the Class, pretest, and posttest variables in the "Name"

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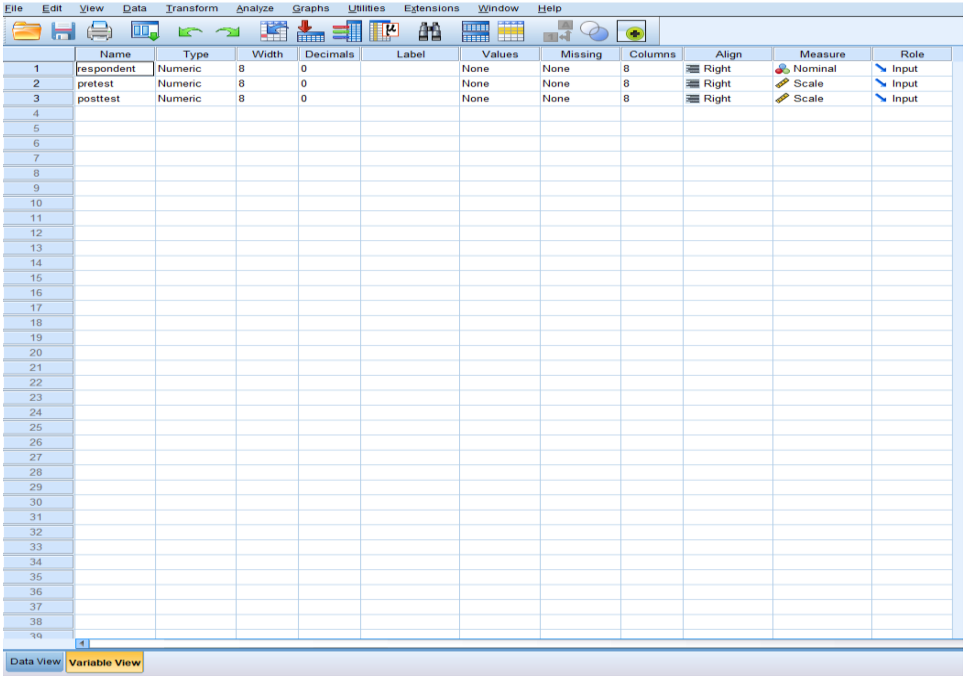
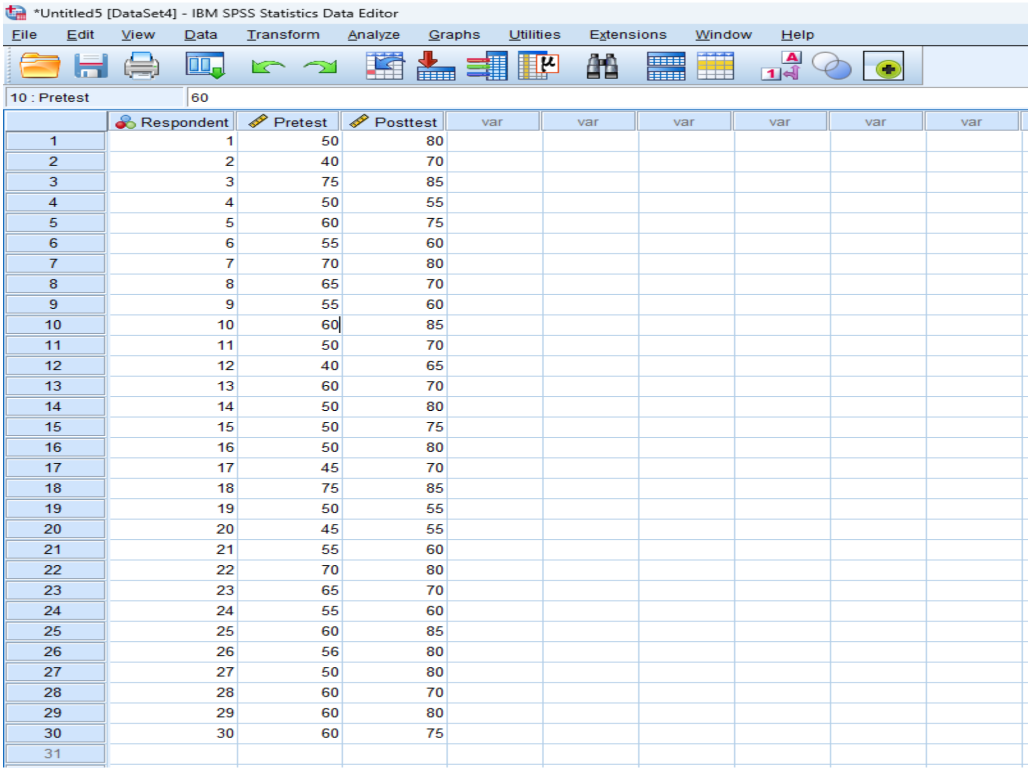
column. Then, the class variable from the unknown to nominal, and the pretest and posttest variables from the unknown to scale, are listed in the "Measure" column. In the "Decimals" column it is changed from 2 to 0 (see **Figure 61**).



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	respondent	Numeric	8	0		None	None	8	Right	Nominal	Input
2	pretest	Numeric	8	0		None	None	8	Right	Scale	Input
3	posttest	Numeric	8	0		None	None	8	Right	Scale	Input

Figure 61. Display the "Variable View" worksheet settings in a paired samples t-test with SPSS.

2) After that, click "Data View" and then enter data in the respondent, pretest, and posttest columns. After the data is filled in, the pretest and posttest scores from the 30 respondents as shown in **Figure 62**.



	Respondent	Pretest	Posttest
1	1	50	80
2	2	40	70
3	3	75	85
4	4	50	55
5	5	60	75
6	6	55	60
7	7	70	80
8	8	65	70
9	9	55	60
10	10	60	85
11	11	50	70
12	12	40	65
13	13	60	70
14	14	50	80
15	15	50	75
16	16	50	80
17	17	45	70
18	18	75	85
19	19	50	55
20	20	45	55
21	21	55	60
22	22	70	80
23	23	65	70
24	24	55	60
25	25	60	85
26	26	56	80
27	27	50	80
28	28	60	70
29	29	60	80
30	30	60	75

Figure 62. Data input results Paired sample t-test with SPSS.

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3) The data must first be checked for normality before doing an independent sample t-test using SPSS version 26. The procedure for determining if data is normal is the same as that described in the preceding chapter's section on normality testing. The output data will then appear as illustrated in **Figure 63**. According to **Figure 63**, the output findings of the pretest and posttest Shapiro-Wilk normality tests each have a significance value above 0.05. This demonstrates that the data are normality distributed.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
pretest	.152	30	.076	.946	30	.136
posttest	.189	30	.008	.953	30	.209

a. Lilliefors Significance Correction

Gambar 63. Output results of the paired sample t-test normality test with SPSS.

4) A paired sample t-test can be performed once the data has been established to be normally distributed. This can be accomplished by selecting "Analyze" from the toolbar, choosing "Compare Means" from the dropdown menu, and then selecting "Paired-Samples T-test" as shown in **Figure 64**.

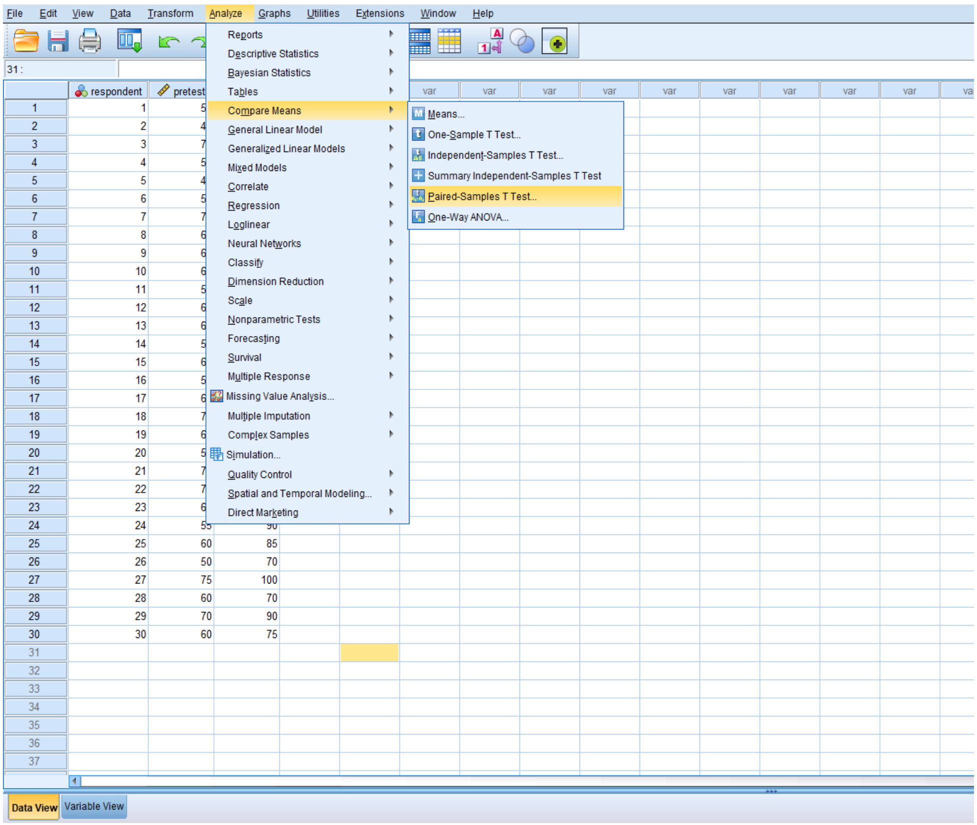

Figure 64. Settings for calculating the Paired Sample t-test test with SPSS.

5) After clicking "Paired-Samples T Test" a box will appear as shown in **Figure 65**. Enter the pretest and posttest variables in the Paired Variables box. The pretest is entered into "Variable 1" (left side) and the posttest is entered into "Variable 2" (right side), then next click "OK".

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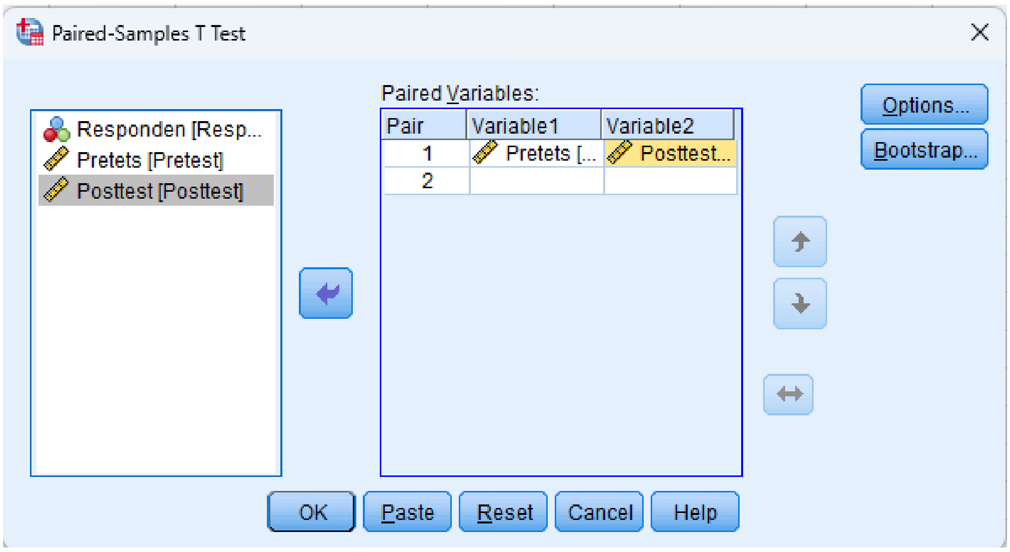

Figure 65. Paired-samples t test box.

6) The SPSS calculation results display will show up as a t-test calculation table once you select "OK" in step 5 (see **Figure 66**). According to **Figure 66**, the pretest-posttest data's significance value (2-tailed) is 0.00.

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pretest	59.83	30	9.421	1.720
	posttest	83.93	30	7.552	1.379

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	pretest & posttest	30	.448	.013

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	pretest - posttest	-24.100	9.057	1.654	-27.482	-20.718	-14.575	29	.000

Figure 66. Paired Sample t-test Results Output Page with SPSS.

The formulation of the research hypothesis in the peered sample t-test is as follows:
Ho = There is no difference in the pretest and posttest of class XI students on the acid-base material project-based learning method.
H1 = There is a difference in the pretest and posttest of class XI students on acid-base material using a project-based learning method. The basis for decision-making in the One Sample T Test is

(i) If the Sig. (2-tailed) < 0.05 then H0 is rejected
(ii) Conversely, if the Sig value. (2-tailed) > 0.05, then H0 is accepted.

Based on the output of the "Paired-Samples T Test" table in **Figure 66**, it is known that the Sig value, (2-tailed) is 0.000 < 0.050, thus by the basis for decision-making above it can be concluded that H0 is rejected. Thus, there are differences in the pretest and posttest of class IX students on acid-base material using a project-based learning method.

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4.4 Example of How to Process Data not Normally Distributed (Non-Parametric Statistics) to Test Significance Differences

4.4.1 Mann-whitney test

The Mann-Whitney Test is a non-parametric statistical method that is used to compare groups of independent sample t-test data with the assumption of normality not being met. This test is a test used to test two small independent samples (Two Independent Sample Test). The Mann-Whitney test requirements are as follows (Happ *et al*., 2019):

(i) Sample data is not normally distributed
(ii) Two samples that know each other are not related or have no influence on each other (sample members of two different groups)
(iii) Ordinal or interval data scale samples
(iv) The number of samples in both groups is the same

Here, we present a demonstration of how to perform the Mann-Whitney test using SPSS. Data obtained from research conducted by Usman (2016). The data are the results of science learning for class IX students as many as 60 students who were divided into two classes, namely classes A and B (see **Table 9**).

Table 9. Example of Mann Whitney test research data (The results are different).

No	Science learning outcomes		Code	
	Class A	Class B	Class B	Class A
1	56	87	1	2
2	72	92	1	2
3	67	87	1	2
4	80	82	1	2
5	70	89	1	2
6	68	86	1	2
7	76	90	1	2
8	70	86	1	2
9	70	80	1	2
10	58	85	1	2
11	56	87	1	2
12	72	92	1	2
13	67	87	1	2
14	80	82	1	2
15	70	89	1	2
16	68	86	1	2
17	76	90	1	2
18	70	86	1	2
19	70	80	1	2
20	40	85	1	2
21	30	87	1	2
22	72	52	1	2
23	67	87	1	2
24	80	50	1	2
25	70	89	1	2
26	68	86	1	2
27	76	90	1	2
28	70	86	1	2
29	70	80	1	2
30	58	85	1	2

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The detailed steps for the Mann-Whitney test are presented below:

1) Open a new SPSS worksheet, then click "View Variables" in the bottom left corner. In the "Name" column, write Class and Learning_outcomes. Then, in "Measure" the column for the Class variable is changed from unknown to nominal and the Learning_oucomes variable is changed from unknown to scale. After that, the "Decimals" column is changed from 2 to 0 (see **Figure 67**).

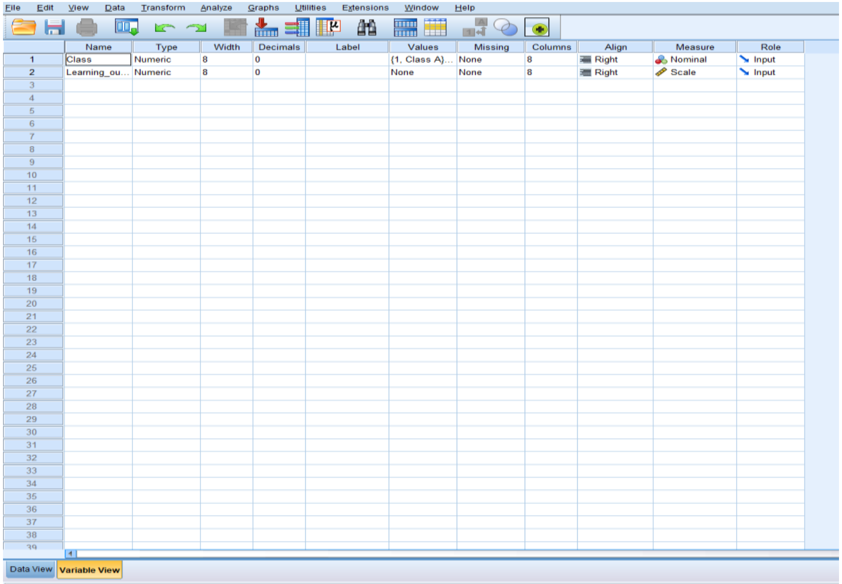

Figure 67. Display the "Variable View" worksheet settings in a Mann-Whitney test with SPSS.

2) After that, to fill in the variables in the "Values" section, click the "None" column, and then the "Value Label" dialog box will open, in the "Value" box, enter number 1, in the "Label" box, enter Class A, and then click "Add"; then, fill in the "Value" box again with the number 2, and in the "Label" box write Class B, then click Add. If the variable properties have been appropriately filled in, the next step is to click the "OK" button. If the process of filling up all variable characteristics is followed successfully, the display in SPSS will appear like **Figure 68.**

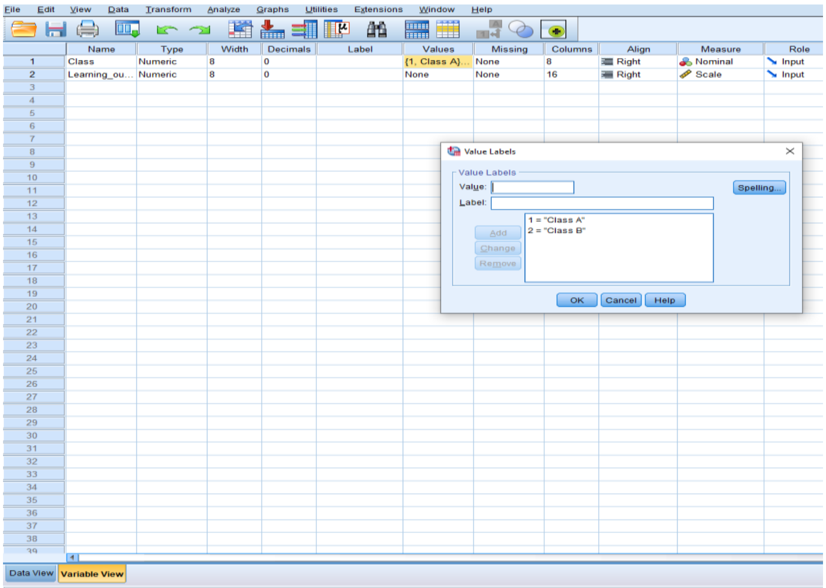

Figure 68. View variable settings: Values dialog in the Mann-Whitney test with SPSS.

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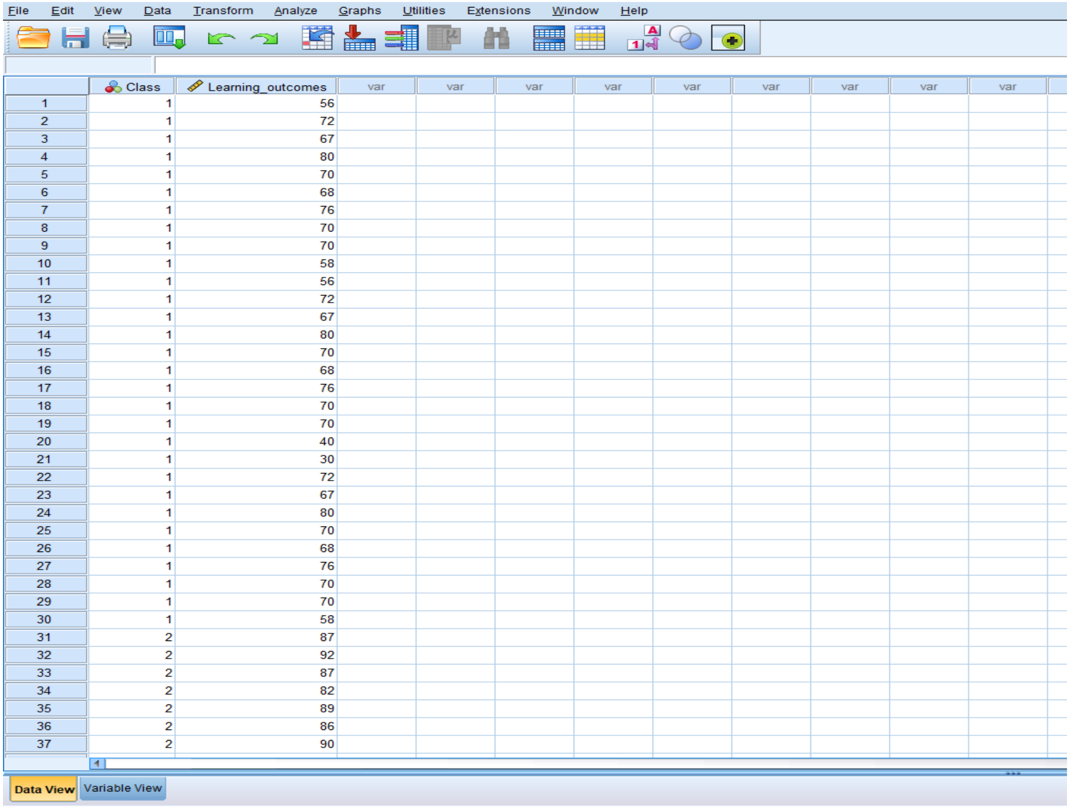
3) After completing step 2. Next, enter the data. Click "Data View" then enter data in the class and learning outcomes columns. After the data is filled in, a display will appear as in **Figure 69.**



	Class	Learning_outcomes
1	1	56
2	1	72
3	1	67
4	1	80
5	1	70
6	1	68
7	1	76
8	1	70
9	1	70
10	1	58
11	1	56
12	1	72
13	1	67
14	1	80
15	1	70
16	1	68
17	1	76
18	1	70
19	1	70
20	1	40
21	1	30
22	1	72
23	1	67
24	1	80
25	1	70
26	1	68
27	1	76
28	1	70
29	1	70
30	1	58
31	2	87
32	2	92
33	2	87
34	2	82
35	2	89
36	2	86
37	2	90

Figure 69. Data input results from Mann-Whitney test with SPSS.

4) Previously, to carry out the Mann-Whitney test, the data was checked for normality using SPSS version 26. However, the data used here was confirmed to be normally distributed. The method for testing data normality is the same as that explained in the previous chapter regarding normality testing. The output results of the normality test are presented in **Figure 70.** Based on **Figure 70**, the output findings of the Shapiro-Wilk normality test have a significance value below 0.05. This shows that the data is not normally distributed. Because the data is not normally distributed, statistical analysis of different tests uses the Mann-Whitney test.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Learning_outcomes	Class A	.291	30	.000	.788	30	.000
	Class B	.308	30	.000	.587	30	.000

a. Lilliefors Significance Correction

Gambar 70. Output results of the Mann-Whitney normality test with SPSS.

5) The next stage is to carry out Mann-Whitney calculations using SPSS. On the toolbar, click the "Analyze" menu then click "Non-Parametric Tests" then click "Legacy Dialogs" then click "2 Independent Samples..." as shown in **Figure 71.**

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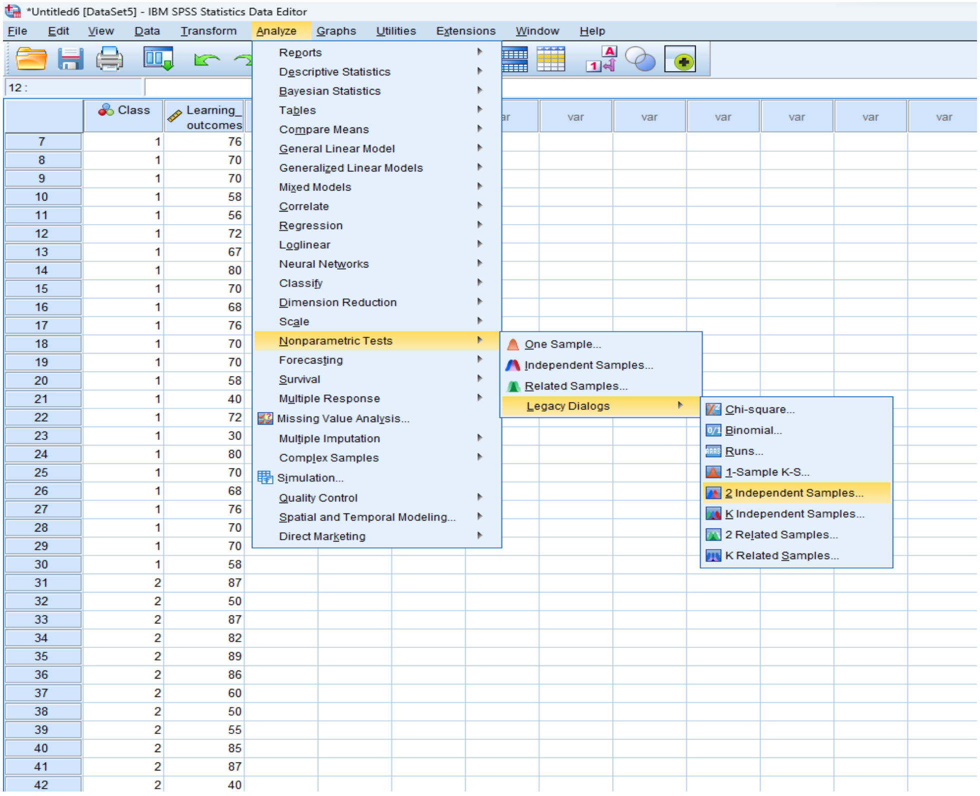
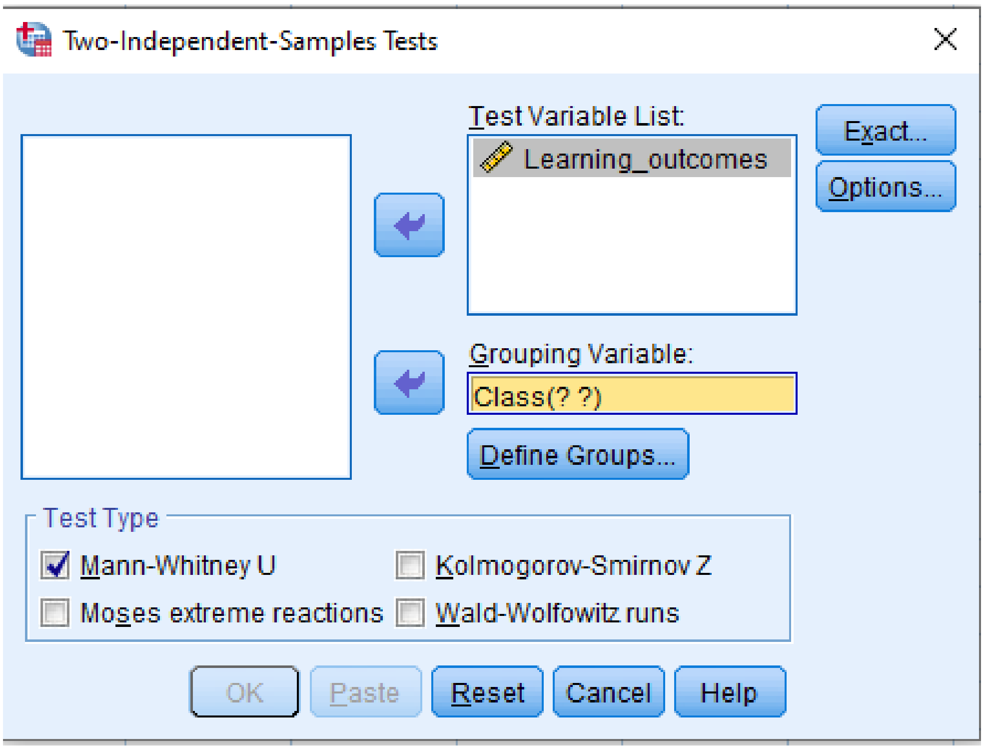


Figure 71. Settings for calculating the Mann-Whitney test with SPSS.

6) After clicking "2 Independent Samples" a box will appear as in **Figure 72**. Then, move the Learning_oucomes variable to the "Test Variable List" box and move the Class variable (??) variable to the Grouping Variables box. After that, click "Define Groups." then the "Two-Independent-Samples Tests" dialog box will appear as in **Figure 73**, and click "Continue". Then, to end the command, click "OK".



Gambar 72. Mann-Whitney test Box.

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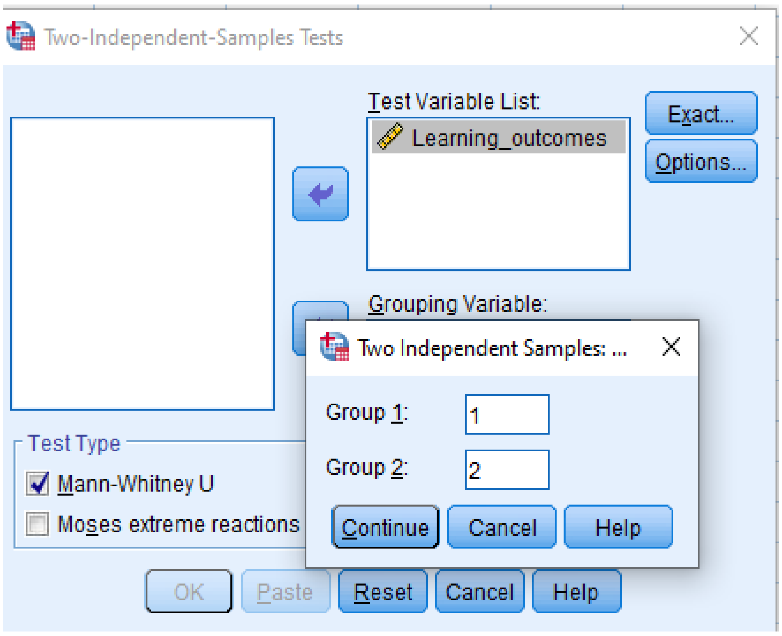

Gambar 73. Setting the "Two Independent Samples" dialog box in the Mann-Whitney test with SPSS.

7) After clicking "OK" the output of the Mann-Whitney test table calculation results will appear which is shown in **Figure 74**. Based on the results in **Figure 74**, the value of Asymp.Sig. (2-tailed) is 0.000.

Mann-Whitney Test

Ranks

	Class	N	Mean Rank	Sum of Ranks
Learning_outcomes	Class A	30	17.52	525.50
	Class B	30	43.48	1304.50
	Total	60		

Test Statistics[a]

	Learning_outcomes
Mann-Whitney U	60.500
Wilcoxon W	525.500
Z	-5.779
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Class

Figure 74. Mann-Whitney t-test results output page with SPSS.

The following is how the study hypothesis is expressed in the peered Mann-Whitney test:
H0 = There is no difference in learning outcomes for class A students and class B students.
H1 = There is a difference in learning outcomes for class A students and class B students.
Mann-Whitney's decision is made based on the following criteria:
(i) H0 is not accepted if the Sig. (2-tailed) < 0.05.
(ii) On the other hand, H0 is accepted if the Sig value (2-tailed) > 0.05.

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The Asymp. Sig. (2-tailed) value is 0.00 < 0.05 based on the output of the "Mann-Whitney" table in **Figure 74**. Therefore, using the criteria described above, it can be said that H0 is rejected. As a result, there are differences in learning outcomes for classes A and B.

4.4.2 Wilcoxon test

The Wilcoxon test is an alternative test to the paired sample t-test if it does not meet the normality assumption. This test is also known as the Wilcoxon Match Pair Test. The Wilcoxon test functions to test differences between paired data, test comparisons between observations before and after treatment, and determine the effectiveness of treatment. The conditional assumptions of the Wilcoxon test are (Liu et al., 2021):

(i) The dependent variable is ordinal or interval or ratio data scale but is not normally distributed
(ii) The independent variable consists of two categories which are paired
(iii) The shape and distribution of data between the two paired groups is symmetrical

Here we provide a demonstration of Wilcoxon action research from the Knief & Forstmeier (2021) investigation. Data information in the form of pretest and posttest scores for class X biology for 30 students can be seen in **Table 10**.

Table 10. Example of Wilcoxon Test research data (there are differences).

No	Biology learning outcomes	
	Pretest	Posttest
1	56	87
2	72	92
3	67	87
4	80	82
5	70	89
6	68	86
7	76	90
8	70	86
9	70	80
10	58	85
11	56	87
12	72	92
13	67	87
14	80	82
15	70	89
16	68	86
17	76	90
18	70	86
19	70	80
20	58	85
21	56	87
22	72	92
23	56	87
24	72	92
25	67	87
26	80	82
27	70	89
28	68	86
29	76	90
30	70	86

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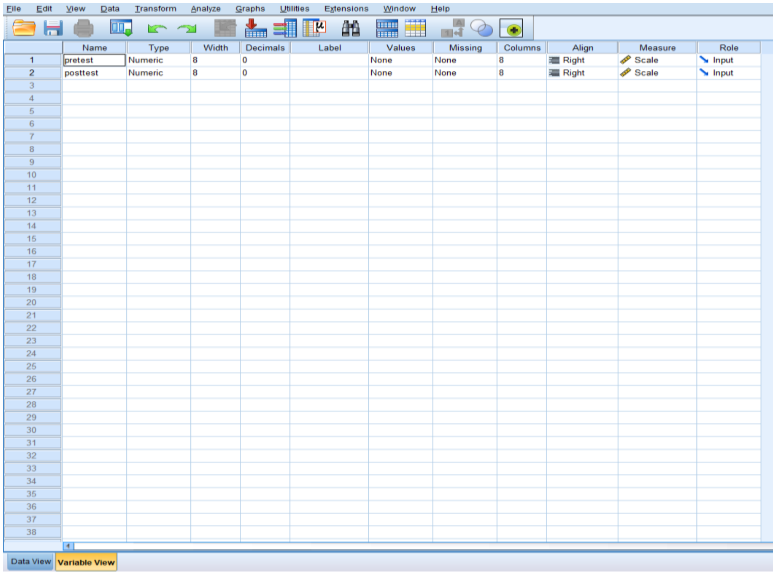
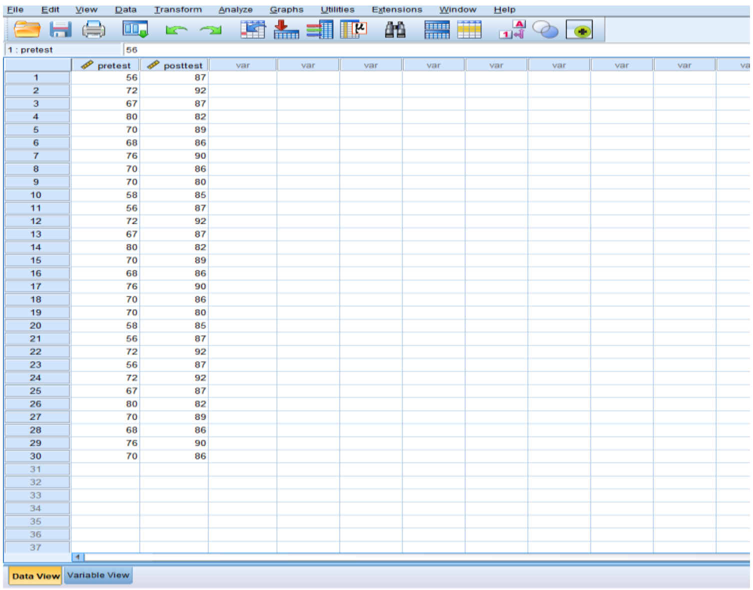
Below are the detailed steps for carrying out the Wilcoxon test:

1) Open a new SPSS worksheet, then select "View Variables" at the bottom left. Write Pretest and Posttest in the "Name" column. Next, the Pretest and Posttest variables in the "Measure" column are changed from unknown to scale. The decimal column is then adjusted from 2 to 0 (see **Figure 75**).
2) After you have finished setting up the Variable View worksheet. Next, click "Data View" and then enter the prepared data. The Data View display is presented in **Figure 76**.
3) Before, the data was examined for normality using SPSS version 26 to perform the Wilcoxon test. The regularly distributed nature of the data utilized here was nonetheless verified. As was discussed in the last chapter on normality testing, the procedure for determining if data is normal is the same here. **Figure 77** displays the normality test output results. According to **Figure 77**, the Shapiro-Wilk normality test's output pretest and posttest findings have a significance level below 0.05. As a result, it can be shown that the data is not normally distributed. Due to the non-normal distribution of the data, the Wilcoxon test is used in the statistical analysis of various tests.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	pretest	Numeric	8	0		None	None	8	Right	Scale	Input
2	posttest	Numeric	8	0		None	None	8	Right	Scale	Input

Figure 75. Display the “Variable View” worksheet settings in the Wilcoxon test with SPSS.



	pretest	posttest
1	56	87
2	72	92
3	67	87
4	80	82
5	70	89
6	68	86
7	76	90
8	70	86
9	70	80
10	58	85
11	56	87
12	72	92
13	67	87
14	80	82
15	70	89
16	68	86
17	76	90
18	70	86
19	70	80
20	58	85
21	56	87
22	72	92
23	56	87
24	72	92
25	67	87
26	80	82
27	70	89
28	68	86
29	76	90
30	70	86

Figure 76. Display the “Data View” worksheet settings in the Wilcoxon test with SPSS.

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Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretets	.277	30	.000	.816	30	.000
Posttest	.252	30	.000	.867	30	.001

a. Lilliefors Significance Correction

Figure 77. Output results of the Wilcoxon normality test using SPSS.

4) The next step is to use SPSS to do Wilcoxon computations. As illustrated in **Figure 78,** select "Analyze" from the toolbar, then "Non-Parametric Tests," "Legacy Dialogs," and "2 Related Samples..."

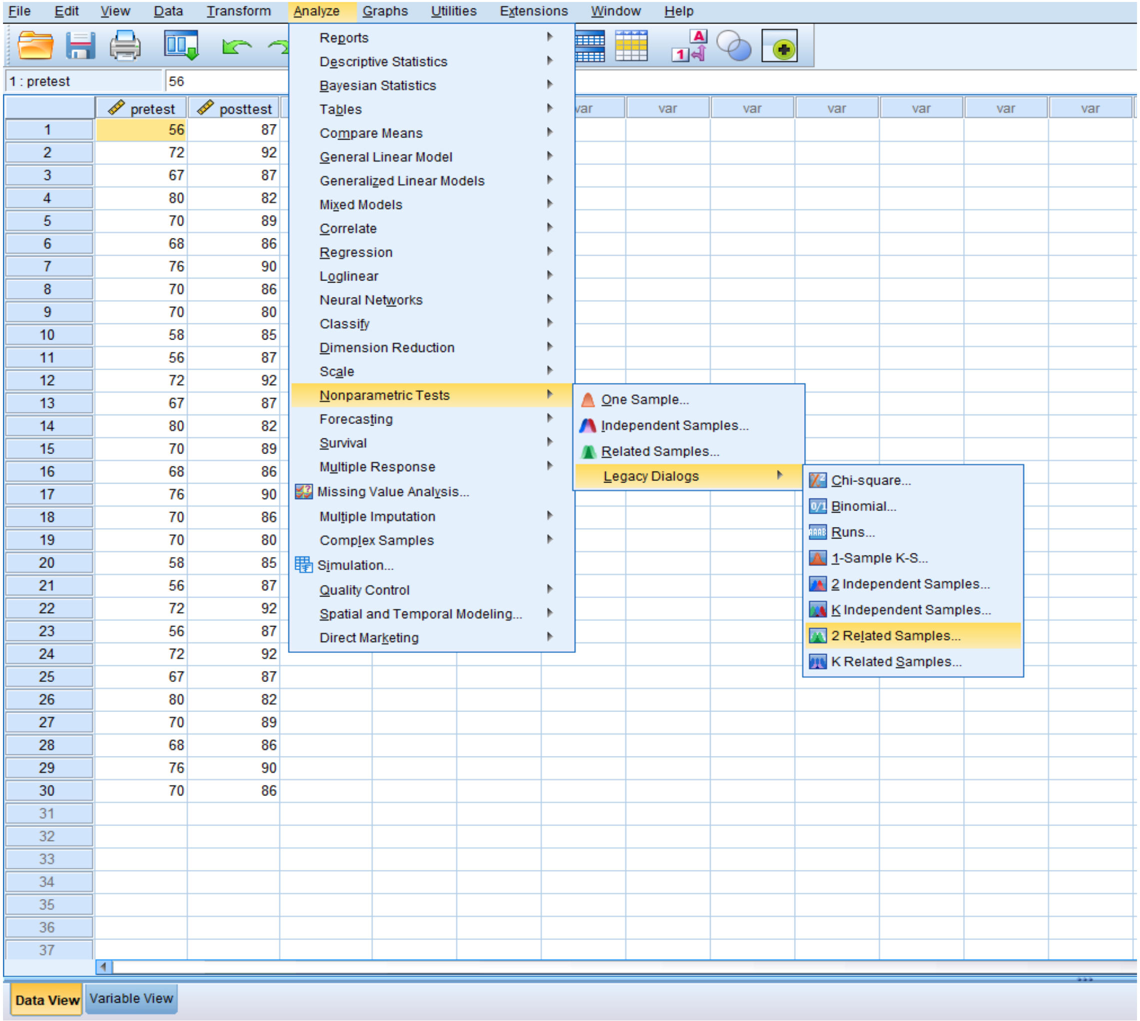

Figure 78. Settings for calculating the Wilcoxon test with SPSS.

5) After clicking "2 Related Samples" a box will appear as in **Figure 79**. Then move the variables [pretest] and [posttest] to the "Test Pairs" box. Then, move the variable [pretest] to column “variable 1” and [posttest] to column “variable 2”. After that, in "Test Type" checklist Wilcoxon and click "OK". (See **Figure 79**).

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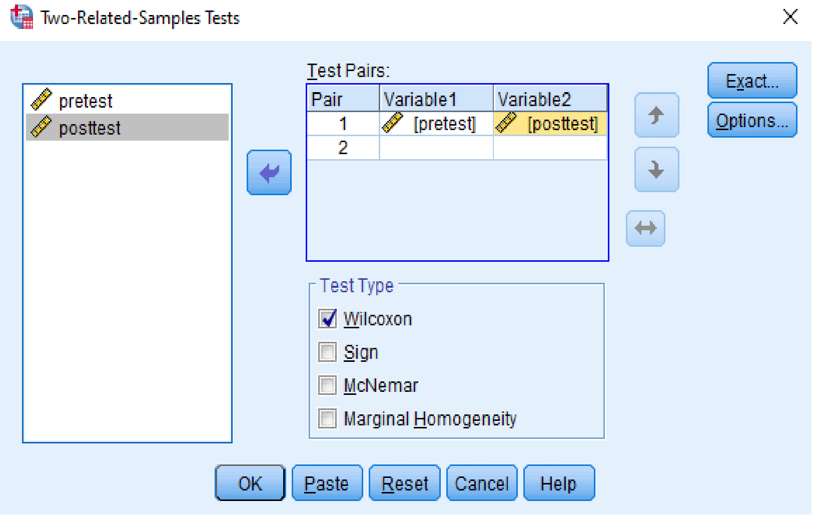

Figure 79. Wilcoxon test dialog box.

6) The output of the Mann-Whitney test table calculation results will appear after clicking "OK," as illustrated in **Figure 80**. The value of Asymp.Sig. (2-tailed) is 0.00 according to the findings in **Figure 80**.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
posttest - pretest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	30[b]	15.50	465.00
	Ties	0[c]		
	Total	30		

a. posttest < pretest

b. posttest > pretest

c. posttest = pretest

Test Statistics[a]

	posttest - pretest
Z	-4.793[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Figure 80. Wilcoxon t-test Results Output Page with SPSS.

The peered Wilcoxon test for the study hypothesis is presented as follows:
H0 = There is no difference between the pretest and posttest biology scores
H1 = There is a difference between the pretest and posttest biology scores. The following factors are used to determine whether to use the Wilcoxon test:

(i) H0 is not accepted, if the Sig. (2-tailed) < 0.05.
(ii) On the other hand, H0 is accepted if the Sig value (2-tailed) > 0.05.

According to **Figure 80**, the output result of the Mann-Whitney test calculation is 0.00 < 0.05, meaning that H0 is rejected thus it can be concluded that there is a difference in the biology pretest and posttest scores.

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4.5 An Example of Processing Difference Test Data Based on Real Applications in the Field of Education

To understand further how to carry out a statistical difference test (t-test), we provide a step-by-step example of a real case of class IX Islamic Middle School students which is presented in determining understanding of the concept of a steam engine as an electricity generator. energy using conventional methods and experimental demonstrations 60 students were divided into two classes, namely control and experimental classes. Data obtained in real cases in the form of pretest and posttest results are presented in **Table 11**. Here, the different analysis test that we use is the independent sample t-test statistical test because we want to examine the difference between the use of conventional learning methods and experimental demonstrations on student learning outcomes. All analyses were carried out using SPSS.

Table 11. Experimental and control data from class IX students.

Score (%)					
Control Class			Experiment Class		
Respondent	Pre-test	Post-test	Respondent	Pre-test	Post-test
X1	50	58	Y1	70	80
X2	64	62	Y2	70	70
X3	58	60	Y3	64	70
X4	60	58	Y4	70	65
X5	62	66	Y5	80	75
X6	65	40	Y6	70	80
X7	70	60	Y7	70	70
X8	60	62	Y8	64	70
X9	70	72	Y9	70	65
X10	50	80	Y10	80	75
X11	40	75	Y11	70	80
X12	30	80	Y12	50	60
X13	40	80	Y13	80	90
X14	40	85	Y14	30	92
X15	50	55	Y15	80	88
X16	40	70	Y16	86	90
X17	70	78	Y17	76	92
X19	60	40	Y18	78	94
X20	75	80	Y19	50	70
X21	30	60	Y20	60	90
X22	30	40	Y21	50	60
X23	40	30	Y22	60	85
X24	40	50	Y23	40	50
X25	50	10	Y24	60	80
X26	50	30	Y25	46	60
X27	60	70	Y26	80	90
X28	70	60	Y28	70	80
X29	50	45	Y29	50	60
X30	60	80	Y30	80	94

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The steps for carrying out data analysis are in **Table 11** using SPSS:

1) Open the SPSS worksheet. Then click "Variable View", in the "Name" column write pretest, posttest, and class. The decimal column was changed from 2 to 0 and the "Measure" column for the pretest and posttest variables was changed from unknown to scale. Meanwhile, the class variable in the "Measure" column is changed from unknown to nominal (See **Figure 81**).

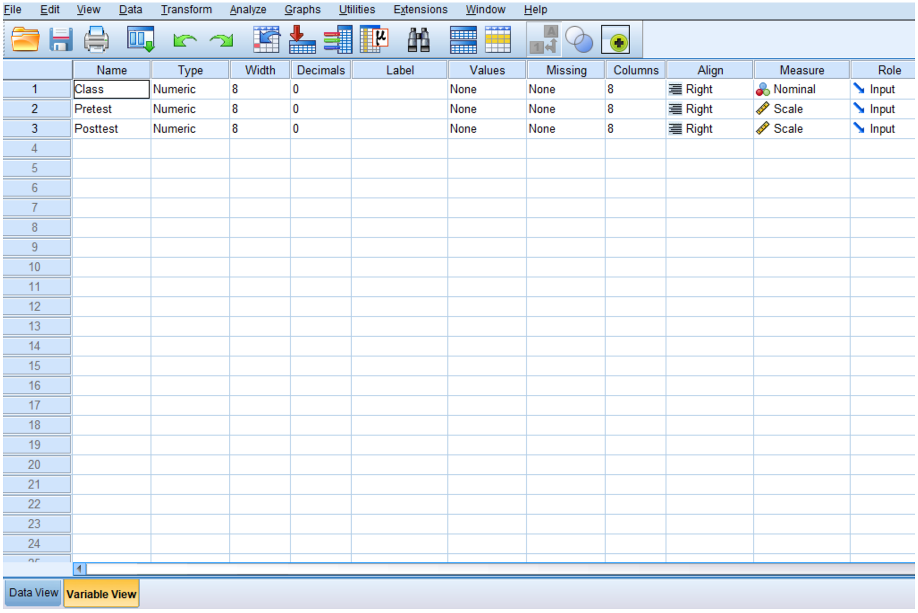

Figure 81. Display the “Variable View” worksheet settings.

2) After that, fill in the variables in the Values section by clicking the None column until the Value label dialog appears. Then, in the "Value" box, enter number 1. In the "Label" box, enter Class Control, then click Add. Then, fill in the "Value" box again with the number 2, and in the "Label" box write Class Experiment, then click Add. If you have successfully filled in the variable properties correctly, the next step is to click the "OK" button. If the process of filling in all variable properties is carried out correctly, the display in SPSS will appear as in **Figure 82**. If the value label has been filled in, results will appear as in **Figure 83.**

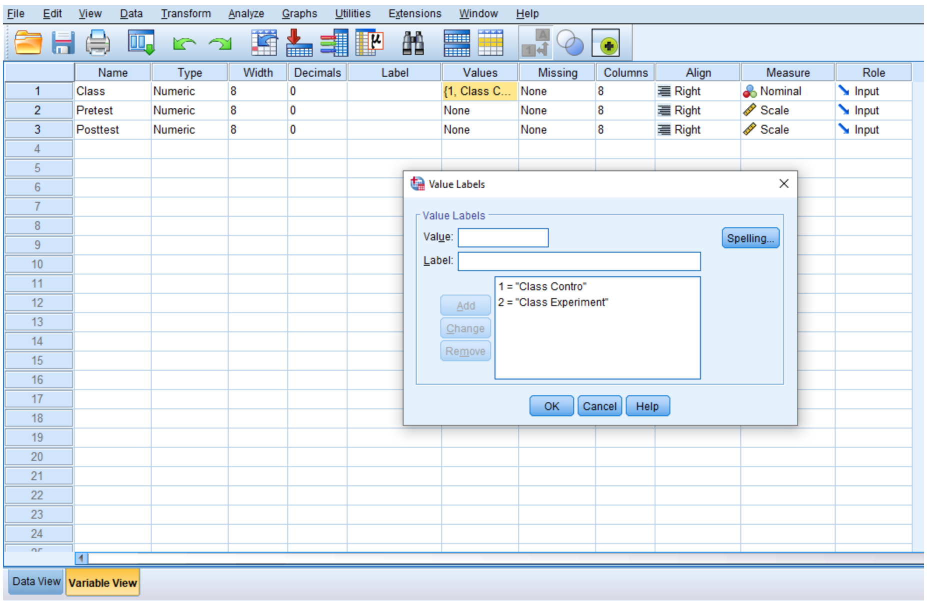

Figure 82. Display the “Variable View”: Dialog value labels worksheet settings.

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p- ISSN 2528-1410 e- ISSN 2527-8045

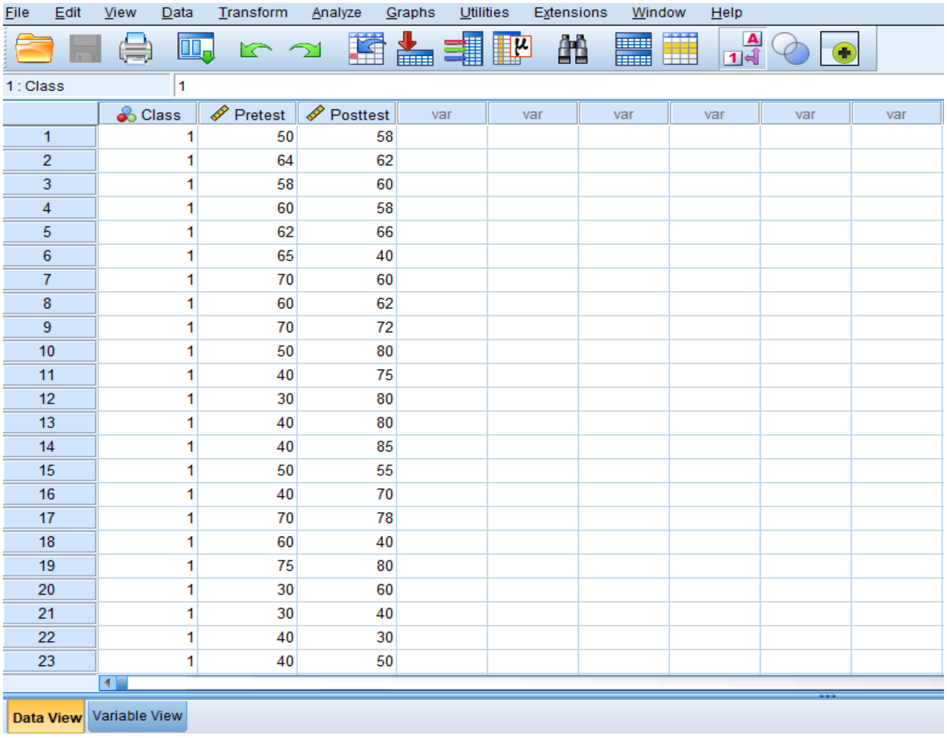

Figure 83. Display the "Data View" worksheet settings.

3) Before carrying out the difference test analysis, first carry out a normality test to see the distribution of the data. To perform normality test calculations with SPSS, click the "Analyzer" menu on the toolbar then click "Descriptive Statistics" on the submenu and click "Explore" (See **Figure 84**).

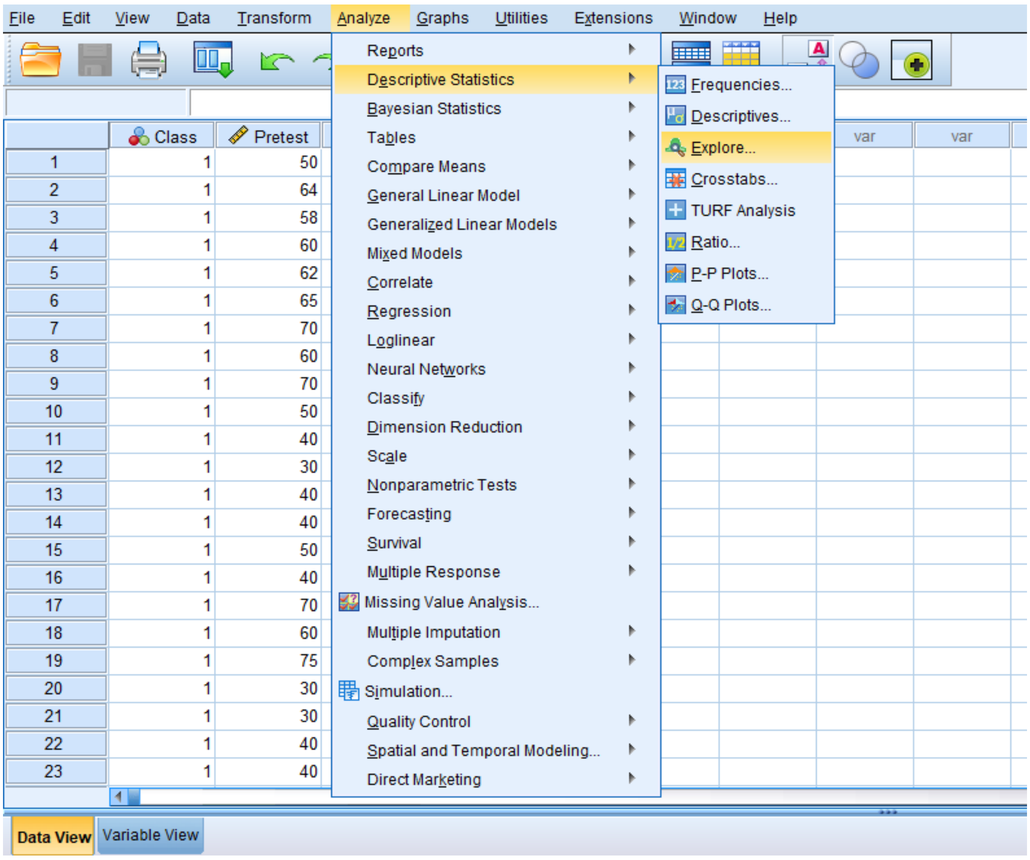

Figure 84. Settings for calculating the normality test with SPSS.

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4) After you have finished setting up the normality test calculation method, the "Explore" box will appear as in **Figure 85**. Then, move the pretest and posttest variables to the "Dependent List" box, while the class variables are moved to the "Factor List" box. If thus, then click on the right side of "Plots" and a box will appear as in **Figure 86**. After that, check "Normality plots with test" and click "Power estimation" then click "Continue". To end the command, click "OK". To test normality, the Shapiro-Wilk test was used because the sample was less than 50, where each class, namely the control class and the experimental class consisted of 30 students.
5) After that, the normality test windows output results appear. **Figure 87** shows the output results of the normality test with SPSS. Based on **Figure 87**, the Sig. Shapiro Wilk > 0.05 which indicates that the data in this study is normally distributed.

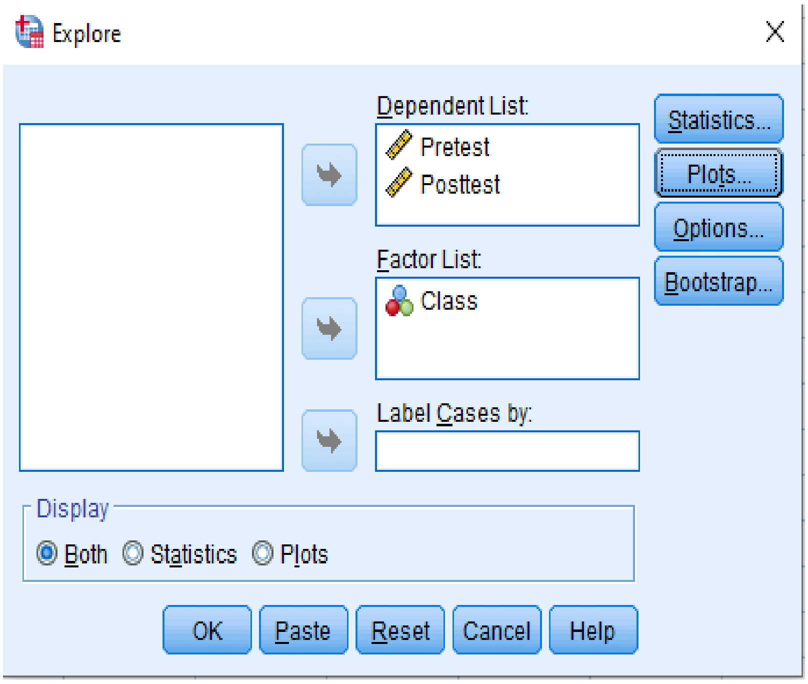

Figure 85. Explore settings on the normality test with SPSS.

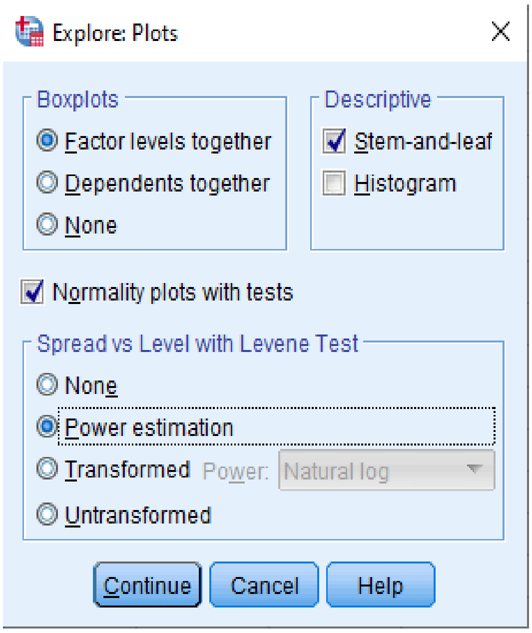

Figure 86. Explore: Plots settings in the normality test with SPSS.

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Tests of Normality

	Class	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Pretest	1	.162	30	.043	.933	30	.060
	2	.155	30	.062	.936	30	.070
Posttest	1	.184	30	.011	.944	30	.113
	2	.144	30	.113	.938	30	.080

a. Lilliefors Significance Correction

Figure 87. Normality test results output page with SPSS.

6) Because the research data is normally distributed, independent sample t-test analysis can be carried out. Calculation of the independent sample t-test with SPSS is done by clicking "Analyze" then clicking "Compare Mean" and clicking "Independent-Samples T-test". (See **Figure 88)**.

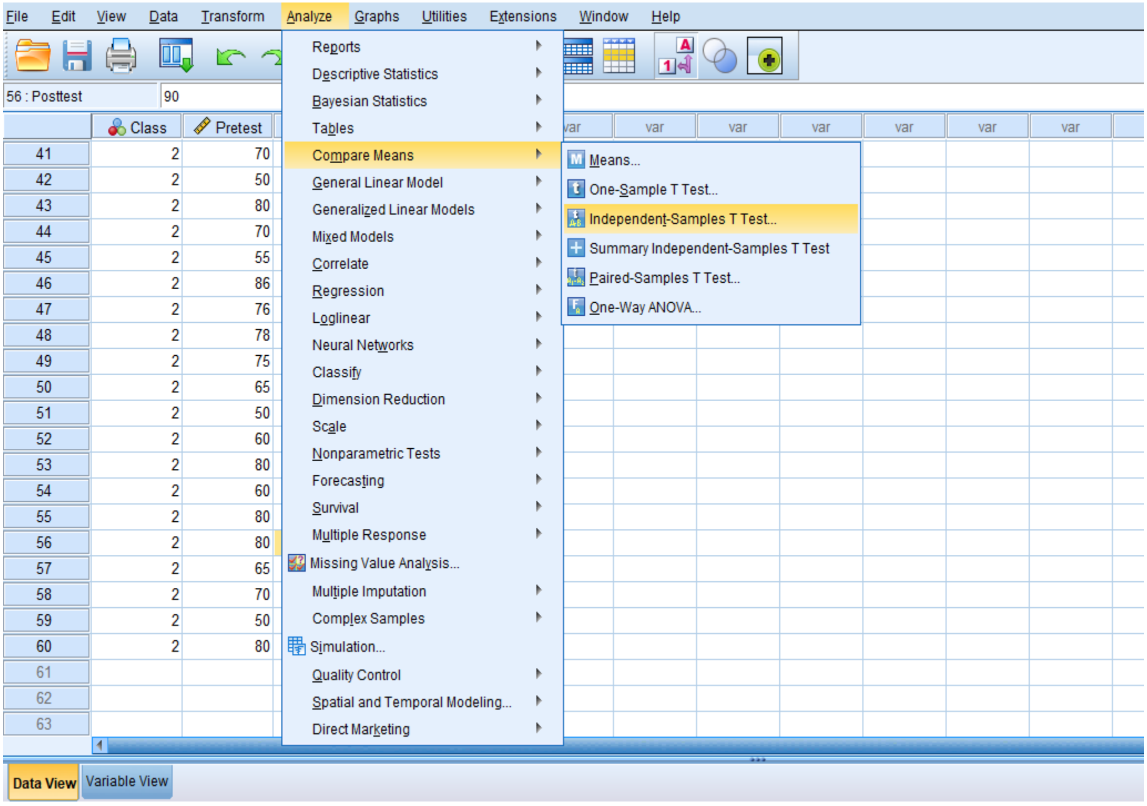

Figure 88. Settings for calculating the Independent sample t-test with SPSS

7) After clicking "Independent-Samples T Test" a display will appear as shown in **Figure 89**. Enter the pretest and posttest results in the "Test Variable(s)" column then in the variable grouping column select "Class (? ?). If thus, click Define Group (see **Figure 90**). In "Define Group" select "Use specified values" with Group 1 filled with the number 1 and Group 2 filled with the number 2. After that click "Continue" and click "OK" to end the command.
8) The output of the results of the Independent Sample t-test table calculation will be displayed after pressing "OK," as illustrated in **Figure 91**. Based on the findings in **Figure 91,** it show that Asymp. Sig. (2-tailed) pretest and posttest each have values of 0.009 and 0.046.

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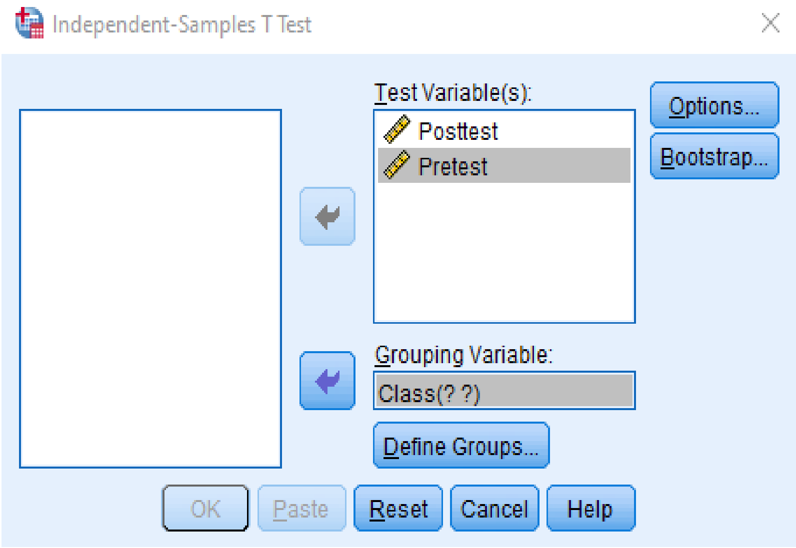

Figure 89. Independent-Samples T test dialog box

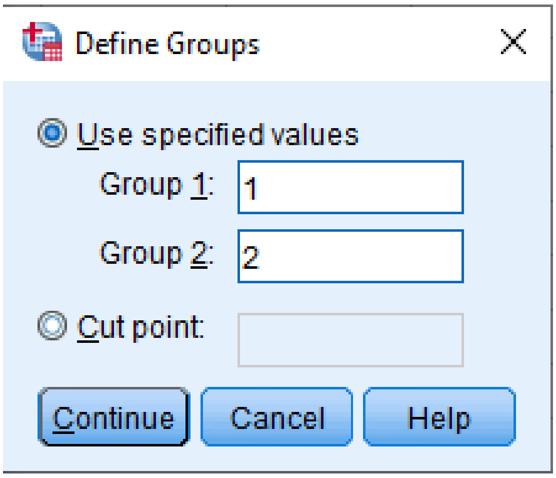

Figure 90. Setting the dialog box "Independent samples t-test: Define Groups" in the independent sample t-test with SPSS

Independent Samples Test

		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
Posttest	Equal variances assumed	7.284	.009	-3.437	58	.001	-5.033	1.465	-7.965	-2.102
	Equal variances not assumed			-3.437	50.090	.001	-5.033	1.465	-7.975	-2.092
Pretest	Equal variances assumed	4.158	.046	-5.073	58	.000	-15.333	3.023	-21.384	-9.283
	Equal variances not assumed			-5.073	54.180	.000	-15.333	3.023	-21.393	-9.274

Figure 91. Output results of Independent Sample t-test test data calculations.

The study hypothesis is stated as follows in the standard Independent sample t-test:

(i) H0 = There is no difference in learning outcomes using demonstration and conventional experimental methods

(ii) H1 = There are differences in learning outcomes using demonstration and conventional experimental methods

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Based on **Figure 91**, the output results of the independent sample t-test calculation of the pretest and posttest values are 0.009 and 0.046. From these results, it is known that both values are below 0.050, which means H0 is rejected and H1 is accepted. This shows that there are differences in learning outcomes using forced and conventional experimental methods. Based on these findings, it can be concluded that the experimental demonstration method is the best compared to conventional methods.

5. CONCLUSION

This article discusses the importance and ways of carrying out mean difference tests in statistical analysis. The mean difference test is a useful tool to determine whether there are significant differences between two or more groups of data. Apart from that, this article also discusses practical steps on how to carry out a mean difference test using various statistical software, such as IBM SPSS. This includes the steps to design an experiment, collect data, select appropriate statistical methods, and interpret the results of a mean difference test. Overall, this article provides important insights into the role of the mean difference test statistic in data analysis and how to carry it out correctly, thereby helping researchers and data analysts make stronger and more relevant conclusions in various research contexts.

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.

7. REFERENCES

Afifah, S., Mudzakir, A., and Nandiyanto, A. B. D. (2022). 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. *Indonesian Journal of Teaching in Science*, *2*(1), 81-92.

Afifah, S., Mudzakir, A., Nandiyanto, A. B. D., Ragadhita, R., Maryanti, R., Al Husaeni, D. F., and Fiandini, M. (2023). Sustainability literacy to vocational students through distance learning with experimental demonstration: Ionic liquid experiment and its application as fire retardant. *Journal of Technical Education and Training*, *15*(1), 55-72.

Agus, K. D., Elza, T., and Rahmat, P. (2021). Evaluation of the results of attitudes and self-efficacy of middle school students in science subjects. *Journal of Education Research and Evaluation*, *5*(4), 525-535.

Al Husaeni, D.F., and Nandiyanto, A.B.D. (2022). Bibliometric using VOSviewer with publish or perish (using Google Scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. *ASEAN Journal of Science and Engineering*, *2*(1), 19-46.

Alfajri, M. I., Rozi, F., Azmi, M., Sariani, S., and Miladiyenti, F. (2023). Automatic measurement on learning effectiveness towards english pronunciation application using paired sample T-Test. Journal Polingua: *Scientific Journal of Linguistics, Literature and Language Education*, *12*(1), 23-27.

Alvi, N. V., and Yerimadesi, Y. (2022). Effectiveness of the acid-base e-module based on guided discovery learning on the students learning outcomes of class XI students at SMAN 7 Padang. *Pancaran Pendidikan*, *11*(2), 1-8.

Ananda, P. D., and Atmojo, S. E. (2022). The Impact of the discovery learning model on problem-solving ability and scientific attitude of elementary school teacher education students. *International Journal of Elementary Education*, *6*(2), 259-267.

Arican, M., and Kuzu, O. (2020). Diagnosing preservice teachers' understanding of statistics and probability: Developing a test for cognitive assessment. *International Journal of Science and Mathematics Education*, *18*, 771-790.

Birt, J., and Cowling, M. (2017). Toward future'mixed reality'learning spaces for STEAM education. *International Journal of Innovation in Science and Mathematics Education*, *25*(4), 1-16.

Cvitanovic, C., Hobday, A. J., van Kerkhoff, L., Wilson, S. K., Dobbs, K., and Marshall, N. A. (2015). Improving knowledge exchange among scientists and decision-makers to facilitate the adaptive governance of marine resources: a review of knowledge and research needs. *Ocean and Coastal Management*, *112*, 25-35.

De Winter, J. C. (2019). Using the Student's t-test with extremely small sample sizes. *Practical Assessment, Research, and Evaluation*, *18*(1), 10.

Delacre, M., Leys, C., Mora, Y. L., and Lakens, D. (2019). Taking parametric assumptions seriously: Arguments for the use of Welch's F-test instead of the classical F-test in one-way ANOVA. *International Review of Social Psychology*, *32*(1), 1-12.

Dogan, E., Altinoz, B., Madaleno, M., and Taskin, D. (2020). The impact of renewable energy consumption to economic growth: A replication and extension of. *Energy Economics*, *90*, 104866.

Hairida, H. (2016). The effectiveness using inquiry based natural science module with authentic assessment to improve the critical thinking and inquiry skills of junior high school students. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 209-215.

Happ, M., Bathke, A. C., and Brunner, E. (2019). Optimal sample size planning for the Wilcoxon-Mann-Whitney test. *Statistics in medicine*, *38*(3), 363-375.

Hayat, B. (2022). Adjustment for guessing in a basic statistics test for Indonesian undergraduate psychology students using the Rasch model. *Cogent Education*, *9*(1), 2059044.

Herrero, A. C., Recio, T., Tolmos, P., and Vélez, M. P. (2023). From the steam engine to steam education: An experience with pre-service mathematics teachers. *Mathematics*, *11*(2), 473.

Kilic, D. (2016). An Examination of using self-, Peer-, and teacher-assessment in higher education: A Case study in teacher education. *Higher Education Studies*, *6*(1), 136-144.

Knief, U., and Forstmeier, W. (2021). Violating the normality assumption may be the lesser of two evils. *Behavior Research Methods*, *53*(6), 2576-2590.

DOI: https://doi.org/10.17509/ijost.v9i1.64035
p- ISSN 2528-1410 e- ISSN 2527-8045

Li, X., Wu, Y., Wei, M., Guo, Y., Yu, Z., Wang, H., and Fan, H. (2021). A novel index of functional connectivity: phase lag based on Wilcoxon signed rank test. *Cognitive Neurodynamics*, *15*, 621-636.

Malele, V., and Ramaboka, M. E. (2020). The design thinking approach to students STEAM projects. *Procedia CIRP*, *91*, 230-236.

McGovern, E., Moreira, G., and Luna-Nevarez, C. (2020). An application of virtual reality in education: Can this technology enhance the quality of students' learning experience?. *Journal of education for business*, *95*(7), 490-496.

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., and Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of cardiac anaesthesia*, *22*(1), 67.

Morris, T. P., White, I. R., and Crowther, M. J. (2019). Using simulation studies to evaluate statistical methods. *Statistics in medicine*, *38*(11), 2074-2102.

Nandiyanto, A. B. D., Fiandini, M., Hofifah, S. N., Ragadhita, R., Al Husaeni, D. F., Al Husaeni, D. N., and Masek, A. (2022). Collaborative practicum with experimental demonstration for teaching the concept of production of bioplastic to vocational students to support the sustainability development goals. *Journal of Technical Education and Training*, *14*(2), 1-13.

Nandiyanto, A. B. D., Tiyana, R., Azizah, D. N., and Hofifah, S. N. (2020). Demonstrating the biobriquettes production using variations in particle size and binder concentration using audio-visual to vocational students. *Journal of Engineering Education Transformations*, 34(Special Issue), 87-94.

Nwogwugwu, C. E., and Ovat, S. V. (2021). Role of gender in students' perception of research and statistics in education: A panacea for sustainable governance. *Global Journal of Educational Research*, *20*(2), 139-143.

Obafemi, K. E. (2019). Step-by-step deployment of Independent T-Test Using SPSS in early childhood studies. *Outlook on Human Capacity Building and Development*, 532-538.

Orcan, F. (2020). Parametric or non-parametric: Skewness to test normality for mean comparison. *International Journal of Assessment Tools in Education*, *7*(2), 255-265.

Paul, J., and Jefferson, F. (2019). A comparative analysis of student performance in an online vs. face-to-face environmental science course from 2009 to 2016. *Frontiers in Computer Science*, *1*, 1-9.

Ragadhita, R., Nandiyanto, A. B. D., Maryanti, R., Al Husaeni, D. F., Al Husaeni, D. N., Fiandini, M., and Masek, A. (2023). Best practice in distance learning with experimental demonstration on the concept of the automotive brake pad fabrication from domestic waste to vocational students for supporting education for sustainable development. *Journal of Technical Education and Training*, *15*(1), 40-54.

Savalei, V., and Rhemtulla, M. (2013). The performance of robust test statistics with categorical data. *British Journal of Mathematical and Statistical Psychology*, *66*(2), 201-223.

Soni, S. (2022). Cause related marketing and sales promotion: An analysis of comparative impact on consumer attitude. *Nmims Management Review*, *30*(3), 69-87.

DOI: https://doi.org/10.17509/ijost.v9i1.64035
p- ISSN 2528-1410 e- ISSN 2527-8045

Sun, P., Wang, M., Song, T., Wu, Y., Luo, J., Chen, L., and Yan, L. (2021). The psychological impact of COVID-19 pandemic on health care workers: A systematic review and meta-analysis. *Frontiers in psychology*, *12*, 626547.

Susanti, G., and Rustam, A. (2018). The effectiveness of learning models realistic mathematics education and problem based learning toward mathematical reasoning skills at students of junior high school. *Journal of Mathematics Education*, *3*(1), 33-39.

Usman, M. (2016). On consistency and limitation of independent t-test Kolmogorov Smirnov Test and Mann Whitney U test. *IOSR Journal of Mathematics*, *12*(4), 22-27.

Ustaoglu, A., Kursuncu, B., Alptekin, M., and Gok, M. S. (2020). Performance optimization and parametric evaluation of the cascade vapor compression refrigeration cycle using Taguchi and ANOVA methods. *Applied Thermal Engineering*, *180*, 115816.

Vinje, H., Brovold, H., Almøy, T., Frøslie, K. F., and Sæbø, S. (2021). Adapting statistics education to a cognitively heterogeneous student population. *Journal of Statistics and Data Science Education*, *29*(2), 183-191.

Wan, F. (2021). Statistical analysis of two arm randomized pre-post designs with one post-treatment measurement. *BMC medical research methodology*, *21*(1), 1-16.

Zakaria, M. Y., Malmia, W., Irmawati, A., Amir, N. F., and Umanailo, M. C. B. (2019). Effect mathematics learning achievement motivation on junior high school students 1 namlea. *International Journal of Scientific and Technology Research*, *8*(10), 1495-1498.

DOI: https://doi.org/10.17509/ijost.v9i1.64035
p- ISSN 2528-1410 e- ISSN 2527-8045