The ANOVA Technique in Higher Education Institutions: Teachers Performance Evaluation

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Abstract: *Higher education institutions in the world seek in light of the intense competition and the challenges it faces, to upgrade their academic services to be prestigious universities. Since the university teacher is the focus in the educational institution, therefore, there is increasing interest to the tasks his carries. Thus, the main objective of this study is to use ANOVA technique,it is one of the statistical tools that are used in measuring and analyzing. It was employed in this study to measure the performance levels of the teachers of the Engineering Technical College - Basra for four departments using the manual method as well as the use of the Excel program. The study concluded that there is a discrepancy in the teaching performance of the college and the four departments. Use of the Tukey HSD equation, the department with the lowest performance evaluations of the teachers was identified.*

Keywords: ANOVA, Higher Education, Teachers, Performance Evaluation, Variance, One-Way variance analysis

1. Introduction

Improving the performance of universities is a global concern and quality is the choice, as quality in higher education is considered one of the most important means by which universities compete and demonstrate its strength and distinction. Because of the clear answers provided to the university's vision and the goals it seeks to achieve. As well as the means it provides to improve the level of university performance and how the local university becomes the level of international universities. And because it provides criteria for measuring the success of the university through evaluation systems that are tools for measuring productivity (Naqib & Ismail, 2020).

The importance of teacher's performance evaluation stems from the importance of the teacher, as it is considered one of the pillars of the teaching process. The performance evaluation aims to identify the general competence of teachers as well as to identify aspects of development in performance.

Through the use of ANOVA technique, college deans can check whether there are any statistically significant differences between the department's teachers. And also allow them to sort data into denominations and see whether this sorting illustrates some variation in the sample data as well as the ability to test important relationships between sample data that fall into various denominations makes the ANOVA technique a robust tool in the decision-making process.

2. Research Methodology

The research problem, the importance and objectives of the research, and the research hypotheses, as well as the method used in the research, all represent the research methodology.

First: The research problem

To find out the problem of the study, we ask the following questions:

1) Can ANOVA analysis of variance method be applied in the college under study?
2) Can the use of ANOVA analysis of variance method help in finding appropriate solutions by determining the size of the variance in teachers' performance levels?
3) How can the college use the ANOVA analysis of variance method to reduce the size of the variance in the performance of teachers?

Second: The importance of research

This research derives its importance from the following:

1) The current research sheds light on an important aspect in universities, which is the focus of the educational process, which is the level of teaching performance within its college.
2) The lack of research that dealt with the variables of the study, especially the performance of teachers.
3) The value of the research stems from the importance of the statistical tool ANOVA, and how it is used to improve the performance of teachers and thus improve the performance of colleges.

Third: Research Objectives

The research seeks to achieve the following objectives:

1) Using the ANOVA method to measure and analyze the variance in the performance levels of teachers using the Excel program.
2) The other objective is to try to determine whether there is a statistically significant difference between the groups. If there are differences, we will need to determine where these differences are located within the groups and find out their causes.
3) Use the F-test to test hypotheses.

Fourth: Research hypotheses

Ho: The mean results of the evaluation of the performance of the teachers and the four departments are equal.

H1: The mean results of the evaluation of the performance of the teachers and the four departments are not equal.

3. Literature Review

Performance Evaluation

Performance evaluation prepares regular reports of employee performance within corporations. It is a repeated systematic process for assessing employee performance and productivity by reference to pre-established criterions and organizational goals and use feedback about people's performance to recognize them for correct or motivate them performance. Performance evaluation is very important to most employees. It is a gauge process, it is a practice in controlling and ruling,(www.iedunote.com).It is a systematic way to examine how well an employee is performing in them job. The word systematic means the performance evaluation process should be a planned system that allows feedback to be given in a formal as opposed to informal (www.saylordotorg.github.io).

This process can be used for both developmental and administrative purposes. The research on performance evaluation includes examination of the psychometric aspects of the appraisal tools, the cognitive process and the biases involved, and the social context. Although performance evaluation is an important tool for managing employees, managers, and workers are rarely satisfied with it. Therefore, clearly defining the purposes of the performance evaluation and addressing the employees' reactions are necessary to the success of the performance evaluation (Dijk, et.al, 2015).The primary goals of a performance evaluation are to provide an equitable measurement of an employees, obtained right evaluation documentation to protect both the employee and employer. And obtain a high level of quality and quantity in the work produced. To establish a performance evaluation system, follow steps it below (www.aafp.org):

1) Place the evaluation form.
2) Determine the metrics that are used to measure performance.
3) Determine the guidelines for feedback.
4) Developing procedures to correct the course of the process.
5) Create an evaluation schedule.

The performance evaluation process begins with the definition of appropriate performance criteria. Should be based this criteria on professional teaching standards and should be advanced enough to evaluation teaching quality across the continuous of development, from beginner to expert teacher (www.aft.org). And then to measure the actual performance and compare it with the predetermined criteria. Then corrective actions are taken, these criteria focus
on two main aspects(Al-Qudah & Al-Momani, 2011: p 257):
- Objectively: it displays at the primary components, required of the character of work, consisting of manufacturing process.
- Self-discovery: or behavioral traits of an individual's personal.

ANOVA Technique

Analysis of variance (ANOVA) is a statistical technique used to detect differences between experimental group averages. It is a statistical test for detecting differences in group means when there is one parametric dependent variable and one or more independent variables (Sawyer & Steven, 2009). The ANOVA technique is a set of manners used in analysing statistical data, data that depends on several factors with simultaneous influences, in order to determine the most significant ones and to evaluation their influences (DURA, et. al, 2006).

The analysis of variance is one of the significant statistical techniques that are interested with the process of studying the relevance between a dependent variable with another variable, or several independent variables. Which is usually descriptive and does not interest in determining the type of relevance between dependent variables and independent variables, and there are varied types of analysis of variance, including analysis of variance with one factor and analysis of variance with two factors and analysis of variance of repeated data. In this paper the first type of analysis was used which is the ANOVA of One Variance Analysis - One-Way.

One-Way Variance Analysis (One Level)

To find out if there are any significant differences between the means of two or more independent groups, one-way analysis of variance (ANOVA) is performed. It's also critical to understand that the one-way ANOVA is a multiple usage test statistic and cannot tell us which particular groups were statistically significantly different from one another; it can only confirm that at least two groups were distinct. In our study, there could be three, four, five, or more groups; it's critical to identify how these groups differ from one another. But before employing it, three things must be accomplished (www.jmasi.com):

1) Samples are independent and random.
2) Each of these samples' societies has a normal distribution.
3) The communities that made up the random sample were equally diverse.

Applying Anova Technique in Educational Services

The current era is witnessing rapid developments, whether at the level of manufacturing or educational organizations. In addition to the revolution of information and communications technology and its impact on the educational process and the consequent increase in global competition among educational institutions. Because of the active and distinguished role these institutions play in serving societies, this paper has dealt with a fundamental pillar in the educational process of these institutions, which is the teachers. As the program for evaluating the performance of teachers approved in the educational institutions affiliated with the Iraqi Ministry of Higher Education and Scientific Research is a correct step for mapping the road map in the educational institution's policy.

The performance of teachers is a significant indicator on which many significant decisions are made since it impacts the course of the institution's activities, whether in a favorable or bad way. It establishes how close or far the institution is to accomplishing the goals and putting the plans into action, and in doing so, indicates how successful or unsuccessful the institution is. For this purpose, monitoring teacher performance creates close integration between the effective and analytical environment, information technology, and the integration of daily strategies and operations.

Because of the importance of evaluating the performance of the teachers, the Technical Engineering College in Basra, one of the set of the Southern Technical University. Was keen to possess and qualify scientific cadres that possess a variety of capabilities, due to its great role in achieving international quality standards for colleges, and this aspect paid great attention at all levels.

The process of evaluating the performance of teachers in Iraqi universities is carried out according to the performance standards approved in international universities. Through the Internet, an electronic form is to be filled out after granting the user name and password to the concerned authority to conduct the evaluation in the university colleges and institutes. The direct officer evaluates the faculty, such as (department head, associate dean, dean, etc.) under the supervision of the college dean.

The performance of teachers from the scientific titles campaign (assistant teacher, teacher, assistant professor, professor) is evaluated for one academic year or for one semester (fifteen weeks). Whereby the faculty provides the department with the required data from him in the evaluation form, and the evaluation process is carried out by Head of the department after checking the data provided by the teachers and inserting it into the electronic form.

The electronic performance evaluation form consists of a set of axes that includes the axis of administrative and leadership capabilities. And the second is related to the teaching aspect. An axis related to scientific and research activity, another axis that relates to personal skills and areas of investment, an axis related to the educational aspect. Another axis that shows strengths, and finally an axis that shows weaknesses through the statement of penalties addressed to the teaching during the evaluation period. Each axis contains a set of data and questions. The grades are distributed to questions according to the weight of each axis. The scores are collected at the end of each axis so that the final evaluation scores are calculated after collecting all the scores and knowing the final evaluation of the teacher.

The teachers evaluation was obtained from the Quality Assurance and Performance Evaluation Division of Technical Engineering College in Basra, to use this data in measure and analyze the variance in the performance of teacher levels, by use ANOVA technique. Data that was used for 6 samples and for 4 departments, as shown in Table (1). Through this data we will test the following hypotheses:
Ho: The mean results of the evaluation of the performance of the teachers and the four departments are equal.
H1: The mean results of the evaluation of the performance of the teachers and the four departments are not equal.

Table 1: Teachers Performance Evaluation for the academic year 2020/2021

Sample	College departments			
	Thermal Mechanics	Electric Power	Chemical and Petrochemical	Environment and Pollution
1	81	77	87	70
2	82	56	82	73
3	83	76	85	86
4	83	75	85	98
5	82	70	83	77
6	75	68	84	73
Sum	486	422	506	477
Mean (μ)	81	70.33333	84.3	79.5
Total Main of Samples (Tμ)=$\sum\mu$/ K		314.8333/4		78.79
Sample Size (n)				6
Groups Number (K)				4
Sample Size (N)				24

Source: Preparing the researcher based on the data of the College

From the above table, which shows the assessments of 24 teaching staff (sample) for four departments, it can explain the following:
- All the values recorded in the table, are not the same and therefore there is a variance in all the values of 24 samples, and this is called the total variance (TV).
- The assessments are not the same in the departments, and therefore there is a variation within the assessments of each section. This variation is called a variation within the group (WGV).

- The mean for the four divisions is not equal, so there is a clear variance between the divisions. This variance is called the variance between groups (BGV).

Beginning, an ANOVA technique is used to find whether there are differences overall in the mean teachers performance evaluation for each of the department (Mouritsen, et. al, 2016).To find the variance manually according to the following equations (Panneerselvam & Sivasankaran, 2014):

Total Variance (TV) = Within Group Variation (WGV) +Between Groups Variation (BGV)

The Total Variance (TV) equation came from the following equation:

$$TV = \sum_{i=1}^{k} \sum_{j=1}^{n} (Xij - T\mu)^2$$

Likewise, two other equations can be obtained for Within Group Variation (WGV) and Between Groups Variation (BGV)

$$WGV = \sum_{i=1}^{k} \sum_{j=1}^{n} (Xij - \mu i)^2$$
$$BGV = \sum_{i=1}^{k} (\mu i - T\mu)^2$$

We use Table (1) data in these equations to find the variance manually as shown below:

$TV = (81-78.79)^2 + (82-78.79)^2 + (83-78.79)^2 + (83-78.79)^2 + (82-78.79)^2 + (75-78.79)^2 + (77-78.79)^2 + (56-78.79)^2 + (76-78.79)^2 + (75-78.79)^2 + (70-78.79)^2 + (68-78.79)^2 + (87-78.79)^2 + (82-78.79)^2 + (85-78.79)^2 + (85-78.79)^2 + (83-78.79)^2 + (84-78.79)^2 + (70-78.79)^2 + (73-78.79)^2 + (86-78.79)^2 + (98-78.79)^2 + (77-78.79)^2 + (73-78.79)^2$
$=1581.958$

$BGV = n\sum_{i=1}^{k} (\mu i - T\mu)^2$
$= 6 [(81 - 78.79)^2 + (70.333 - 78.79)^2 + (84.3 - 78.79)^2 + (79.5 - 78.79)^2]$
$= 645.7917$

$WGV = TV - BGV$
$= 1605.96 - 215.125 = 936.1667$

To test the hypotheses of this paper, and to see if there is any difference between the average deviations of values within the data recorded for each department, which can be used as a basis for decision-making. First it will be manually tested using Table (2) equations:

Table 2: Steps to find F Calculated

Source of Variance	Sum of squares (SS)	df	Mean squares (MS)	F Calculated	F Tabulated (Sig.)
Between Groups	$SS_B = n \sum_{i=1}^{k} (\mu i - T\mu)^2$	K – 1	S_B^2	S_B^2/S_W^2	$F_{\alpha (K-1), (N-K)}$
Within Groups (Error)	$SS_W = TV - BGV$	N – K	S_W^2		
Total	$SS_T = \sum_{i=1}^{k} \sum_{j=1}^{n} (Xij - T\mu)^2$	N – 1			

Source: www.jmasi.com

Null Hypothesis
Ho: The mean results of the teachers performance evaluation and the four departments are equal.
$$H_o: \mu 1 = \mu 2 = \mu 3 = \mu 4$$

If it finds that it is correct, then the alternative hypothesis **(H1)** will be rejected.

Alternative Hypothesis
H1: The mean results of the teacher's performance evaluation and the four departments are not equal.

$$H1: \mu 1 \neq \mu 2 \neq \mu 3 \neq \mu 4$$

To test the null hypothesis, all means are equal, as shown below:

$$H_o: \mu 1 = \mu 2 = \mu 3 = \mu 4$$

Two important parameters are calculated by the ANOVA variance analysis method, which is the value of F Calculated (F_{Calcu}) or F,and the value of F Criticalor Tabulated (F_{Tabul}). If the value of (F_{Calcu}) is greater than the value of (F_{Tabul}), then the null hypothesis will be rejected and vice versa, it will be accepted for that then the rule of decision is:

If $F_{Calcu} > F_{Tabul}$ reject Ho otherwise accept H1
$MS_B = BGV/K-1 = 645.7917/4-1 = 215.2639$
$MS_W = WGV/N-K = 936.1667/24-4 = 46.80833$
$F = MS_B / MS_W = 215.2639/46.80833 = 4.598837$

Table 3: Result of F Calculated

Source of Variance	Sum of squares (SS)	df	Mean squares (MS)	F Calculated	F Tabulated (Sig.)
Between Groups	645.7917	3	215.2639	4.598837	3.098391
Within Groups (Error)	936.1667	20	46.80833		
Total	1581.958	23			

Source: Preparing the researcher based on Table (2)equations.

From the table above, we conclude the following:
Value of F Calculated(F_{Calcu}) = 4.598837
Value of FTabulated (F_{Tabul}) = 3.098391

Value of F Calculated (F_{Calcu}) **greater than** Value of FTabulated (F_{Tabul}) Therefore, the null hypothesis is rejected at the significance level of $\alpha = 0.05$ and the alternative hypothesis is accepted that the mean results of the teacher's performance evaluation and the four departments are not equal. Because there are statistically significant differences between group means, it is necessary to know the cause of

these variances by Post Hoc Test. Use test of Tukey HSD (Honestly Significant Difference test. Which it is used if the sample size is equal in groups:

Formula Tukey HSD:
$HSD_\alpha = q_\alpha$

$$\sqrt{MS_W/n} = 3.958 \sqrt{46.8/6} = 11$$

$q_\alpha = 3.96$ Tukeytabulated value corresponding to the 0.05 level of significance which comes through the intersection of

the column that equals the number of groups (K=4) with the row that equals the (df=20).

To find the groups that caused the differences, we subtract the means from some, then we compare the absolute value of the result with the HSD_α value. If the value of the difference between the means is less than the value of HSD_α, this indicates that there are no differences. If the value of the difference between the means is greater than the value of HSD_α, this indicates that there are differences between the means and the difference is due to the lowest mean as shown below:

Table 4: Result of Difference between the Means Departments

No.	Difference between Means		Result of Difference (Absolute)	Value of HSD_α	Decision
	Department	Means Differences			
1.	Thermal Mechanics – Electric Power	(81-70.333)	10.66		No Difference
2.	Thermal Mechanics – Chemical and Petrochemical	(81-84.33)	3.333		No Difference
3.	Thermal Mechanics – Environment and Pollution	(81-79.5)	1.5		No Difference
4.	Electric Power - Chemical and Petrochemical	(70.33-84.33)	14	11	**Difference**
5.	Electric Power - Environment and Pollution	(70.333-79.5)	9.167		No Difference
6.	Chemical and Petrochemical - Environment and Pollution	(84.333-79.5)	4.833		No Difference

Source: Preparing the researcher.

From the above table, we notice the biggest difference between the means of the ElectricPower and Chemical and Petrochemical department. This difference was due to the ElectricPower department that had the lowest means.

Using the Excel program and through the data analysis function we find the variances, F Calculated Value and F Tabulated Value as shown in the solution steps in the table below:

	A	B	C	D	E	F	G
1	A	B	C	D	E	F	G
2		Using ANOVA to check out the TeachersPerformance Levels					
3		Teachers Performance Evaluation for the academic year 2018/2019					
4			College departments				
5		Sample	Thermal Mechanics	Electric Power	Chemical and Petrochemical	Environment and Pollution	
6		1	81	77	87	70	
7		2	82	56	82	73	
8		3	83	76	85	86	
9		4	83	75	85	98	
10		5	82	70	83	77	
11		6	75	68	84	73	
12		Sum	486	422	506	477	
13		Mean (μ)	81	70.33333	84.3	79.5	
14		Total Main of Samples (Tμ)=$\sum\mu$ / K			314.8333/4	78.79	
15		Sample Size (n)				6	
16		Groups Number (K)				4	
17		Sample Size (N)				24	
18	[1] Click the Tools menue and then Data_Analysis to activate the Analysis ToolPak						
19	[2] Choose the "Anova: Single Factor" opition and fill in the dialog box as follows:-						
20							

		INPUT	Input Range: Highlight (or enter) the range C6:F11
21			
22			Grouped by: Columns
23			Labels in First Row: Click OK with mouse
24			

		OUTPUT	Output Range: Click OK with mouse.
25			
26			Enter a suitable output cell, e.g A27

27	Anova: Single Factor						
28	SUMMARY						
29	Groups	Count	Sum	Average	Variance		
30	Column 1	6	486	81	9.2		
31	Column 2	6	422	70.33333333	61.86666667		
32	Column 3	6	506	84.33333333	3.066666667		
33	Column 4	6	477	79.5	113.1		
34							
35	ANOVA						
36	Source of Variation	SS	df	MS	F	P-value	F crit
37	Between Groups	645.7917	3	215.2638889	4.598836864	0.013229873	3.098391
38	Within Groups	936.1667	20	46.80833333			
39	Total	1581.958	23				
40							
41							

Figure (1) Results of the analysis of variance of the Teachers Performance Level
Source: Preparing the researcher based on data of the College and the Excel program

4. Conclusion

ANOVA technique is a useful statistical tool that is concerned with analyzing variance and identifying sources of difference between means, and is not concerned with determining the type of relationship between dependent and independent variables. In this paper, through the ANOVA technique, with two methods are manual and using the Excel program there was a clear variance in the performance of the teachers for the four departments. The Value of F_{Calcu} greater than Value of F_{Tabul} Therefore, the null hypothesis is rejected (The means of the four department are equal),at the significance level of $\alpha = 0.05$ and the alternative hypothesis is accepted that the mean results of the teachers performance evaluation and the four departments are not equal. By use test of Tukey HSD (Honestly Significant Difference test),we know the cause of these variances Electric Power department that had the lowest means.

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