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Using Analysis of Variance in the Academic Achievement to Compare Three Learning Patterns for University Students

Abdalla Mohammed Mohammedzain Ahmed[1,2], Faiz Mohammed Ahmed Hamarai[3]

[1]Department of Administration, Imam Muhammad Ibn Saud Islamic University, Riyadh, KSA
[2]Department of Statistics, Omdurman Islamic University, Omdurman, Sudan
[3]Department of English, Imam Mohammad Ibn Saud Islamic University, Riyadh, KSA
Email: Aahmed@imamu.edu.sa, hamaraif@yahoo.com

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Abstract

The researchers conducted this study to statistically compare traditional, distant and blended learning on the academic achievement of students at the university level. Data were collected with the aim of finding out which learning pattern; (traditional, distant or blended learning) has a higher average of academic achievement for the university students. Data were analyzed using the one-way analysis of variance (ANOVA) test. This confirmed the validity of the study hypothesis, which states that there are statistically significant differences between the achievement averages of the three learning patterns. By using the multiple comparison test, a significant difference between the means of traditional and distant learning patterns was found. There was also significant difference between the means of traditional and blended learning patterns. No significant difference was found between the means of the distant and blended learning patterns on the academic achievement of the university students. The researchers of the study recommended the application of distant or blended learning patterns in university learning because the average academic achievement of the students in these two patterns of learning was greater than that of the traditional learning pattern.

Keywords

One-Way ANOVA, Academic Achievement, University Students, Traditional Learning, Distant Learning, Blended Learning

1. Introduction

The rapid spread of Coronavirus in 2019, spared no country and affected all walks of people's life and of course education was no exception. (Jena, 2020) states that the spread of COVID-19, has frozen all activities including education. He adds that "The institutions got closed with cease of educational activities and created many challenges for the stake holders."

Academic institutions from kindergarten to college and university levels were shut down. As a result, ministries of education turned to adopt other alternatives to replace face-to-face or traditional pattern of learning. In the university context, both distant and blended learning patterns were adopted to replace the traditional learning pattern. The testing system was changed due to change in the learning system. This change inspired the researchers of this study to conduct statistical comparison to explore the academic achievement of the university students in three patterns of learning; traditional, distant and bended learning.

2. Methodology

Data for the study were collected from a course called "Intermediate Accounting". This course was taught for three successive semesters in the Administration Department, College of Sharia'a and Islamic Studies, Imam Mohammad Ibn Saud Islamic University. Traditional learning pattern was adopted in the first semester, distant in the second, and the blended in the third. The study considered the stability of the course instructor as well as the assessment methods. This means that all the variables in the three semesters except for the teaching pattern remain constant. To achieve the goals of the study the researchers used SPSS. For the purpose of the study, the following testing tools were used:

- The data normality test was conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests.
- The one-way ANOVA test, is used to compare more than two averages.
- Multiple comparison tests were used to see where the differences between the means of each pair lie.

3. Problem of the Study

With the emergence of Corona Virus Pandemic, it became impossible to continue the traditional learning pattern. This made universities adopt other practical alternatives. Distant and blended learning patterns emerged to replace traditional learning that had previously prevailed. The study problem raised as an attempt to explore how useful these two patterns are in the advantages of academic achievement of the university students. This situation inspired the researchers of this study to conduct an investigation to find out which leaning pattern; traditional, distant, or blended learning pattern has the highest academic achievement for the university students.

4. Significance of the Study

The significance of this study lies in the fact that it used the one-way ANOVA test, which is one of the parametric tests that is more robust and valid in the hypothesis's tests compared to non-parametric tests. The researchers used both the descriptive and the analytical approaches in their study.

5. Objective of the Study

The primary objectives of this study were:

1) To compare between the academic achievement of the university students who received the traditional and the students who received distant learning.

2) To compare between the academic achievement of the university students who received the traditional and the students who received blended learning.

3) To compare between the academic achievement of the university students who received the distant and the students who received blended learning.

4) To find out which teaching pattern(s) (traditional, distant or blended learning) has/have a higher average in the academic achievement of the university students.

6. Hypothesis of the Study

In their study, the researchers sought to find an answer to the following hypothesis:

There are statistically significant differences in the average academic achievement of the traditional, distant, and blended learning patterns.

7. Patterns of Learning

Learning is a non-stop journey and it is an ongoing process. People need to learn every now and then to enrich their experience and to add new skills to the shelf of their knowledge. In terms of academic leaning, Won Kim (2007) thinks that traditional learning can be divided into "classroom-based or virtual-based, formal or informal and scheduled or self-paced". Also, Rossett, Douglis and Frazee (2003) classify it into "technology-based or people based, independent or dependent and directive or discovery oriented".

Traditional or face-to-face learning is a learning pattern in which both the instructor and the students meet and interact in one place such as classrooms of lecture rooms. Although this pattern of learning was favored, spread and the past, it received criticism by some scholars who believe it does not give enough experience for students to depend on themselves and participate actively in the classroom. According to Broughton, Brumpit, Pincas and Wilde (2002) traditional learning method is "heavily relies on teacher instruction and it does not offer adequate opportunities to students for participation". Qazi and Simon (2012) say that Pakistani students who receive traditional learning, lack the adequate experience to interact dynamically in their business communication classes. Papert (1993) contributes that learning business communication using the traditional method views learning merely as a store for saving knowledge for a "short-real time". However, some researchers like (Xu & Smith Jaggars, 2013) think that traditional learning is indispensable and even necessary for some kinds of students particularly "younger, male, and black students". They also think that it "may be at a disadvantage in their ability to adapt to online courses". Wijekumar et al. (2006) argue that teacher-student interaction of the traditional learning must be taken into consideration, as online students may be exposed to a kind of isolation from their instructors if traditional methods of assessments such as subjective tests are rigorously applied.

In the last few years, an inclusive demand for "technology-based" learning found its way to the academic domain. The break out of the Corona Virus Pandemic increased the need for some other alternatives of learning patterns to replace the traditional learning pattern. Therefore, the Internet appeared a practical solution. Distant and blended learning patterns appeared as two online-dependent alternatives to bridge the gap made by the traditional learning pattern.

The use of the Internet in people's daily life cannot be ignored. Worldwide digital population (2018) states that "over 4.1 billion people were active internet users and 3.3 billion were social media users". The Internet, appeared as a key feature of the technological progress. It plays a significant role in almost most of the academic activities. Educational institutions including universities take the internet advantage and change some course into either distant or blended learning to replace the old face-to-face pattern.

Malalla (2004) believes that multiple academic institutions adopted E Learning as a substitution to the traditional pedagogical system of learning. According to him, the process of transferring from face-to-face learning to E-learning is rapidly accelerating.

The distant learning pattern is not new. It is relatively an old learning pattern. Its basic concept depends on the presence of the learner in a place differs from the source of education, which may be the book, the teacher, or even a group of learners. In the Past, before the introduction of the Internet, people used the communication devices which were available at that time. Ferri, D'Andrea, Grifoni, & Guzzo (2018) say that distant learning is an old pattern of learning. However, people used available communication devices at that time such as, television, radio and telephone to deliver lessons and reduce the direct contact between the teacher and the students. In the current times, old fashion of communication devices disappeared and other modern technological devices replaced them. ICT appeared to revolutionize the academic field. Electronic devices such computers and smart phones, occupy a comfortable position in education in general and in learning in particular. This of course facilitates the learning process and makes it easier for both the students and the instructor to interact. (Sangrà et al., 2012) state electronic learning is the prominent pattern of distant learning that utilizes ICT to serve education.

Alkhateeb et al. (2010) draw the attention to the privacy problems that may be created by the use of the ICT tools in. They indicate the privacy problem resulted from using electronic devices in education. They believe that "new services on the Internet can be swiftly integrated into existing applications such as integrating Wiki with Web 3.0. The primary risk comes from the fact that students and lecturers are not entirely realized that their universities do not control these web services".

Blended learning has also found acceptance and become important worldwide. Its importance results from the fact that it has not completely cancelled the traditional pattern of learning, which has been around for centuries. Horn and Staker (2013) describe blended learning as a formal education program in which the student learns partly through the Internet with the possibility of controlling the time, place and speed required. Because both traditional and distant learning patterns have their merits and demerits, blended learning appeared to solve the problems of the washout of these two learning patterns. Blended learning is a smart solution brought to the academic domain. It takes the advantages of the two learning patterns (traditional and distant learning patterns). It is a clear manifestation of using technology in learning. Some researchers define the blended pattern of learning. For example, Kudrik, Lahn and Mørch (2009) describe blended learning as the "combination of two kinds of learning environment, physical classroom learning and online learning to enhance the learning outcomes." Kim, Bonk and Oh (2008) think that it is "the mixing of traditional face-to-face approach with online approach".

Some studies conducted to investigate the importance of blended learning on the academic achievement of the students at the university level. Alshwiah (2009) conducted a study to explore the impact of blended learning and the students' attitudes toward the English language academic achievements at Arabian Gulf University. The researcher divided the study samples into control group and experimental group. Findings of the study indicated no significant difference between two groups regarding achievement or attitude towards English Language.

8. Analysis of Variance (ANOVA)

8.1. One-Way ANOVA

Larson (2008) says the analysis of variance is a statistical technique, which uses a response variable (continuous random variable) and is measured under the conditions defined by discrete factors (classification variables, often with nominal levels). Frequently, ANOVA is used to test equality among several means by comparing variance among groups relative to variance within groups (random error).

ANOVA test, it imposes no restriction on the number of means, that unlike t test (Howell, 2010: p. 318).

Wegner (2016: p. 298) believes that when more than two population means are compared for equality, a test statistic—known as the F-statistic—is used. According to him, the test procedure that is used to compute the F-statistic is called (ANOVA).

In many research areas, there is a need to compare the means of a numeric random variable across multiple populations.

Ostertagová & Ostertag (2013) say that Analysis of variance (ANOVA) is a statistical procedure concerned with comparing means of several samples. It can be thought of as an extension of the t-test for two independent samples to more than two groups. The purpose of (ANOVA) is to test for significant differences between class means.

8.2. Assumptions ANOVA

The analysis of variance that requires a set of assumptions is as follows:

According to (Howell, 2010: pp. 320, 321):

1) Normality: The observations in each group come from normal distribution.

2) Independence: The observations are independent of one another.

3) Equal variance: In each of populations has the same variance (homoscedasticity).

Bobbitt (2021) adds, "in general, a one-way ANOVA is considered to be fairly robust against violations of the normality assumption as long as the sample sizes are sufficiently large".

8.3. Null and Alternative Hypotheses

Marques de Sá (2007) says that, that given the asymmetry of the (F) distribution, one needs to compute the two (1 − α/2) percentiles of (F) for a two-tailed test, and reject the null hypothesis if the observed (F) value is unusually large or unusually small. Note also that for applying the (F) test it is not necessary to assume that the populations have equal means.

The null hypothesis becomes:

$$H_0 : \mu_1 = \mu_2 = \cdots = \mu_k$$

Against the alternative hypothesis:

$$H_1 : \text{One or more means are different from the others}$$

Rejection Region: Kuzma and Bohnenblust (2004: p. 181) state that H_0 is rejected if the computed (F) statistic is greater than the table value in (F). Wegner (2016: p. 305) says that, is interpreted the influence of the factor on the response variable as when the null hypothesis is rejected in favor of the alternative hypothesis, it is assumed that the response variable is influenced by the factor, that there is a statistical relationship between the factor and the response variable – they are statistically dependent.

8.4. ANOVA Calculation

According to Sawyer (2009) ANOVA calculation involves the partitioning of variance from calculations of sum of squares and mean squares. Three metrics are used in calculating the ANOVA test statistic.

1) The grand Mean, which is the mean of all scores in all groups.

2) Sum of Squares, which are of two kinds, the sum of all squared differences between group means and the grand mean (between-groups sum of squares) and

the sum of squared differences between individual data scores and their respective group mean (within-groups sum of squares).

3) Mean Squares, is also of two kinds (between-groups mean squares, within-groups mean squares), which are the average deviations of individual scores from their respective mean, is calculated by dividing sum of squares by their appropriate degrees of freedom.

Kuzma and Bohnenblust (2004: p. 179) say that "we need to describe the procedure for computing ANOVA, this procedure may be used for both equal and unequal numbers for any number K groups. The observations within each group are indicated with double notation. With the first subscript indicating the group number and the second subscript indicating the observation in that group. The mean for group (1) is denoted by the familiar $\bar{x}$ and is given by the formula":

$$\bar{x}_1 = \sum_{j=1}^{n_1} \frac{x_1}{n_1} \tag{1}$$

The sum of all observations are given by:

$$\sum_{i=1}^{k} \sum_{j=1}^{n_1} x_{ij} \tag{2}$$

The overall mean is obtained by dividing the total of all observations of all groups by the total number of observations N, where:

$$N = \sum_{i=1}^{k} n_i \tag{3}$$

The next formulas give the between-groups sum of squares (SSb):

$$\mathrm{SSb} = \left[\frac{\left(\sum x_1\right)^2}{n_1} + \frac{\left(\sum x_2\right)^2}{n_2} + \cdots \right] - \frac{\left(\sum_{i=1}^{k} \sum_{j=1}^{n} x\right)^2}{N} \tag{4}$$

The next formulas give the within-groups sum of squares (SSw):

$$\mathrm{SSw} = \sum_{i=1}^{k} \sum_{j=1}^{n} x^2 - \left[\frac{\left(\sum x_1\right)^2}{n_1} + \frac{\left(\sum x_2\right)^2}{n_2} + \cdots \right] \tag{5}$$

The total groups sum of squares (SSt). Because SSb + SSw = SSt

$$\mathrm{SSt} = \sum_{i=1}^{k} \sum_{j=1}^{n} x^2 - \frac{\left(\sum_{i=1}^{k} \sum_{j=1}^{n} x\right)^2}{N} \tag{6}$$

(Kuzma & Bohnenblust, 2004: pp. 179, 180) "Any two of the three formulas above will allow one to complete the necessary calculations" (**Table 1**).

8.5. Levene's Test

Gastwirth et al. (2010) contribute that before comparing the sample means by using the multiple comparison tests, one should check that the underlying populations have a common variance.

Marques de Sá (2007: p. 131) thinks that a problem with the (F) test is that it is rather sensitive to the assumption of normality. A less sensitive test to the normality assumption (a more robust test) is Levene's test, which uses deviations from

Table 1. One-way (ANOVA).

One-way ANOVA				
Source of variation	**Sum of Squares (SS)**	**Degrees of freedom (df)**	**Mean Square (MS)**	**F-statistic**
Between Groups	SSb	$(k-1)$	$\text{MSb} = \dfrac{\text{SSb}}{K-1}$	$\dfrac{\text{MSb}}{\text{MSw}}$
Within Groups	SSw	$(N-k)$	$\text{MSw} = \dfrac{\text{SSw}}{N-k}$	
Total	SSt	$(N-1)$	–	

Source: Ostertagová & Ostertag, 2013.

the sample means. The Levene's test does not assume that all populations are normally distributed and is recommended when the normality assumption is not viable.

The widely used hypothesis for the test of equal variances, when, for example, there are two groups, is

$$H_0 : \sigma_1^2 = \sigma_2^2$$

$$H_1 : \sigma_1^2 \neq \sigma_2^2$$

Nordstokke and Zumbo (2010) believe that wherein, a two-tailed test of the null hypothesis (H_0) that the variances are equal against the alternative hypothesis (H_1) that the variances are not equal is performed.

8.6. Multiple Comparisons

Midway et al. (2020) believe that the lack of specifically being able to compare group means with ANOVA has long been known and a sub-field of multiple comparisons tests began to develop by the middle of the 20th century.

Ostertagová & Ostertag (2013) say that Post hoc comparisons (or post hoc tests, multiple comparison tests) are tests of the statistical significance of differences between group means calculated after ("post") having done ANOVA that shows an overall difference. Multiple comparison methods are designed to investigate differences between specific pairs of means. This provides the information that is of most use to the researcher.

Sawyer (2009) argues that if an ANOVA does not yield statistical significance on any main effects or interactions, the null hypothesis (hypotheses) is (are) accepted, meaning that the different levels of independent variables did not have any differential effects on the dependent variable. When statistical significance is obtained in an ANOVA, additional statistical tests are necessary to determine which of the group means differ from each other. These follow-up tests are referred to as multiple comparison procedures or post hoc tests.

Multiple comparison involves multiple pairwise comparisons in a fashion designed to maintain alpha for the family of comparisons to a specified level, typically 0.05.

Consider (k) independent random variables that have normal distribution with unknown means $\mu_1 = \mu_2 = \cdots = \mu_k$, respectively, and with unknown but common variance σ^2.

9. Applied Study

For the purpose of the study, data were collected and analyzed (see **Appendix—**data). In their data analysis, the researchers used the following statistical tests:

- Tests of normality were conducted through Kolmogorov-Smirnov and Shapiro-Wilk. These tests were done to see the dependency of the normal distribution.
- The researchers also used the One-Way ANOVA, test as one of the parametric tests, to confirm the difference between the averages of the three patterns of learning (traditional, distant and blended).
- The study also utilized the Levene test for the homogeneity of the variance.
- Multiple Comparisons tests were used to see where differences between means exactly lie. (The comparison for each pair is used to compare two averages.)

From Table 2:

Firstly, the two groups, Traditional and distant learning, are based on the Kolmogorov-Smirnova test, because the sample size in each is greater than 50.

Following are the results of the two patterns:

- Traditional learning: It is found that the sig value equal is 0.200 it is greater than 0.05, which means that the data follows a normal distribution.
- Distance learning: It is found that the sig value equal is 0.200 it is greater than 0.05, which means that the data follows a normal distribution.

Secondly, blended learning is based on the Shapiro-Wilk test, because the sample size is less than 50.

- Blended learning: It is found that the sig value equals 0.109 which is greater than 0.05. This means that the data follow a normal distribution.

Because the data for three groups follow a normal distribution, researchers can use parametric tests to analyze the data.

Table 2. Data normality test.

Tests of Normality						
Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Traditional learning	0.091	57	0.200*	0.972	57	0.208
Distant learning	0.096	61	0.200*	0.962	61	0.053
Blended learning	0.102	40	0.200*	0.955	40	0.109

The Shapiro-Wilk test is commonly used to test for normality for group sample sizes (N) less than 50, Kolmogorov-Smirnov is useful for larger samplings ($N > 50$). Sawyer (2009). *This is a lower bound of the true significance. [a]Lilliefors Significance Correction Source: Table 2 above was prepared by researches based on the results of analysis of the SPSS program.

Table 3 shows the descriptive statistics of the academic achievement. It is described as follows:

- Traditional learning: A sample size of 57 students with mean of 68.7719, standard deviation 18.672 and standard error of mean of 2.47317.
- Distant learning: A sample size of 61 students with mean of 85.5246, standard deviation 7.37249 and standard error of mean of 0.94395.
- Blended learning: sample size of 40 students with mean 81.75, standard deviation 9.73956 and standard error of mean 1.19311.
- The total size of the three samples equals 158, with a mean of 78.5253, standard deviation 14.99711 and standard error of mean of 1.03993.

Figure 1 shows the means of the three learning patterns. It is noted that the mean of the traditional learning is less than 70, and the mean of the distant learning and blended learning are greater than 80.

From Table 4, it is found that the value of (F) equals 25.829 with a level of significance of 0.000, and a value of less than 0.05. This means that there are statistically significant differences between of the three learning patterns of the academic achievements for university students. In order to know where these differences exist. One should know the homogeneity of the variance (Table 5 shows homogeneity of variances).

From Table 5, the Levene Statistic value is equal to 20.366 with a significant level of 0.000 and a value of less than 0.05. This means that the heterogeneity of the variance for the three learning patterns (traditional, distant and blended). Welch's ANOVA test is used instead, because Welch's test is a good approach for performing an ANOVA analysis (see Table 6).

Table 3. Descriptive statistics.

	N	Mean	Std. Deviation	Std. Error
Traditional learning	57	68.7719	18.67200	2.47317
Distant learning	61	85.5246	7.37249	0.94395
Blended learning	40	81.7500	9.73956	1.53996
Total	158	78.5253	14.99711	1.19311

Source: Table 3 above was prepared by researches based on the results of analysis of the SPSS program.

Table 4. Differences between groups by using one-way (ANOVA).

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8826.651	2	4413.325		
Within Groups	26484.748	155	170.869	25.829	0.000
Total	35311.399	157			

Source: Table 4 above was prepared by researches based on the results of analysis of the SPSS program.

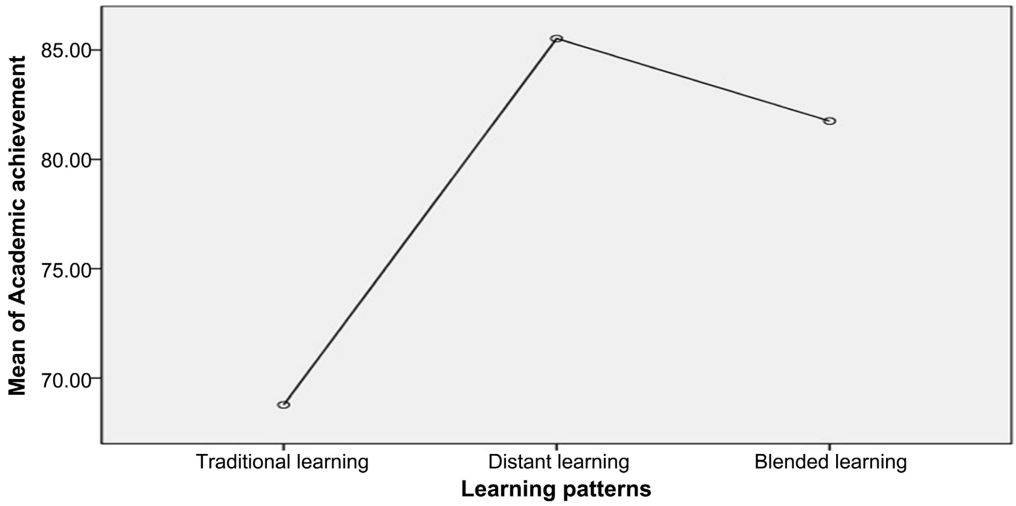

Figure 1. Shows means groups. Source: This diagram was prepared by researches based on the results of analysis of the SPSS program.

Table 5. Homogeneity of variances by using Levene's test.

Test of Homogeneity of Variances			
Levene Statistic	**df_1**	**df_2**	**Sig.**
20.366	2	155	0.000

Source: Table 5 above was prepared by researches based on the results of analysis of the SPSS program.

Table 6. Welch's ANOVA test.

Robust Tests of Equality of Means				
Academic achievement				
	Statistica	df_1	df_2	Sig.
Welch	20.296	2	85.748	0.000

[a]Asymptotically F distributed. Source: Table 6 above was prepared by researches based on the results of analysis of the SPSS program.

Welch's is test used when variances are unequal, and when the homogeneity of variances assumption is not met, especially with unequal sample sizes. Welch's test is a good approach for performing an ANOVA analysis. (Real statistic using excel).

Table 6 shows the (statistic = 20.296, 2, 85.748). The significance value = 0.000 is less than 0.05, that is confirmed in Table 3 which are statistically significant differences between the three learning patterns of the academic achievements for university students. The study used the multiple comparisons tests which do not assume equal variances. Tamhane's test was conducted to find out the differences between three pairs (traditional and distant learning), (traditional and blended learning), (distant and blended learning) (see Table 7).

Table 7. Multiple comparisons by Tamhane test.

Multiple Comparisons					
Dependent Variable: Academic achievement					
	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
Tamhane	Traditional learning	Distant learning	−16.75266-*	2.64719	0.000
		Blended learning	−12.97807-*	2.91342	0.000
	Distant learning	Traditional learning	16.75266*	2.64719	0.000
		Blended learning	3.77459	1.80624	0.116
	Blended learning	Traditional learning	12.97807*	2.91342	0.000
		Distant learning	−3.77459-	1.80624	0.116

*The mean difference is significant at the 0.05 level. Source: Table 7 above was prepared by researches based on the results of analysis of the SPSS program.

Below are the results of the Tamhane's multiple comparisons test (Table 7) which explains the differences between three pairs: The results show that:

- There are differences between the means of the two patterns of learning (traditional and distant) because its Sig value = 0.000 which is less than 0.05.
- There are differences between the means of the two patterns of learning (traditional and blended) because its Sig value = 0.000 which is less than 0.05.
- There are no differences between the means of the two patterns of learning (distant and blended) because its Sig value = 0.116 which is greater than 0.05.

10. Results

After analyzing the data, the researchers reached the following results:

1) Study data for the three learning patterns follow a normal distribution.

2) There are statistically significant differences between the three learning patterns.

3) There is heterogeneity of the variance for the three learning patterns.

4) There are differences between the means of academic achievement of traditional and distant learning, and also differences between the means of academic achievement of traditional and blended learning, but there are no differences between the means of academic achievement of distant and blended learning.

Recommendations

The study recommended the application of distant or blended learning patterns in university learning because the average academic achievement of the students in these two patterns of learning was greater than that of the traditional learning pattern.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Data:

Traditional Learning		Distant Learning		Blended Learning	
18	65	97	97	96	80
70	60	87	92	82	91
90	100	90	80	70	90
76	47	85	85	87	86
82	49	86	92	87	95
77	60	86	75	75	76
97	95	90	82	71	61
73	65	80	90	66	95
51	85	86	75	82	81
71	60	90	95	71	86
51	87	95	65	85	71
85	70	82	97	82	61
85	41	67	80	91	76
43	90	95	95	91	95
67	70	80	87	96	76
60	41	87	85	90	81
45	66	80	87	81	75
100	65	82	87	92	91
70	60	80	82	81	76
91	72	77	86	66	85
100	54	70	86		
66	100	95	87		
86	60	81	76		
37	42	85	87		
60	46	81	96		
71	70	86	90		
98	81	90	76		
72	62	91	81		
65		95	82		
		98	87		
		81			