

## USING PROFILE ANALYSIS MODEL IN MEASURING STUDENTS' PERFORMANCE IN STUDENT'S SUDANESE SECONDARY CERTIFICATE

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### ABSTRACT

This study aims at using Profile analyses of students' performance in secondary schools in Sudan academic year (2018) the study was conducted for both science and Arts section students for six subjects. (Box's M) analysis showed that the students' performance in government and private schools is not equal, both in Science and Arts section students in the basic subjects. However, (Hotelling's Trace) test showed that there is a significant difference between the students' performance in government and private schools in both Science and Arts section student's in the basic subjects, also the school type does affect students' performance in the basic subject. The findings prevail that through general profile lines it is unsymmetrical about the means for students' performance in the government and private sector and weak points for the students have been determined both in the governmental and private sector.

**KEYWORDS:** Profile Analysis, Box's M, MANOVA, Performance, Sudanese Secondary Certificate

### INTRODUCTION

The Profile Analysis Method is a multivariate statistical technique used to determine the differences between the groups. It is repeated to measure the extension of Multivariate Analysis of Variance MANOVA by which a researcher typically seeks to demonstrate that classes are not distinct when implementing Profile Analysis. That is to compare (g) students' group according to their performance in (p) number of tests to present the performance measured with specific standards for each group through hypothesis tests. Therefore, A profile analysis is conducted to explore the differences in students' performance in the secondary certificate in the academic year (2018) both in private and government schools, where students' performance is considered a critical factor for university admission as well as their choices. This research aims at applying Profile Analysis method for comparing the students' performance of Sudanese Secondary Certificate in (year 2018) in the government and private education. The research has been divided two parts, part one reviews the theoretical aspect of Profile Analysis while part two contains the application aspect of the Profile Analysis for the basic subjects for Student's sudanese secondary certificate, such as: Arabic language, Islamic studies, English language, Special mathematics for both Science and Art section students,

Physics, Chemistry (Science section students), and Basic mathematics, Geography and History (Arts section students).

2. STUDY PROBLEM

The research problem is represented in the non-use of advanced statistical methods in measuring the performance of students in the secondary certificate exam in Sudan. Moreover, it reflects the society’s views about the low quality of education provided in government academic secondary schools compared to private schools, which prompted the researcher to use a more modern method, i.e. the Profile Analysis method, to measure students’ performance, gives an idea clearer compared to the traditional methods.

2.1 Hypotheses

- 1. There are differences in the performance of students in secondary schools between government schools and private schools.
2. The students' performance in the governmental schools is better than the private schools.
3. The profiles analysis for the types of schools are not parallel.

3. MATERIAL AND METHODS

3.1 Profile Analysis Model

The structure of Profile Analysis for the analysis of repeated measurements is now considered. Suppose that repeated measurements have been from k groups of subjects at p occasion. Let y\_ij = (y\_ij1, ..., y\_ijp)^T represent the response vector from the j^th subject in group i for j = 1, ..., n\_k, i = 1, ..., k. The profile analysis model is:

y\_ij = mu\_i + e\_ij ..... (1)

Where the vector e\_ij = (e\_ij1, ..., e\_ijp) is the vector of error for j^th subject in group I and mu\_i = (mu\_i1, ..., mu\_ip) is the population mean vector for the i^th group. Error vectors are assumed to be independent and normally distributed with mean vector

0 and common covariance matrix Sigma [1]. Thus

y\_ij = N\_t(mu\_i, Sigma) ..... (2)

**3.2 Test of parallelism**

The hypothesis of parallelism is:

$$H_{01} : \begin{bmatrix} \mu_{11} - \mu_{12} \\ \mu_{12} - \mu_{13} \\ \mu_{1,t-1} - \mu_{1t} \end{bmatrix} = \begin{bmatrix} \mu_{21} - \mu_{22} \\ \mu_{22} - \mu_{23} \\ \mu_{2,t-1} - \mu_{2t} \end{bmatrix} = \dots = \begin{bmatrix} \mu_{s1} - \mu_{s2} \\ \mu_{s2} - \mu_{s3} \\ \mu_{s,t-1} - \mu_{st} \end{bmatrix} \dots \dots \dots (3)$$

Testing this hypothesis is equivalent to carry out multivariate analysis of variance (MANOVA) model. On the (t-1) difference between adjacent time point from each sampling.

**3.3 Tests of No Differences Among Groups**

If the parallelism hypothesis is reasonable, the test for differences among groups can be carried out using the sum (or average) of the repeated observations from each subject. Because the s groups are independent, this test of H<sub>02</sub> is equivalent to that from a one-way ANOVA on the totals (or means) across time from each subject. In this case null the hypothesis is:

$$H_{02} : ABC = D$$

$$\text{Where } A_{(s-1) \times s} = (I_{s-1}, -1_{s-1}), C_{t \times t} = I_t \text{ and } D_{(s-1) \times 1} = 0_{s-1}$$

A multivariate test for differences among groups can also be carried out without assuming parallelism. In this case null the hypothesis is:

$$H_{01} : \begin{bmatrix} \mu_{11} \\ \mu_{12} \\ \cdot \\ \mu_{1t} \end{bmatrix} = \begin{bmatrix} \mu_{21} \\ \mu_{22} \\ \cdot \\ \mu_{2t} \end{bmatrix} = \dots = \begin{bmatrix} \mu_{s1} \\ \mu_{s2} \\ \cdot \\ \mu_{st} \end{bmatrix} \dots \dots \dots (4)$$

**3.4 Multivariate Analysis of Variance (MANOVA)**

Multivariate analysis of variance (MANOVA) is used to test the equality of several mean vectors for several groups whose population is distributed normal. The mathematical model is as follows:

$$y_{ij} = \mu_i + \alpha_i + e_{ij} \dots \dots \dots (5)$$

With the hypothesis:

$$H_0 : \underline{\mu}_1 = \underline{\mu}_2 = \dots \underline{\mu}_k$$

$$H_1 : \underline{\mu}_1 \neq \underline{\mu}_2 \neq \dots \underline{\mu}_k$$

3.4.1 Wilks' Lambda  $\Lambda$  Test

$$\Lambda = \frac{|W|}{|W+Q|} \dots \dots \dots (5)$$

Where:

$$W = \sum_{i=1}^k \sum_{\alpha=1}^{n_i} (\underline{X}_{\alpha}^i - \underline{\mu}^i) (\underline{X}_{\alpha}^i - \underline{\mu}^i)'$$

$$Q = \sum_{i=1}^k n_i (\underline{\mu}^i - \underline{\mu}) (\underline{\mu}^i - \underline{\mu})'$$

After calculating Wilks'  $\Lambda$ , we use Bartlett's  $\chi^2$  - statistic for testing null hypothesis given by

$$\chi^2 = -\left(n - 1 - \frac{t+k}{2}\right) \log \Lambda \cong \chi^2 \frac{t(t+1)(k-1)}{2} \dots \dots \dots (6)$$

We reject  $H_0$  at  $\alpha$  level of significance if  $\chi^2 \frac{t(t+1)(k-1)}{2}, \alpha$ ; otherwise accept.

**Table 1. MANOVA Table**

Source of variation	df	sum of product matrix	$\Lambda$
Between Groups	k-1	$Q = \sum_{i=1}^k n_i (\underline{\mu}^i - \underline{\mu}) (\underline{\mu}^i - \underline{\mu})'$	$\frac{ W }{ W + Q }$
Within Groups	n-k	$W = \sum_{i=1}^k \sum_{\alpha=1}^{n_i} (\underline{X}_{\alpha}^i - \underline{\mu}^i) (\underline{X}_{\alpha}^i - \underline{\mu}^i)'$	
Total	n-1	$W + Q = \sum_{i=1}^k \sum_{\alpha=1}^{n_i} (\underline{X}_{\alpha}^i - \underline{\mu}^i) (\underline{X}_{\alpha}^i - \underline{\mu}^i)'$	

Generally, multivariate variance analysis is an expansion of using F test, in addition to existence appropriate statistics tests such as (Pillai's trace, Lawley, Hotelling's trace), all these tests approximately imply to F test (Seber 1984).

**3.4.2 Box's Test for Equality of Covariance Matrices**

Box's test is a parametric test used to compare variation in multivariate mean vector is that the covariance matrices of potentially different population are same (Richard A. Johnson & Dean W. Wichern 2007),

With the hypothesis:

$$H_0 : \Sigma_1 = \Sigma_2 = \dots \Sigma_g$$

Where g covariance matrices for  $\ell$ th population  $\ell = 1, 2, \dots, g$  pooled sample covariance matrix given by:

$$S_{pooled} = \frac{1}{\sum_{\ell}(n_{\ell}-1)} [(n_1 - 1)S_1 + (n_2 - 1)S_2 + \dots + (n_g - 1)S_g] \dots \dots \dots (7)$$

Here  $n_{\ell}$  the sample size  $\ell$ th group,  $S_{\ell}$  us the  $\ell$ th sample covariance. Box's test based on his  $\chi^2$  approximation to the sampling distribution of  $-2 \ln \Lambda$  where:

$$\Lambda = \prod_{\ell} \left( \frac{|S_{\ell}|}{|S_{pooled}|} \right)^{(n_{\ell}-1)/2} \dots \dots \dots (8)$$

$-2 \ln \Lambda = M$  (Box's M statistic) gives:

$$M = [\sum_{\ell}(n_{\ell} - 1)] \ln |S_{pooled}| - [\sum_{\ell}(n_{\ell} - 1) \ln |S_{\ell}|] \dots \dots \dots (9)$$

Box's Test for Equality of Covariance Matrices:

$$u = \left[ \sum_{\ell} \frac{1}{(n_{\ell}-1)} - \frac{1}{(n_e-1)} \right] \left[ \frac{2p^2+3p-1}{6(p+1)(g-1)} \right] \dots \dots \dots (10)$$

Where p is mummer of variable and g is number of groups. Then

$$c = (1 - u)M = (1 - u) \{ [\sum_{\ell}(n_{\ell} - 1)] \ln |S_{pooled}| - [\sum_{\ell}(n_e - 1) \ln |S_{\ell}|] \} \dots \dots \dots (11)$$

Has approximate  $\chi^2$  distribution with:

$$v = g \frac{1}{2} p(p + 1) - \frac{1}{2} p(p + 1) = \frac{1}{2} p(p + 1)(g - 1) \dots \dots \dots (12)$$

Degree of freedom. At significance level  $\alpha$ , reject  $H_0$  if  $c > \chi^2_{\frac{1}{2}p(p+1)(g-1)}(\alpha)$ .

**3.4.3 T<sup>2</sup> Hoteling Test for Equality of Covariance Matrices**

It is used to test the difference between the mean values of two groups of multiple variables, where the null hypothesis is there is no difference between the mean vector of the independent variables between two groups.

**Hotelling’s T<sup>2</sup> statistic**

$$T^2 = n(X - \mu)' W^{-1} (X - \mu) \dots\dots\dots (13)$$

X : A vertical vector representing the mean of the responses p .

W : A matrix with degree p × p .

X ~ N<sub>p</sub> (μ, v) a random variable that follows a Gaussian distribution and S ~ W<sub>p</sub> (m, v) , does not depend on

$$\frac{m - p + 1}{pm} T^2 \sim F_{(p, m-p+1)}$$

**4. RESULTS AND DISCUSSION**

For the purpose of applying the Profile Analysis method in results of Sudan secondary certificate, the data were taken from the Ministry of Education for the academic year (2018) for both Science and Art section students. The mean and standard deviation were calculated of scores for each subject according to type of school for both Science and Art section students (see Table 2. and Table 3). Then the Profile Analysis estimated for Science and Art section students for each one.

**Table 2. Descriptive statistics of Science section students according to type of school**

Subjects	Type of school	Mean	Std.deviation
Arabic	private	68.8	12.4
	governmental	69.3	12.4
English	private	70.0	11.8
	governmental	69.0	12.4
Islamic	private	69.8	15.1
	governmental	69.8	14.5
basic math	private	58.7	17.6
	governmental	58.1	17.0

physics	private	58.2	16.3
	governmental	58.3	15.3
chemistry	private	58.0	16.9
	governmental	58.8	15.9

**Table 3. Descriptive statistics of Art section students according to type of school**

Subjects	Type of school	Mean	Std.devation
Arabic	private	53.7	14.1
	governmental	55.6	13.8
English	private	53.8	14.2
	governmental	55.1	13.6
Islamic	private	52.3	17.1
	governmental	53.7	16.7
Basic math	private	58.7	14.9
	governmental	58.1	15.8
Geography	private	59.0	14.3
	governmental	60.2	14.9
History	private	58.2	14.3
	governmental	61.0	14.8

**4.1 Results of Science section students**

**4.1.1 Equal levels test**

**Table 4. Box's M test for equal levels Science section students**

Box's M	1446.980
F	68.900
df1	21
df2	5212.477
Sig.	0.000

Table 4 showed the result of Box's M test for investigating the differences in performance of governmental education and private education in the scientific discipline. The result reveals that the p-value  $< \alpha = .01$ , and so we conclude that there is evidence that there are significant differences between the two groups of data set. This indicates that the students' performance of governmental education and private education in the scientific discipline in basic subjects is unequal.

**4.1.2 The Parallel test**

**Table 5. The Parallel test for Science section students**

Multivariate Tests				
Effect		Value	F	Sig
Type of school * the factor	Pillai's Trace	0.012	306.983	0.000
	Wilks' Lambda	0.988	306.983	0.000
	Hotelling's Trace	0.012	306.983	0.000
	Roy's Largest Root	0.012	306.983	0.000

Table 5 presents Parallel test for scientific discipline into different test packages. Namely, Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root.

From the result, we notice that the P-values of Hoteling's Trace in addition to the other test are less than the level of significance (0.05). This indicates that there are significant differences between the two groups and provides an evidence that there is a significant difference between the students' performance of governmental and private education in the scientific discipline of basic subjects.

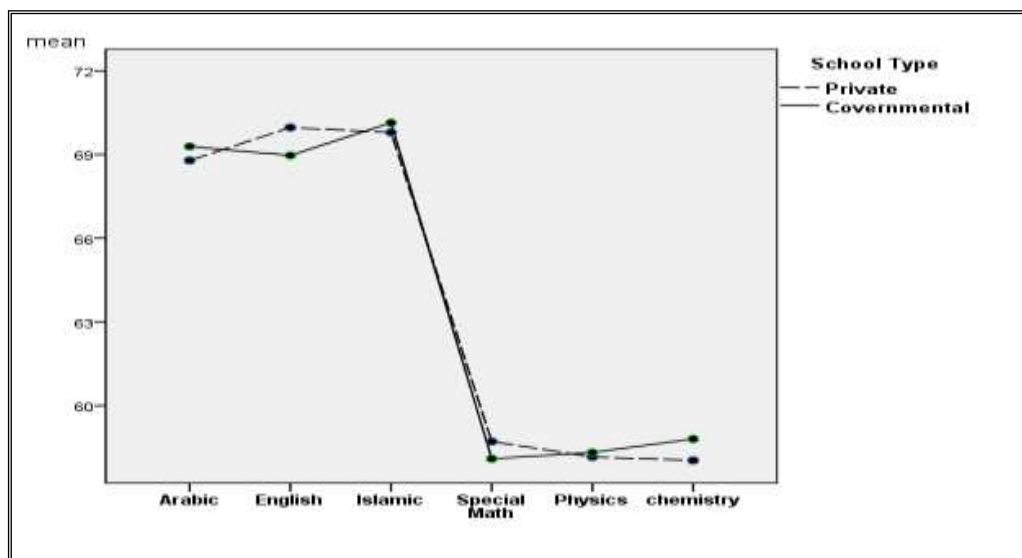
**4.1.3 Interaction test**



**Table 6. Interaction test for government and private schools**

Tests of Within-Subjects Effects						
Source		Type III Sum of Squares	Df	Mean Square	F	P-value
The type of the factor * the school	Sphericity Assumed	73526.600	5	14705.320	278.278	0.000
	Greenhouse-Geisser	73526.600	4.092	17966.874	278.278	0.000
	Huynh-Feldt	73526.600	4.093	17966.092	278.278	0.000
	Lower-bound	73526.600	1.000	73526.600	278.278	0.000

Table (6) above shows, the p-values of Greenhouse-Geisser test for interaction is less than significance level (0.01). That implies there is no effect by the school type on students' performance furthermore, this means the type of school whether government or private does not affect the performance of the Science section students in the basic subjects.



**Figure 1. General profile line for means performance of government and private schools of Science section students.**

Figure 1. shows the curves of the general profile lines for the students' performance in the government and private schools. It is clear that the lines are non-identical, as there is a difference in the means in all basic Science subjects except for the physics subject (there is identical), which indicates there are differences between students' performance in government and private schools in Science section subjects, in addition to the poor students' performance in government and private schools for the Science section students in Special mathematics, Physics and Chemistry.

#### 4.1.4 The interpretation of the findings

The results of analysis of Science section students' scores can be summarized as follows:

1. Box's M test showed that the covariance and covariance matrix of the two groups is not equal because the P-value (0.000) is less than the level of significance (0.01). This implies that the performance of students in the basic scientific subjects of the Science section students is not equal.
2. Hotelling's Trace test showed, the parallelism test (the difference between the means values). There are differences between the means values, because the P-value (0.000) is less than the level of significance (0.01). This means that there are significant differences in the performance of students in the basic scientific subjects of the Science section students.
3. The Greenhouse-Geisser test (for interaction between groups) showed that there is no interaction between the groups because the P-value (0.000) is less than the level of significance (0.01). This means that there are differences in Students' performance in the basic scientific subjects of the Science section students.
4. The general profile lines of the performance of the government and private schools in all basic scientific subjects except for physics are non-identical.

#### 4.2 Results of Art Section Students

##### 4.2.1 Levels equivalent test

**Table 7. Box's M test for levels equivalent Art section students**

<b>Box's M</b>	1503.184
<b>F</b>	71.578
<b>df1</b>	21
<b>df2</b>	19893.685
<b>Sig.</b>	0.000

Table 7 showed the result of Box's M test for investigating the differences in performance of governmental education and private education in the literary discipline. From the table, we notice that the P-value of Box's M test is (0.000), which is less than the significance level (0.05). This indicates that there are significant differences between the two groups. This indicates that the performance of students of governmental education and private education in the literary discipline for the basic subjects is not equal.

**4.3.2 Parallel test**

**Table 8. The Parallel test for the Art Section Students**

Multivariate Tests				
Effect		Value	F	Sig
Type of the school * the factor	Pillai's Trace	0.010	365.959	0.000
	Wilks' Lambda	0.990	365.959	0.000
	Hotelling's Trace	0.010	365.959	0.000
	Roy's Largest Root	0.010	365.959	0.000

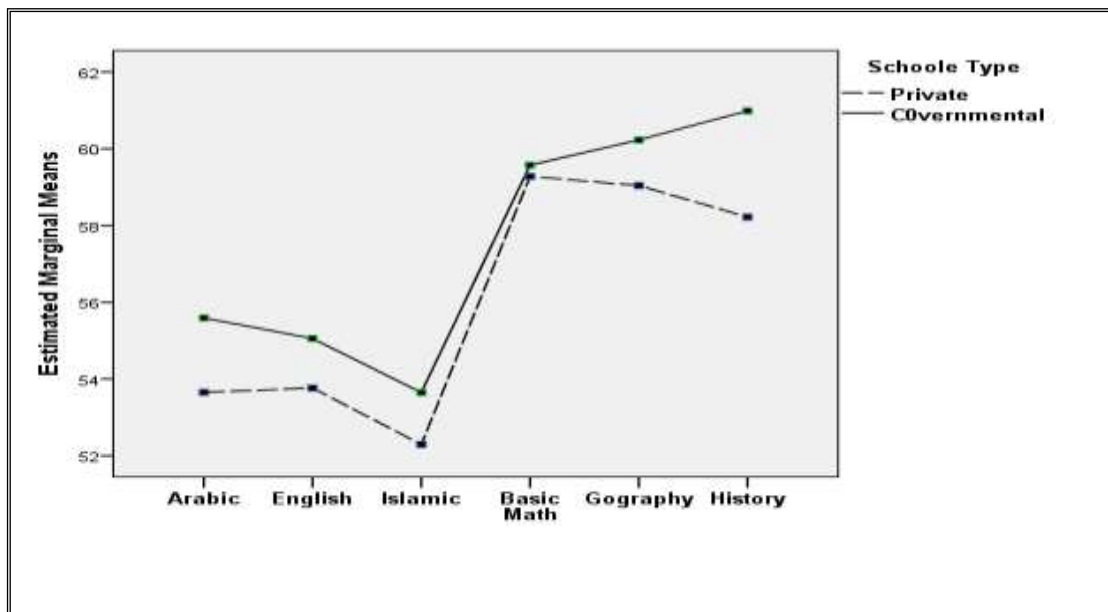
Table 8 shows The Parallel test for the literary discipline. the P-value of Hotelling's Trace and the other tests (P- value 0.000) were less than the significance level (0.05). This indicates that there are significant differences between the two groups. that means that there are differences between the performance of governmental and private education students for the basic subjects of the literary discipline.

**4.2.3 Interaction test**

**Table 9. Interaction test between the government and private schools**

Tests of Within-Subjects Effects						
Source		Type III Sum of Squares	df	Mean Square	F	Sig.
The school * the type of the factor	Sphericity Assumed	156489.331	5	31297.866	389.440	0.000
	Greenhouse-Geisser	156489.331	4.53	34579.447	389.440	0.000
	Huynh-Feldt	156489.331	4.53	34578.339	389.440	0.000
	Lower-bound	156489.331	1.00	156489.331	389.440	0.000

Table 9 depicts the result of Interaction test of differences for governmental and private education according to literary discipline. we note that the Greenhouse-Geisser test P-value (0.000) is the less than the significance level (0.05), this indicates that there is no effect by the school type on students' performance. That means the type of school, governmental or private does not affect students' performance in the literary discipline for the basic subjects.



**Figure 2. General profile line for means performance of government and private schools of Arts section students.**

Figure 2. depicts the curves of the general profile lines for the students' performance mean in the governmental and private education. We notice that the general profile lines are not symmetrical, as there is a difference in the means in all basic scientific subjects except for basic math subject (there is symmetric), which indicates that the differences between students' performance in governmental education and private education in basic scientific subjects refers to poor students' performance in governmental and private education in literacy discipline in Islamic studies, English language and Arabic language.

#### 4.2.4 The interpretation of the findings:

Results of Arts section students can be summarized in the following findings:

1. Box's M test showed that the covariance and variance matrix of the two groups is not equal because the p-values (0.000) is less than the level of significance (0.01). This means that there are unequal differences in the performance of students in the basic scientific subjects of the Arts section students.
2. Hotelling's Trace test showed the parallelism test (the difference between the means values). There are differences between the means values, because the p-values (0.000) is less than the level of significance (0.01). Which means there are significant differences in students' performance in basic subjects.
3. The Greenhouse-Geisser test (for interaction between groups) showed that there is no interaction between the groups because the p-values (0.000) is less than the level of significance (0.01). This means that there are differences in students' performance in the basic scientific subjects of the Art section students.
4. The general profile lines of the performance of government schools' students and performance of private schools' students are non-identical in all the basic scientific subjects for Arts section students.

#### 5. CONCLUSION

From the results of Profile Analysis for Science and Art section students it became clear that: the students' performance in government and private schools for the Science and Art section students in basic subjects is unequal, there are significant differences in students' performance in the basic scientific subjects for the Science and Art section students, The type of schools, government or private, does not affect students' performance in the Science and Art section students for the basic subjects, The general profile lines for the performance of the government schools and the performance of the private schools in all the basic scientific subjects of the Art section students is not equal, there is identical in the physics subject for the Science section students. The performance of students in government schools is better than the performance of students in private schools in all basic Art subjects, which implies government schools is better than private schools, poor performance of Science section students in government and the private schools in subjects such as: Special mathematics, Physics and Chemistry, poor performance students in government and private schools

of Science section students in subjects such as: Islamic studies, English language and Arabic language. In future studies: the exam administration should use the Profile Analysis method to compare the types of education in the process of analyzing the results of the secondary certificate exam in Sudan, make use of the results of this research to find out the areas of weakness and developing the teacher training process to improve the performance of students in geographic governmental education.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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