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An Application of Statistical Testing: A Guide to Basic Parametric Statistics in Educational Research Using SPSS

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ABSTRACT

Statistics is usually associated with a series of numbers, so it is often interpreted as a numerical description. However, statistics in the context of science is not just a series of numbers; statistics is more than just a collection of raw data. Statistics are also used to analyze data, such as graphs, displaying data in tabular form, forecasting, conducting various hypothesis tests, and other uses. The primary purpose of this study is to examine the application of various descriptive and inferential statistical tests in educational research so that it can teach how to collect data, present it in an easy-to-understand form, analyze data, interpret data, and draw conclusions. The data used in this study are secondary data sourced from research, websites, books, and various journals. The research method used is to use a literature review. Based on multiple literature reviews, it was found that the use of appropriate statistical techniques is an essential requirement for the implementation of effective social and behavioral research. In addition, the study concluded that choosing the proper statistical test is necessary for making excellent and specific conclusions. Thus, statistical analysis is essential in making educational research effective, efficient, and flourishing by the objectives set.

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1. INTRODUCTION

Statistics is a discipline that teaches how to collect data, present it in a form that is easy to understand, analyze data, interpret data, and draw conclusions in situations that have uncertainty. Statistics help summarize large amounts of quantitative data so that they are easy to understand, understand the population from which samples are taken, provide guidelines for decision-making, and help make reliable inference results. Statistics have an essential role in hypothesis testing; besides that, statistics also plays a role in the preparation of theoretical models, formulation of hypotheses, development of data collection tools, preparation of research designs, determination of samples, processing, and analysis of data. Nowadays, technological advances are beneficial in various daily activities. Speed, accuracy, durability, and versatility stand out in using computers for data processing. The speed of data processing software on a computer in the data analysis process occurs in just a few seconds, with the note that the data has been recorded and the type of data analysis has been determined. The accuracy of data processing results with a computer is unquestionable if the software used has been tested. The durability of computers as a means of work is far above human endurance; computers can be used continuously for data processing without feeling tired, stressed, or losing concentration. It can happen as long as the program and computer are not damaged and the electricity does not go out. The versatility of computers is shown by the ability of data processing software to perform all kinds of analysis techniques. These techniques range from simple to complex analysis, displaying output as data, tables, graphs, etc.

Using statistics plays a vital role in describing the results of scientific research, which is a systematic, controlled, empirical, and critical investigation of natural phenomena guided by theories and hypotheses about the relationships predicted in these phenomena When research is conducted on a sample, data can be obtained, which are then analyzed using statistical methods, and the results can be generalized to the population. Based on this information, statistics is also interpreted as a way to understand the population based on information obtained from the sample. The level of reliability of the generalization of a statistical test result on a sample is expressed in terms of significance. Generating research is often a key determinant of academic advancement, especially for educators, regardless of their institution of origin (Windish, 2021; Atasoylu *et al*., 2003; Yeh *et al*., 2015; Ryan *et al*., 2019). To help educators develop research skills, produce scholarly work, and obtain research funding, some institutions have established academic research institutes in Education (Varpio *et al*., 2017). Despite these initiatives, institutions may need to provide adequate statistical or methodological support to assist in developing research and evaluating educators' work (Ryan *et al*., 2019). A recent Association of American Medical Colleges survey showed that most schools lack specific biostatistics training. 7 This lack of training can lead to poor statistical knowledge (Msaouel *et al*., 2018; Araoye *et al*., 2020; Schmidt *et al*. 2017), which in turn leads to poor statistical literacy and understanding in describing research results (Schmidt *et al*., 2017). A recent scoping review of several academic development programs found that only some programs focused on statistical application skills in research and scientific writing (Alexandraki *et al*., 2021). Meanwhile, without statistical knowledge, educators or researchers are at a severe disadvantage in publishing their scientific work and thus potentially miss out on opportunities for exemplary academic achievement.

Educational research systematically applies scientific methods to solve educational problems concerning students and teachers. This research seeks to organize data quantitatively and qualitatively to arrive at statistical conclusions. Researchers' demand for

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statistical data analysis continues to increase, and they need statistical methods to be applied in all research activities. In conducting research in various fields, researchers must be aware of using statistical tools to draw appropriate and suitable conclusions; these tools help researchers describe and draw conclusions about research results, which can be published generally. Various statistical methods are currently used in multiple academic fields, depending on the objectives researchers want to achieve. In the scope of education, there are several applications of statistical methods that are commonly used, such as 1) descriptive statistics, including grouping, tabulation, graphical representation, and quantitative description of data; 2) statistical inference theory used in educational research to predict sample survey results (inductive statistics); 3) experimental design theory functions to detect and verify causal relationships between variables (analytical statistics) (Khusainova *et al*., 2016). The use of appropriate statistical techniques is an essential requirement for the effective conduct of social, educational, and behavioral research (Adeyemi, 2009).

Some analyses could only be calculated effectively manually with statistical software packages. They also stated that statistical software has made a tremendous contribution to social and educational research, especially in the demographic and Data analysis field. Thus, the main objective of this study is to examine the application of various statistical tests in educational research to collect data, present it in an easily understood form, analyze data, interpret data, and draw conclusions.

2. LITERATURE REVIEW AND CURRENT KNOWLEDGE

About data processing, statistical science can be divided into:

2.1. Descriptive Statistics

Descriptive statistics is a statistical method used to describe various characteristics of data and collect, summarize, present, and describe data so that it can provide helpful information. Data presented in descriptive statistics are usually in the form of data centralization measures (mean, median, mode), data distribution measures (standard deviation and variance), tables, and graphs (histograms, pies, and bars).

2.2. Inferential Statistics (Inductive)

Inferential statistics is a method related to data analysis on samples, and the results are used to generalize the population. Inferential statistics is based on probability, and the samples analyzed are selected randomly. Inferential statistics attempts to make various inferences about a set of data from a sample. The task of inferential statistics is to estimate, test hypotheses, and make decisions (Neideen & Brasel, 2007). Inferential statistics are classified into (see **Figure 1**):

(i) Parametric Statistics. The use of parametric statistics is based on the assumption that the data taken has a normal distribution and that the data type used is interval and ratio.
(ii) Non-Parametric Statistics. Using non-parametric statistics does not require the data taken to have a normal distribution, and the data type can be nominal or ordinal. Parametric and non-parametric statistics can be used for statistical analysis that is:
    (i) Correlative. The correlative analysis technique is used to determine the relationship or Correlation of a variable with another variable. The analysis techniques that are often used are Pearson correlation and regression.

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(ii) Comparative. Comparative analysis is used to determine the difference in average values between groups. Two commonly used data analysis techniques are the T-test and ANOVA.

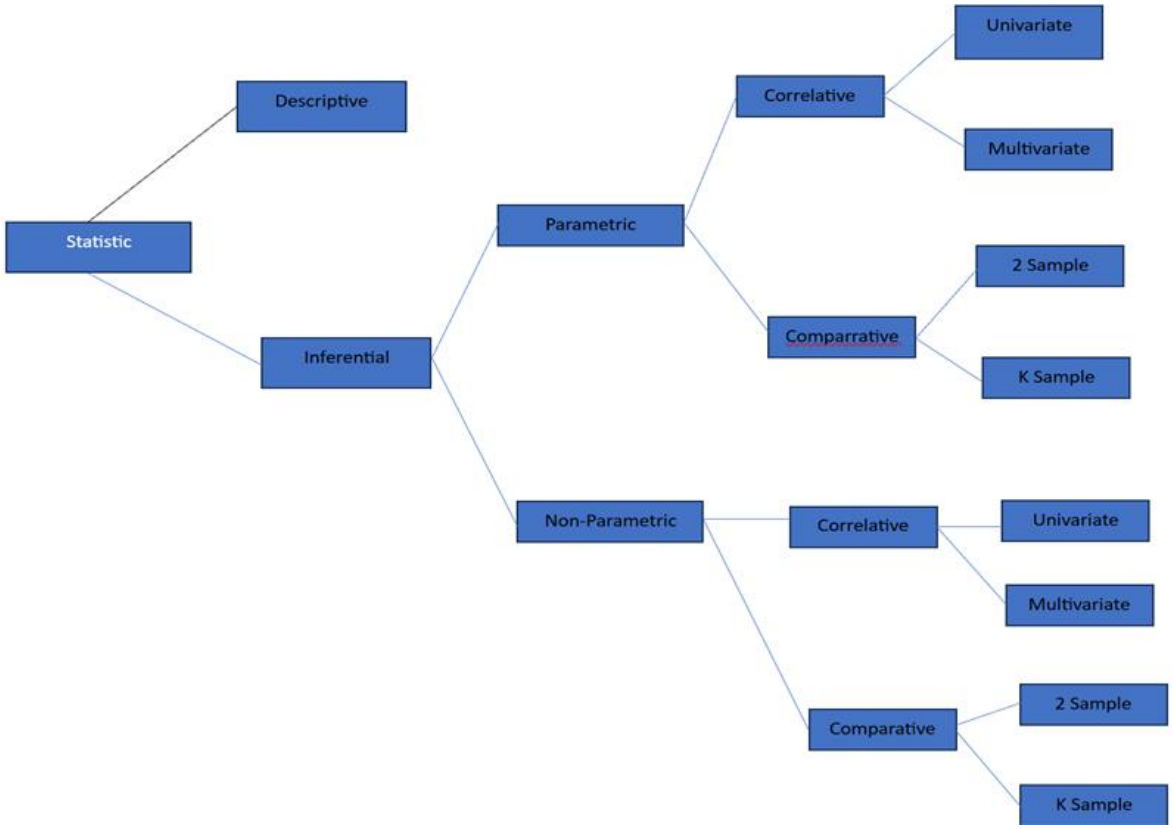

Figure 1. The Classification of statistics and analysis techniques.

3. RESEARCH METHOD

This study uses a quantitative descriptive method to determine the characteristics of a population or a particular phenomenon (Qualtrics (n.d.). Data were collected using a questionnaire as the main instrument. Descriptive research allows researchers to identify patterns in the characteristics of a group and its function as a basis for establishing a norm that needs to be understood in addition to why something happens. This study was conducted at the Indonesian Education University. The respondents of this study were one hundred and twenty (120) undergraduate, master's, and doctoral students. The instrument used was a questionnaire for the primary data collection in this study. This questionnaire consists of five parts that collect data on the importance of statistics in educational research. Statistical methods are used in the study to determine values relevant to understanding statistical analysis. Data transformation is carried out by assigning numerical or ordinal values according to their ranking after the data is sorted, known as ranking; after that, inferential statistical analysis is carried out.

4. RESULTS AND DISCUSSION

4.1. Step-by-Step Analysis

4.1.1. Parametric statistics T-test

The t-test aims to determine whether there is a difference in the average of a group based on specific criteria, or it can also be said to test the comparison. The test can be a one-sample

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t-test, independent sample t-test, or paired sample t-test. One-sample testing, in principle, wants to determine whether a particular value significantly differs from a sample's average.

This study demonstrates how to perform a one-sample T-test analysis with SPSS.

Step 1: Open the SPSS application, in this case study we use SPSS version 26.

Step 2: Enter the view variable data as shown in **Figure 2**.

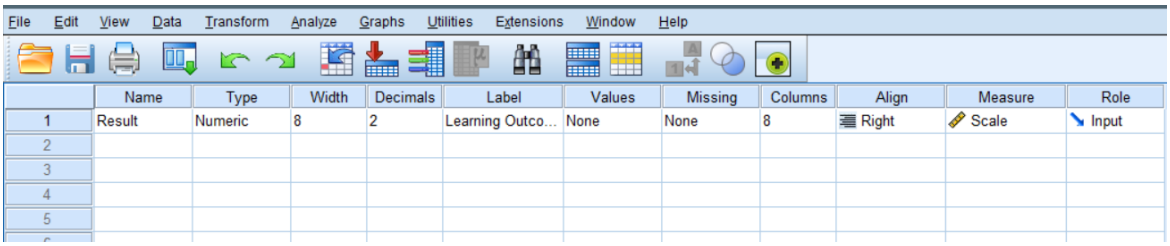

Figure 2. SPSS View Variable Data.

Step 3: Enter student grade data on the "Data View" tab (see **Figure 3**)

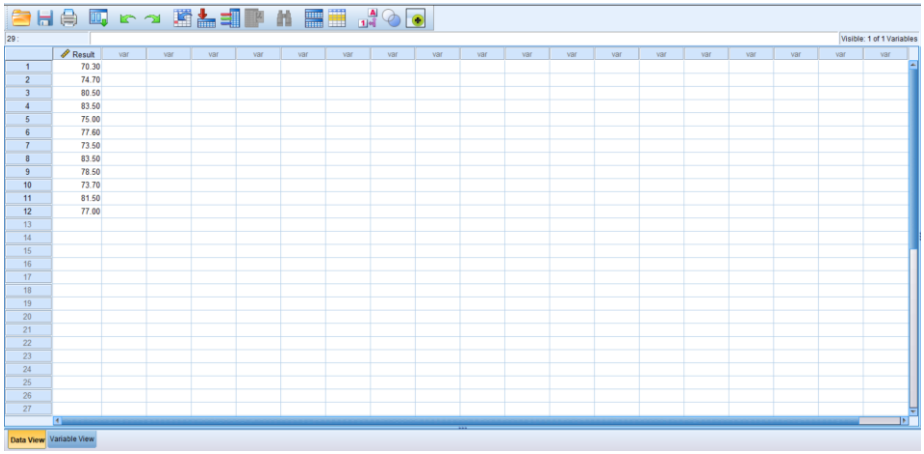

Figure 3. SPSS version 26 Data View page.

Step 4: Click Analyze – Descriptive Statistics – Explore (see **Figure 4**)

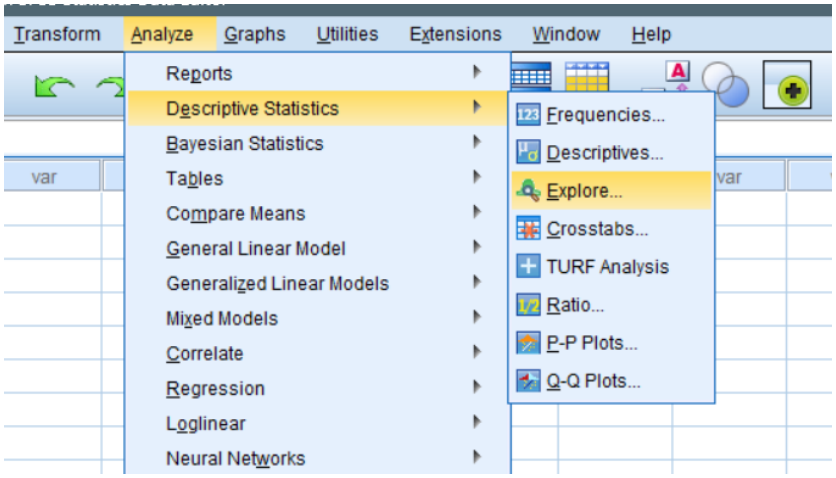

Figure 4. Steps to access the one sample t-test analysis menu in SPSS version 26.

Step 5: The "Explore" dialog box appears, then enter the Learning Outcome variable into the Dependent List box, then click "Plots" (see **Figure 5**).

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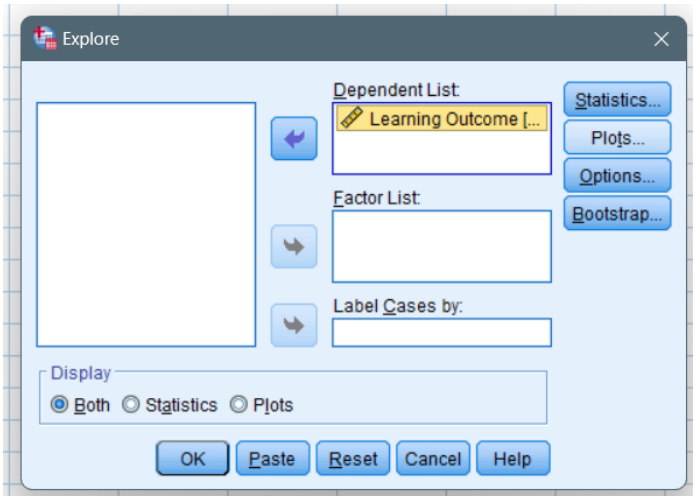

Figure 5. Explore the pop-up menu.

Step 6: The "Explore: Plots" dialog box appears, then check the box (✓) on Normality Plot with tests, then click Continue and OK. (see **Figure 6**).

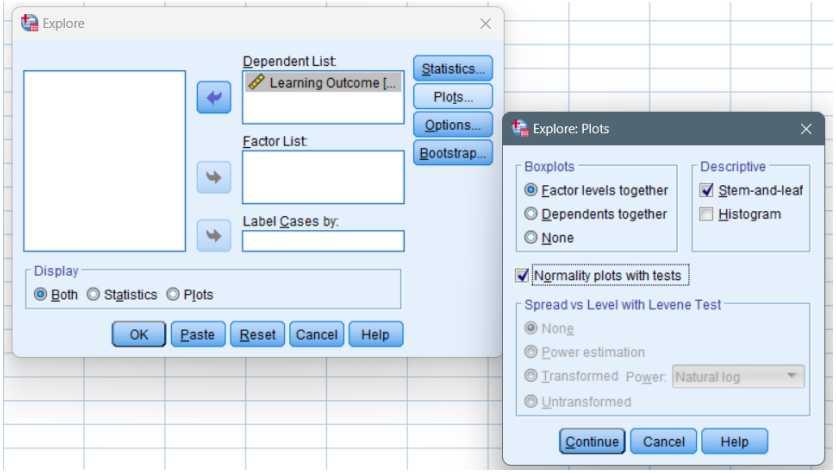

Figure 6. The "Explore: Plots" dialog box.

Then, the results are obtained, shown in **Table 1**.

Table 1. Output of one sample T-test.

	Test Value = 90					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Variable	-13.898	4	0.000	-5.20000	-6.2389	-4.1611

The independent sample T-test aims to compare the means of two groups. This test requires that the Dependent Variable Data is in the form of intervals or ratios and is normally and homogeneously distributed. **Tables 2** and **3** provide examples of the analysis results. To obtain the results shown in **Tables 2** and **3** we used the SPSS version 26 application. The steps we took were:

Step 1: Please enter the view variables and view data (see **Figures 2** and **3**), in this section adjust them to the characteristics of your data.

Step 2: Click Analyze – Compare Means – Independent Sample T-test (see **Figure 7**)

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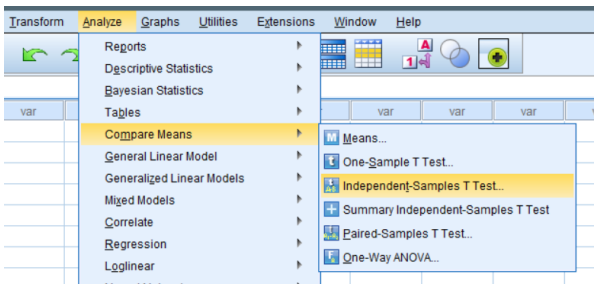

Figure 7. Steps to access the independent-samples t-test analysis menu in SPSS version 26.

Step 3: Please follow the next steps, according to the directions from the application.

Table 2. Group statistics of independent sample t-test.

Variable		N	Mean	Std. Deviation	Std. Error Mean
Group	1	7	2.8200	0.25060	0.09472
	2	7	2.4400	0.49325	0.18643

Table 3. Output of independent sample t-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
variable	Equal variances assumed	4.916.00	0.047.00	1.817.00	12.00	0.094	0.38000	0.20911	-0.07562.0000	0.83562.0000
	Equal variance is not. *assumed*			1.817.00	8.904.00	0.103	0.38000	0.20911	-0.09383.0000	0.85383.0000

A paired sample t-test aims to determine whether there is a difference in the mean for paired groups. The subjects are the same but experience two different measurements or treatments. There are pre and post-tests or measurements in stages 1 and 2; the requirement for conducting a paired sample t-test is that the data must be of interval or ratio type. Examples of the analysis results can be seen in **Tables 4, 5, and 6**.

The steps that can be taken to perform paired sample t-test analysis with the SPSS version 26 application are almost the same as when analyzing one sample T-test and an independent t-test. However, to perform a paired samples t-test, select the menu "Analyze - Compare means - Paired-Samples T Test" (see **Figure 8**).

Table 4. Output of paired samples statistics.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before Treatment	2.1056	25	0.16739	0.03348
	After Treatment	1.5909	25	0.26675	0.05335

Table 5. The output of paired samples correlation.

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		N	Correlation	Sig.
Pair 1	Before & after treatment	25	-0.071	0.035

Table 6. Output of paired samples T-test.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Before and After Treatment	0.51463	0.32487	0.06497	0.38053	0.64873	7.921	24	0.000

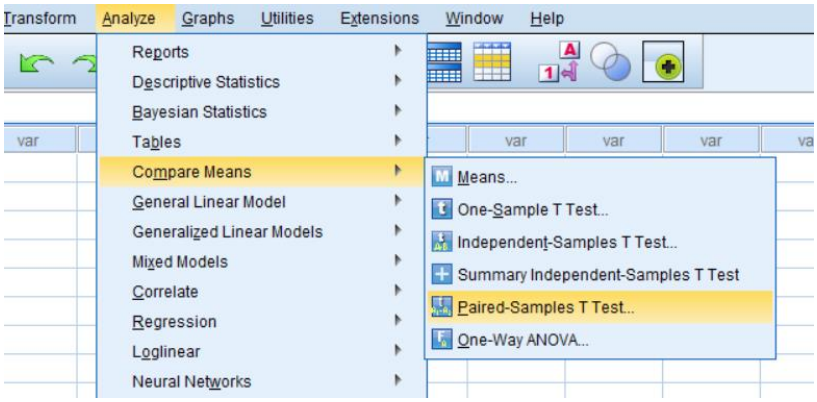

Figure 8. Steps to access the paired-samples t-test analysis menu in SPSS version 26.

4.1.2. Parametric statistics one-way ANOVA

The one-way ANOVA test is intended to determine whether there is a difference in the average of more than two sample groups. How to perform a one-way ANOVA test in the SPSS application is by accessing the Analyze - Compare Means - One Way ANOVA menu (see **Figure 9**). **Tables 7, 8,** and **9** below provide examples of analysis results.

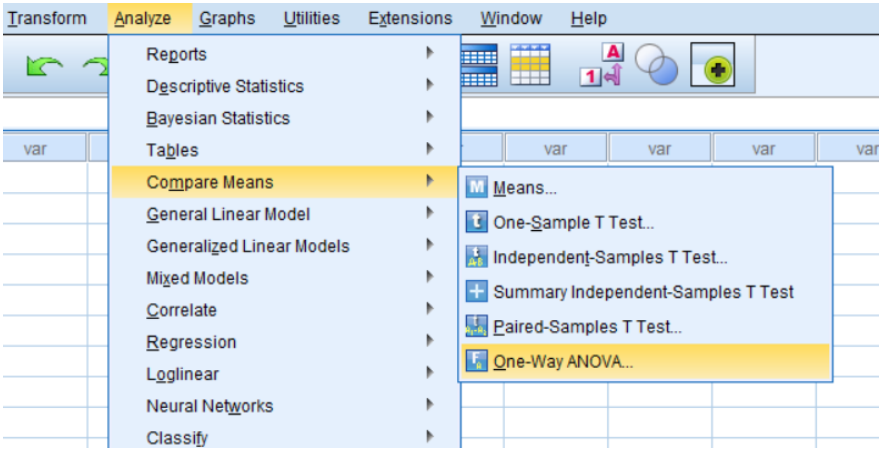

Figure 9. Steps to access the one-way ANOVA analysis menu in SPSS version 26.

Table 7. The output of descriptive data of one-way ANOVA.

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	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Group 1	11	3.6970	0.52609	0.15862	3.3435	4.0504	2.67	4.00
Group 2	5	2.4000	0.54772	0.24495	1.7199	3.0801	2.00	3.00
Group 3	4	2.2500	0.50000	0.25000	1.4544	3.0456	2.00	3.00
Total	20	3.0833	0.85754	0.19175	2.6820	3.4847	2.00	4.00

Table 8. Output of homogeneity of variances.

Levene Statistic	df1	df2	Sig.
0.243	2	17	0.787

Table 9. The output of one-way ANOVA.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.255	2	4.627	16.674	0.000
Within Groups	4.718	17	0.278		
Total	13.972	19			

2.3.3. Correlation

The correlation test aims to measure the closeness of the relationship between two variables (X and Y). The closeness of the relationship between X and Y is called the correlation coefficient and is symbolized by "r." The value of "r" is between -1 and +1. A positive "r" value means that if X increases, Y increases; if the value of "r" is negative, it means that if X increases, Y decreases or vice versa. An example of the analysis results can be seen in **Tables 10** and **11**.

Table 10. The descriptive data of correlation.

	Mean	Std. Deviation	N
Variable 1	4.1350	1.17053	40
Variable 2	3.5458	1.12927	40

Table 11. The output of Pearson correlation.

		Variable 1	Variable 2
Variable 1	Pearson Correlation	1	-0.445**
	Sig. (2-tailed)		0.004
	N	40	40
Variable 2	Pearson Correlation	-0.445**	1
	Sig. (2-tailed)	0.004	
	N	40	40

**. Correlation is significant at the 0.01 level (2-tailed).

Pearson correlation analysis can be done using SPSS, you can access the Analyze – Correlate – Bivariate menu (see **Figure 10**)

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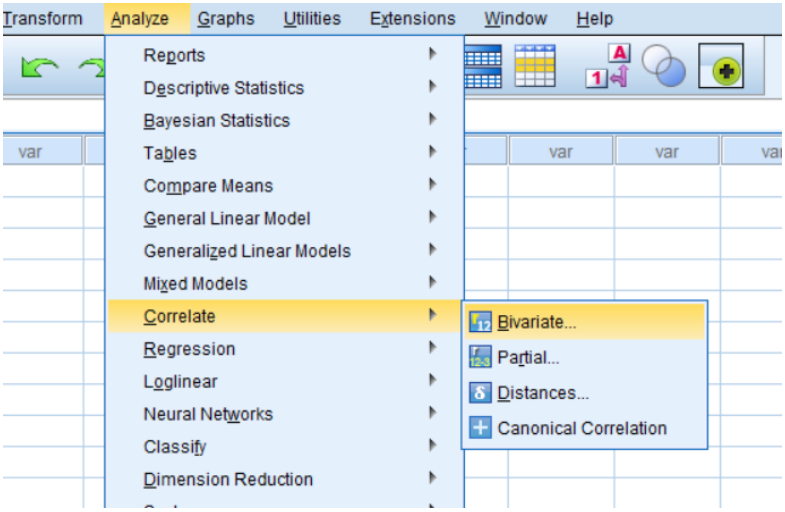

Figure 10. Steps to access the Pearson correlation analysis menu in SPSS version 26

Then the Bivariate Correlations box page appears, as shown in **Figure 11**.

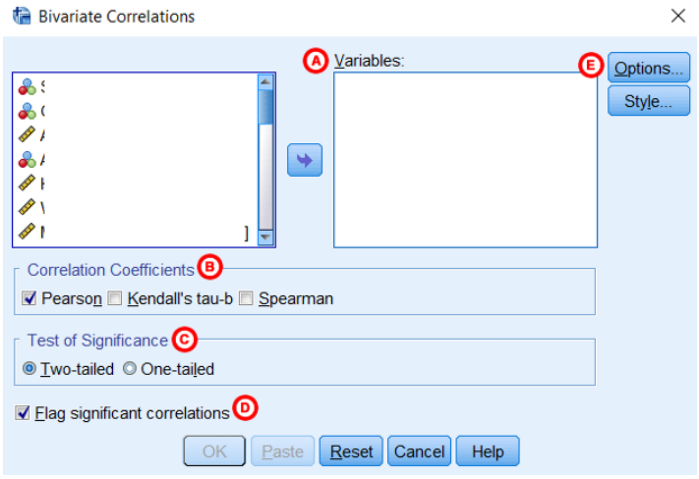

Figure 11. The bivariate correlations box page.

The explanation in **Figure 11** is as follows.

A. **Variables**: You must select at least two continuous variables to use in a bivariate Pearson correlation, but you can choose more than two. The test generates a correlation coefficient for each pair of variables in this list.

B. **Correlation Coefficient**: There are several types of correlation coefficients. By default, Pearson is selected. Selecting Pearson generates a test statistic for a bivariate Pearson correlation.

C. **Significance Test**: Select a two-tailed or one-tailed test, depending on the significance test you want. SPSS uses a two-tailed test by default.

D. **Mark significant correlations**: By checking this option, SPSS marks statistically significant correlations with an asterisk (**) in the output. By default, SPSS marks statistical significance at the alpha = 0.05 and alpha = 0.01 levels, but not at the alpha = 0.001 level (which is treated as alpha = 0.01).

E. **Other Options**: Clicking on "Options" opens a window where you can specify what statistics to include that are shown in **Figure 12** (e.g., Mean and standard deviation, Cross-product deviation, and covariance) and how to handle Missing Values (e.g., Ignore cases pairwise or listwise). Keep in mind that the pairwise/listwise setting does not affect the calculation if you

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are only entering two variables, but it can make a big difference if you are entering three or more variables into the correlation procedure.

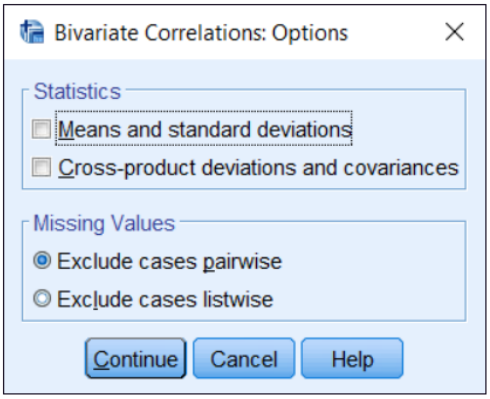

Figure 12. Bivariate correlations: Options.

The study results in **Table 12** present the data collected on the importance of statistical applications in educational research as observed by respondents. The results of the survey stated that statistical applications in educational research are critical (X = 4.76). The study's results also said that statistical applications enable effective research implementation, especially in disclosing research data (X = 5.02). In addition, statistical applications in research are also observed as an essential part of choosing the proper method for collecting data (4.22), making decisions and predictions (3.85), Developing critical thinking and analytical thinking (3.77), Helping to use the correct analysis (3.34), in drawing conclusions and inferences (3.33); and in presenting effective results (3.27); and finally, basic statistics facilitate the evaluation of results, (3.01). Based on the descriptive data, the function of statistical applications in educational research has high significance. Educational research is only meaningful with fundamental statistical analysis; for academics, knowledge of basic statistics is very important to use or apply when conducting research.

Table 12. The result of the Level of Importance.

Indicator	N	WM
Enable effective conduct of research	120	5.02
Help select proper methods to collect data	120	4.22
Help employ the correct analysis	120	3.85
Help present results effectively	120	3.34
Help make decisions and predictions	120	3.33
Help conclude & inferences	120	3.33
Facilitate evaluation of outcomes	120	3.27
Develop critical thinking and analytical thinking	120	3.01

Statistical analysis and educational research are two variables that give life and meaning to each other in developing the scientific world in education. Educational research allows for systematically collecting and analyzing information about educational methods. This research should be viewed as a critical, reflective, and professional activity that adopts rigorous methods to collect data, analyze it, and solve all educational challenges (Agarwal, 2021). Meanwhile, statistics is a science that deals with collecting, organizing, and analyzing data and drawing conclusions from samples of the entire population (Winters & Winters, 2010). Statistics is a valuable tool in research because it helps researchers take complex data sets, break them down, and draw critical and meaningful conclusions from the data (Ali & Bhaskar,

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2016). Statistics and its analysis give meaning to meaningless numbers, giving life to numbers and data. The influence of statistical applications in educational research significantly helps collect, classify, and tabulate all numerical facts. In the education sector, statistics help provide accurate information for better decisions. Other reasons include ensuring quality education, as statistics is valuable in various situations, such as analyzing data sets to make informed decisions, especially those related to education.

Statistical analysis helps obtain accurate findings for the learning process and develops data collection and analysis approaches. Statistics in research is essential in conducting a series of research processes that include planning, designing, data collection, analysis, drawing meaningful interpretations, and reporting research findings. Furthermore, the results obtained from a research project are meaningless raw data unless analyzed with statistical tools. Therefore, statistics in research are essential to justify research findings (Altman & Bland, 2009; Udto & Ibrahim, 2023). In addition, statistics also play a significant role in education, including identifying areas that need improvement and evaluating the effectiveness of teaching methods. Statistical analysis can help educators evaluate the effectiveness of various teaching methods and interventions. In addition, Al-Haddad (2024) explains that statistics are essential for educators to understand student performance using descriptive statistics, allows educators to see trends in student performance using data visualization, allows educators to compare different teaching methods using hypothesis testing, and provides methods and techniques for collecting reliable and valid data in educational assessment. Statistics helps design assessment instruments, such as tests, surveys, and questionnaires, to collect information about students' knowledge, skills, and attitudes.

5. CONCLUSION

The results of this study underline the importance of the Application of Statistical Testing as a guide to basic parametric statistics in educational research. Respondents emphasized the critical role of statistical testing applications in conducting effective research, selecting methods, making decisions, and evaluating results. Statistics has emerged as an essential tool in education, facilitating areas for improvement and enhancement of education, evaluating teaching methods, monitoring student progress, optimizing resource allocation, and assessing policy impacts. Based on various literature reviews, it was found that the use of appropriate statistical techniques is an essential requirement for conducting effective social and behavioral research. In addition, the study concluded that selecting the correct statistical test is essential for making excellent and specific conclusions. Thus, statistical analysis is vital in making educational research effective, efficient, and flourishing by the stated objectives.

6. ACKNOWLEDGMENT

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7. AUTHORS' NOTE

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. The authors confirmed that the data and the paper are free of plagiarism.

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