European Journal of Statistics and Probability, 13 (1) 29-40, 2025
Print ISSN: 2055-0154(Print)
Online ISSN 2055-0162(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Generalization of the Fixed Effects Model with Interaction on Multivariate and their Application

Abu Elgasim Abbas Abow Mohammed[12]

1. Department of Management Information System –Business and Economic College - Qassim University-Saudi Arabia
2. Department of Statistics-College of Economic and Political Sciences- Omdurman Islamic University-Sudan

E-mail: AA.Mohammed@qu.edu.sa

doi: https://doi.org/10.37745/ejsp.2013/vol13n12940 Published June 25, 2025

Citation: Mohammed AEAA (2025) Generalization of the Fixed Effects Model with Interaction on Multivariate and their Application, *European Journal of Statistics and Probability*, 13 (1) 29-40

Abstract: *This study applied a multivariate analysis model to investigate specifically the effect of grades and gender as independent variables on the overall rate and student rate of academic performance among 512 students at Qassim University. The Multivariate Analysis of Variance (MANOVA) was used to estimate the variances and determine if there were differences between groups, as well as to determine the effect of each of these independent variables on the dependent variables, in addition to determining the effect of the joint interaction between grades and gender on the overall rate and student rate. The results revealed that female students had higher average rates than male students, and that male students' grades were more dispersed. Notably, grades significantly impacted academic performance, while gender had no effect. The study recommends using multivariate models in educational research and suggests further studies with additional variables to enhance educational outcomes.*

Keyword: investigate, effect, application, Generalization, MANOVA

INTRODUCTION

Most of the time we seek to study multivariate phenomena to know the relationships between them and sometimes for the purpose of prediction in different fields of science. There are different types of methods, dependence method that depending on the nature and the number of variables, there are several techniques that can analyze structures like multiple regression and discriminant analysis, and logit analysis, and multivariate analysis of variance, canonical correlation analysis ,and the other independence method this depend on the nature of data input if the variables have at least interval scale properties that techniques are principal components analysis ,and factor analysis, metric multidimensional scaling, cluster analysis. The main purpose of this paper is describe many variable into sets on the basis of a sample. The study aims to describe variables by extending univariate concepts to a multivariate model, identifying significant differences between population means, developing a multivariate model, and assessing its statistical significance. More specifically, this study provide an analysis of educational variables, examine the relationships between them, and the impact of some on others, where they seek to determine the effect of grade and gender variables on the variables of overall rate and student rate.

Problem formulation
The need to understand the relationships between many variables makes multivariate analysis an inherently difficult subject. Often, the human mind is whelmed by the sheer bulk of the data. Additionally, more mathematics is require to derive multivariate statistical techniques for making inferences than in univariate setting.

Multivariate analysis is a mixed bag, it is difficult to establish a classification scheme for multivariate techniques that is both widely accepted and indicates the appropriateness of the techniques. The axes of the study problem related to multivariate can be put in a form similar to univariate. The main question is: What is the possibility of applying multivariate analysis methods? Which include reduction and classification data, investigation of relationships between variables, hypothesis-testing construction. The study aims to answer the following questions:

1. How applicable is multivariate analysis in the educational field?
2. What is the effect of grades and gender on the overall rate and student rate?.

LITERATURE REVIEW

Much of literature review of multivariate across different fields. A multivariate model for predicting financially distressed P-L insurers Trieschmann[1]. Multivariate analysis with application in education and psychologyTimm[2]. Graphical techniques for multivariate data Everitt [3]. Multivariate of impact of gender and college major on student levels of environment concern and knowledge Goodale [4]. Browse relationship between job tenure and injury risk and evaluate how the effects of experience and job tenure are modified by age Bena etal[5].

Significance of the Study
1. Contributing to understanding relationships between different variables in the educational environment.
2. Providing valuable information for teachers and researchers on the impact of grades and gender on student performance.

3. Supporting decision-making in education by presenting accurate and reliable results.
4. Enhancing education quality: by identifying factors that affect student performance.

Study Hypotheses

1. First Hypothesis: There are no statistically significant differences in the overall rate among students with different grades.
2. Second Hypothesis: There is no significant effect of gender (male or female) on the student rate.
3. Third Hypothesis: There is no interaction between grades and gender on the overall rate

METHODOLOGY

This study employs a descriptive statistical method to collect, organize, and describe multiple variables using descriptive statistics, and an analytical statistical method to analyze the study data using a multivariate analysis model.

Theoretical formulation

We Star this section by the organization of data, and descriptive statistic to describe the data of study, after that we provide inferences about multivariate.

a) Organization of data

The multivariate method uses the notation x_{ij} to indicate the particular value of kth variable that is observed on the jth item, that we can display the data as a rectangular array, called X with n rows and p columns Daniel Denis[6]. :

$$Z = \begin{bmatrix} X_{11} & X_{12} & & X_{1k} & & X_{1p} \\ X_{21} & X_{22} & \vdots & X_{2k} & \vdots & X_{2p} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ X_{j1} & X_{j2} & \vdots & X_{jk} & \vdots & X_{jp} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ X_{n1} & X_{n2} & & X_{nk} & & X_{np} \end{bmatrix} \ldots (1)$$

The array X, then, contains the data consisting of all observations on all of the variables.

b) Descriptive statistics

Let $X_{11}, X_{21}, \ldots, X_{nk}$ from the n measurements on each of the k variables, where will be k variables, the mean as follow

$$\bar{X}_k = \frac{1}{n}\sum_{j=1}^{n} X_{jk} \qquad k = 1, 2, \ldots . n \ldots (2)$$

And variance for p variables as the follow equation

$$S_k{}^2 = \frac{1}{n}\sum_{j=1}^{n}\left(X_{jk} - \bar{X}_k\right)^2 \ldots (3)$$

As the standard deviation is the square root of the variance as follow

$$\boldsymbol{S} = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(X_{jk} - \bar{X}_k\right)^2} \quad \ldots(4)$$

We use descriptive statistics in multivariate by computed means, and variances and covariance, and correlations from n measurements on p variables in equation as follow.

Sample means $$\bar{X} = \begin{bmatrix} \bar{X}_1 \\ \bar{X}_2 \\ \vdots \\ \bar{X}_p \end{bmatrix} \ldots.(5)$$

Sample variances and covariance $$S_n = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1p} \\ s_{21} & s_{22} & \cdots & s_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ s_{p1} & s_{p2} & \cdots & s_{pp} \end{bmatrix} \ldots(6)$$

Sample correlations $$R = \begin{bmatrix} 1 & r_{12} & \cdots & r_{1p} \\ r_{21} & 1 & \cdots & s_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ r_{p1} & r_{p2} & \cdots & 1 \end{bmatrix} \ldots(7)$$

Two-way factorial model

The assumption for a two way fixed effects analysis of variance are similar to these of the one way analysis of variance model, only now because we have cells in our design, these are groups about which we here to assumption when in volving the interaction.

Table1. ANOVA table For Effect of Two Factor and their Interaction

Source	Sum of Squares(ss)	df
Factor 1	$SS_{Fac1} = \sum_{e=1}^{g} bn(\bar{X}_{e.} - \bar{X})^2$	$g-1$
Factor 2	$SS_{Fac2} = \sum_{k=1}^{b} gn(\bar{X}_{.k} - \bar{X})^2$	$b-1$
Interaction	$SS_{int} = \sum_{e=1}^{g}\sum_{k=1}^{b} n(\bar{X}_{ek} - \bar{X}_{e\cdot} - \bar{X}_{\cdot k} - \bar{X})^2$	$(g-1)(b-1)$
Residual Error	$SS_{res} = \sum_{e=1}^{g}\sum_{k=1}^{b}\sum_{r=1}^{n}(X_{ekr} - \bar{X}_{ek})^2$	$gb(n-1)$
Total(corrected	$SS_{cor} = \sum_{e=1}^{g}\sum_{k=1}^{b}\sum_{r=1}^{n}(X_{ekr} - \bar{X})^2$	$gbn-1$

Comparing Multivariate Population Means (One –way MANOVA) with Univariate

The selection of MANOVA is based on the desire to analyze a dependence relationship represented the differences in a set of dependent measures across a series of groups formed by one or more categorical independent measures. As such, MANOVA represents a powerful analytical tool suitable to a wide array of research question, whether used in actual or quasi-experimental situation.MANOVA can provide insights in to not only the nature and predictive power of the independent measures but also the interrelationships and differences seen in the set of the dependent measures Harris R.J[7].

For more than two populations need to be The selection of MANOVA is based on the desire to analyze a dependence relationship represented the differences in a set of dependent measures across a series of groups formed by one or more categorical independent measures. As such,
e compared. Random samples, collected from each of g populations are arranged as

Population 1: $X_{11}, X_{12}, \dots, X_{1n_1}$
Population2: $X_{11}, X_{12}, \dots, X_{1n_1}$ $\quad\dots$ (8)
$\vdots \qquad\qquad \vdots$
Population g: $X_{g1}, X_{g2}, \dots, X_{1gn_1}$

MANOVA is used first to investigate whether the population mean vectors are the same and, if not, which mean components differ significantly. There is MANOVA model (Jonson& Wichern [8].

$$X_{ej} = \mu + T_e + e_{ej}\ ,\ j = 1, 2, \dots n_e \ and\ e = 1,2, \dots g \quad \dots \ (9)$$

Where the e_{ej} are independent $N_P\ (0, \Sigma)$ variables. H ere the parameter vector μ is an overall mean (level) , and T_e represents eth treatment effect with $\sum_{e=1}^{g} n_e T_e \ = 0$

According to the model in the (9) , each component of the observation vector X_{ej} satisfies the univariate model . The errors for the components of the X_{ej} are correlated, but the covariance matrix Σ is the same for all populations. A vector of observations may be decomposed as suggested by the model. Thus,

$$X_{ej} = \qquad \bar{X} + \qquad (\bar{X}_e - \bar{X}) + \left(X_{ej} - \bar{X}_e\right)$$

$$(observation) \begin{pmatrix} overall\ sample \\ \text{mean}\hat{\mu} \end{pmatrix} \begin{pmatrix} estimated \\ treatment \\ effec\ \hat{T} \end{pmatrix} \begin{pmatrix} residual \\ \widehat{e_{ej}} \end{pmatrix} \quad \dots (10)$$

Analogous to the univariate result the hypothesis of no treatment effects,

$$H_0 : T_1 = T_2 = \cdots T_g = 0$$

Is tested by considering the relative size of the treatment and residual sum of squares and cross products .Equivalently , we may consider the relative size of the residual and total (corrected) sum of squares and cross products. formally , we summarize the calculations leading to the test statistic in a MANOVA tabl

Table2. MANOVA table for comparing Population Mean Vectors

Source of variation	Matrix of sum square and cross products (SSP)	Degrees of freedom (d.f)
Treatment	$B = \sum_{e=1}^{g} n_e (\bar{X}_e - \bar{X})(\bar{X}_e - \bar{X})'$	$g - 1$
Residual (Error)	$W = \sum_{e=1}^{g}\sum_{j=1}^{n_e}(X_{ej} - \bar{X}_e)(X_{ej} - \bar{X}_e)'$	$\sum_{e=1}^{g} n_e - g$
Total (corrected for the mean	$B + W = \sum_{e=1}^{g}\sum_{j=1}^{n_e}(X_{ej} - \bar{X})(X_{ej} - \bar{X})'$	$\sum_{e=1}^{g} n_e - 1$

One test of $H_0: T_1 = T_2 = \cdots T_g = 0$ Involves generalized variances. We reject if the of involves generalized variances

$$A *= \frac{|W|}{|B+W|} = \frac{\left|\sum_{e=1}^{g}\sum_{j=1}^{n_e}(X_{ej}-\bar{X}_e)(X_{ej}-\bar{X}_e)'\right|}{\left|\sum_{e=1}^{g}\sum_{j=1}^{n_e}(X_{ej}-\bar{X})(X_{ej}-\bar{X})'\right|} \quad \ldots (11)$$

Is too small. The quantity $A *= \frac{|W|}{|B+W|}$ proposed by Wilks and distribution of $A *$ can be derived for the special cases listed in table below (3)

Table3. Table Distribution of Wilks' Lambda $A *= |W|/|B + W|$

No of variables	No of groups	Sampling distribution for multivariate normal data
$P = 1$	$g \geq 2$	$\left(\frac{\sum n_e - g}{g - 1}\right)\left(\frac{1 - A *}{A *}\right) \sim F_{g-1, \sum n_i - g}$
$P = 2$	$P \geq 2$	$\left(\frac{\sum n_e - g - 1}{g - 1}\right)\left(\frac{1 - \sqrt{A *}}{\sqrt{A *}}\right) \sim F_{2(g-1), 2(\sum n_i - g - 1)}$
$P \geq 1$	$g = 2$	$\left(\frac{\sum n_e - P - 1}{P}\right)\left(\frac{1 - A *}{A *}\right) \sim F_{P,, \sum n_i - P - 1}$
$P \geq 1$	$g = 3$	$\left(\frac{\sum n_e - P - 2}{P}\right)\left(\frac{1 - \sqrt{A *}}{\sqrt{A *}}\right) \sim F_{2P, 2(\sum n_i - P - 2)}$

Wilks' lambda is a test statistic used in multivariate analysis of variance (MANOVA) to test whether there are differences between the means of identied groups of subjects on a combination of dependent variables Everritt& Dunn [9].

European Journal of Statistics and Probability, 13 (1) 29-40, 2025
Print ISSN: 2055-0154(Print)
Online ISSN 2055-0162(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

A Wilks' lambda is a direct measure of the proportion of variance in the combination of dependent variables that is unaccounted for by the independent variable (the grouping variable or factor) Polit [10].

Variables definition

The study variables are categorized into:

a) dependent variables:

1- Student's grade estimations takes values from 1 to 9, where 1 represents the symbol F and 9 represents the symbol A+ its ordinal variable

2- Overall GPA (Grade Point Average) rate takes values from 0 to 4 and its ordinal variable.

b) independent variables

1- The grades these are the scores obtained by students in tests and exams take values from 0 to 100 and are a continuous quantitative variable.
2- The variable "gender" is categorized as male or female and is considered a nominal categorical variable

RESULTS AND DISCUSSION

In this section, multivariate analysis by taking a sample of 556 grades of preparatory year students from the Department of Management Information System College of Business and Economic. In order to reach conclusions about the multivariate, all the assumptions of multivariate analysis were verified, first, the sample size was large, and then the number of cases in each cell was greater than the number of dependent variables. Additionally, it was ensured that the data followed a normal distribution, and similarly, the data was cleaned by testing for extreme values, as well as verifying the assumptions of linearity and homogeneity of regression, then the multicollinearity and singularity. The study used student grade and gender as independent variables, while the Student's grade estimations and Overall (Grade Point Average) GPA were used as dependent variables. In addition, the Levine's test in Table 3 confirms compliance with the condition of equal variance

Table4. Descriptive Statistic

	grade of Student	Sex	Mean	Std. Deviation	N
	Overall	male	1.617	1.1893	304
		female	2.417	1.1643	252
		Total	1.979	1.2426	556
	Student's grade estimations	male	4.22	2.376	304
		female	5.83	2.329	252
		Total	4.95	2.486	556

Source: Prepared by the researcher from the results using SPSS

For look table 4 the male group, the mean Overall is 1.617and the standard deviation is 1.1893,

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.997	67986.780b	2.000	449.000	.000	.997
	Wilks' Lambda	.003	67986.780b	2.000	449.000	.000	.997
	Hotelling's Trace	302.836	67986.780b	2.000	449.000	.000	.997
	Roy's Largest Root	302.836	67986.780b	2.000	449.000	.000	.997
V (grades of students)	Pillai's Trace	1.235	12.325	118.000	900.000	.000	.618
	Wilks' Lambda	.006	90.710b	118.000	898.000	.000	.923
	Hotelling's Trace	125.618	476.921	118.000	896.000	.000	.984
	Roy's Largest Root	125.296	955.646c	59.000	450.000	.000	.992
S (gender)	Pillai's Trace	.010	2.183b	2.000	449.000	.114	.010
	Wilks' Lambda	.990	2.183b	2.000	449.000	.114	.010
	Hotelling's Trace	.010	2.183b	2.000	449.000	.114	.010
	Roy's Largest Root	.010	2.183b	2.000	449.000	.114	.010
V * S	Pillai's Trace	.327	1.956	90.000	900.000	.000	.164
	Wilks' Lambda	.693	2.007b	90.000	898.000	.000	.167
	Hotelling's Trace	.413	2.058	90.000	896.000	.000	.171
	Roy's Largest Root	.322	3.222c	45.000	450.000	.000	.244

which Indicates the amount of variation or dispersion in the Overall scores, the sample size (N) is 304, which is a relatively large sample, while the mean Overall for the group of female, the mean Overall is 2.417 and the standard deviation is 1.1643, the sample size (N) is 252, females have a higher mean Overall compared to males. Both males and females have similar standard deviations, indicating similar variability in Overall scores and both groups have relatively large sample sizes.
For the male group, the mean total is 4.22 and the standard deviation is 2.376
While the mean Student's grade for the group of female, the mean Student's grade is 5.83 and the standard deviation is 2.329. The mean Student's grade for females is higher than that of males, suggesting that females tend to have higher Student's grade. To test the significance of these differences, refer to Table 5 below

Table 5.Multivariate Tests
Source: Prepared by the researcher from the results using SPSS
For all (Pillai's Trace of the intercept and Wilks' Lambda and Hostelling's Trace and Roy's Largest Root)
The value of (sig =0.00 <0.05) indicates that the intercept is statistically significant Sogand etal, [11], the significant intercept ($p < 0.05$) suggests that the mean vectors of the dependent variables are significantly different from zero. In other words, the overall mean of the dependent variables is significantly different from zero. The results of the multivariate tests (Pillai's Trace, Wilks'

European Journal of Statistics and Probability, 13 (1) 29-40, 2025
Print ISSN: 2055-0154(Print)
Online ISSN 2055-0162(Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Lambda, Hotelling's Trace, Roy's Largest Root) indicate a highly significant statistical relationship (sig = 0.00) between the variable of grades as an independent variable and the dependent variables (overall and Student's grade), then the highly significant statistical relationship indicates that the variable of grades has a significant impact on the dependent variables, Koki &Shimizu[12]. This means that grades have a significant effect on both (the overall and Student's grade). The results suggest that the variable of grades explains a significant portion of the variation in the dependent variables. The Partial Eta Squared values indicate the proportion of variance in the dependent variables that is explained by the independent variable (grades of students) then (a value of 0.618 for Roy's Largest Root indicates that approximately 61.8% of the variance in the dependent variables is explained by the independent variable , a value of 0.992 for Hotelling's Trace indicates that approximately 99.2% of the variance in the dependent variables is explained by the independent variable, which suggests a very large effect , Wilks' Lambda= 0.984 and a value of 0.984 for Wilks' Lambda indicates that approximately 98.4% of the variance in the dependent variables is explained by the independent variable , and a value of 0.923 for Pillai's Trace indicates that approximately 92.3% of the variance in the dependent variables is explained by the independent variable . The values of the multivariate tests (Roy's Largest Root= Hotelling's Trace= Wilks' Lambda=Pillai's Trace =0,01) for the effect of the gender variable on the dependent variables are small values indicate that the gender variable has a small or non-significant effect on the dependent variable, then the gender variable explains a very small proportion of the variance in the dependent variables. The values of the multivariate tests (Pillai's Trace = 0.164 , Wilks' Lambda = 0.167 , Hotelling's Trace = 0.171, Roy's Largest Root = 0.244), for the interaction between student grades and gender are indicate that the interaction between student grades and gender has a weak effect on the dependent variables, then multivariate test values suggest that the interaction explains a small proportion of the variance in the dependent variable
Marozzi. M[13]

Table 6. Levene's Test of Equality of Error Variances

		Levene Statistic	df1	df2	Sig.
(Overall)	Based on Mean	6.321	89	450	.000
	Based on Median	1.163	89	450	.166
	Based on Median and with adjusted df	1.163	89	14.471	.393
	Based on trimmed mean	4.323	89	450	.000
(Student's grade estimations)	Based on Mean	4.131	89	450	.000
	Based on Median	.747	89	450	.954
	Based on Median and with adjusted df	.747	89	12.960	.793
	Based on trimmed mean	2.539	89	450	.000

Source: Prepared by the researcher from the results using SPSS

The Leven statistic, $P = 0.00$, based on the mean, and $P = 0.00$ Based on trimmed mean related to the Overall and Student's grade estimations the result indicates that the Levine's test for equality of variances is significant ($p < 0.05$), suggesting that the assumption of homogeneity of variances is violated. This means that the variances between the groups are not equal). Similarly, we found that the Leven statistic $P = 0.166$ based on median and $P = 0.393$ based median and with adjusted df related to the Overall, and Similarly Leven statistic $P = 0.954$ based on median and $P = 0.793$ based median and with adjusted df related to the Student's grade estimations, In this case, we can discuss the results as follows:

- Given that the Levene's test based on the median is not significant, we can conclude that the variances between groups are relatively equal.
- However, given that the Levene's test based on the mean is significant, Given that the data is ordinal and represents rates, the median is more suitable for representing the data

Therefore, it's better to use the Levene's test based on the median as the primary reference to determine the equality of variances

The non-significant result of Levene's test based on the median indicates that the variances between groups are relatively equal. This is consistent with the nature of ordinal data and allows us to proceed with further statistical analyses with greater confidence

Table 7. Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Total rate	850.368[a]	105	8.099	548.551	.000	.992
	Student rate	3409.781[b]	105	32.474	734.032	.000	.994
Intercept	Total rate	775.570	1	775.570	52531.564	.000	.992
	Student rate	5214.585	1	5214.585	117868.402	.000	.996
V (grade of students)	Total rate	620.940	59	10.524	712.848	.000	.989
	Student rate	2494.383	59	42.278	955.628	.000	.992
S (gender)	Total rate	.008	1	.008	.512	.475	.001
	Student rate	.006	1	.006	.133	.715	.000
V * S	Total rate	1.029	45	.023	1.548	.016	.134
	Student rate	1.819	45	.040	.914	.634	.084
Error	Total rate	6.644	450	.015			
	Student rate	19.908	450	.044			
Total	Total rate	3035.250	556				
	Student rate	17061.000	556				
Corrected Total	Total rate	857.012	555				
	Student rate	3429.689	555				

a. R Squared = .992 (Adjusted R Squared = .990)
b. R Squared = .994 (Adjusted R Squared = .993)

Source: Prepared by the researcher from the results using SPSS

The multivariate variance test for the effect of grades and gender as independent variable on the Overall and Student's grade estimations, we found that P=0.00 is less than the significance level alpha $\alpha = 0.05$. Therefore, we reject the null hypothesis H_0, and consequently, there is a significant effect of grades on both the two Overall and Student's grade estimations

Similarly, for the test of the effect of gender on the Overall, since P=0.475 is greater than the significance level alpha $\alpha = 0.05$, we accept the null hypothesis H_0 , and therefore, there is no significant effect of gender on the overall. Also, sig=0.715 is greater than the significance level alpha $\alpha = 0.05$, so we accept the null H_0 hypothesis, and therefore, there is no significant effect of gender on the Student's grade estimations. Similarly, for the test of the interaction between grades and gender on the overall, we found that P=0.016 is less than alpha $\alpha = 0.05$. Therefore, we reject the null hypothesis H_0 , and consequently, there is a real statistically significant effect of the interaction on the overall. In addition, to examine the effect of the interaction on Student's grade estimations, we found that P=0.634 is greater than the significance level alpha $\alpha = 0.05$. Therefore, we accept the null hypothesis H_0 , and consequently, there is no statistically significant effect of the interaction on Student's grade estimations. Looking at the multivariate determination coefficients, the partial eta squared values indicate that 99.2% of the variation in the overall is due to the independent variables, while 0.8% is due to other factors not included in the model. Also, the test statistic for this coefficient, sig=0.00, indicates that this coefficient is statistically significant. The R Squared values indicate that both models explain a large proportion of the variance in the dependent variable. Model b appears to have a slightly better fit

CONCLUSION

According to results, it can be concluded that the variable of grades has a significant impact on student performance, as measured by the overall rate and Student's grade estimations. This result has important implications for education and research in the field of student learning, while the gender variable has a small or non-significant effect on the Overall and Student's grade estimations. This result suggests that gender does not play a major role in determining the dependent variables.

Recommendations

These results can be used to develop educational programs aimed at improving student performance. Further research can be conducted to explore the relationship between grades and student performance. These results can be used to improve our understanding of the factors that affect student performance.

Based on the findings, the following recommendations can be made:

1. Using multivariate analysis: in educational studies to analyze the relationships between different variables.
2. Considering the impact of grades and gender: on overall rate and student rate when developing educational programs.
3. Providing support: for students with low grades to improve their academic performance.

4. Conducting further studies: to analyze the impact of other variables on student performance

REFERENCES

[1]. Trieschmann, Multivariate analysis model for predicting Financially Distressed P-L Insurers, Journal of Risk and Insurance, Vol 40, Issue3, P327, 1973

[2]. Timm, Neil, Multivariate analysis with application in education and psychology, Brook/Cole Series in Statistics.co. 1975

[3]. Everett, Graphical Techniques for Multivariate Data, Heinemann Educational Book ltd, London, 1978

[4]. Good ale, Multivariate analysis of impact of gender and College major on student levels of Environment concern and Knowledge, international Journal of Environment Education, vol 11, issue 1, 2012

[5]. Bena etal, Job lure and work: a multivariate analysis of relation with previous experience and differences by age BMC public Health, 2013

[6]. Daniel Denis, Applied univariate,Barvariate and Multivariate Statistics : Understanding Statistics for Social and natural Scientists, with applications in SPSS and R, Second Edition, John Wiley and Sons, Inc. 2021

[7]. Harris, R.J, A primer of Multivariate Statistics 3rded Hillsdale, NJ: Law Erlbaum Associates, 2001 .

[8]. Richard A .Jonson, & Dean W. Wichern, Applied multivariate statistical analysis, Sixth Edition, Pearson Education, Inc., USA, 2007

[9]. Everritt B.S& Dunn Applied Multivariate Data Analysis .Edward Arnold London. 1991 , PP 219-220.

[10]. Polit D.F, Data Analysis and Statistics for Nursing Research. Appleton and Lange Stamford, Connecticut PP.320-321 ,1996 .

[11]. Sogand Hasan Zadeh ,etal Impact of Construction Workers Hazard Identification Skill on Their Visual, Journal of Construction Engineering and Management,143(10) 2017

[12] .Koki Shimizu, Hiroki Hashiguchi, Numerical Computation for the exact Distribution of Roy's Largest root Statistic under Linear alternative, Japanese Journal of Statistics and Data Science, 5(2) 2022, 701-715.

[13]. Marozzi, M, Multivariate multidistance tests for high-dimensional low sample size case-control studies, Statistics in Medicine. 34 (9) 2015, 1511–1526.