Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.4, No.12, 2013

Profile Analysis of Students' Academic Performance in Ghanaian Polytechnics: The Case of Bolgatanga Polytechnic

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Abstract
The main purpose of the study was to examine the changes in the average academic performance of students over time and how these changes are related to student segments, choice of program and the entry qualification of the student. The cohort of students admitted into Bolgatanga Polytechnic during the 2009/2010 academic year formed the sample and only students who successfully completed were used. Data on grade point averages (GPA), demographic and socio-economic features from 131 Female and 271 Male students was obtained from the Examinations Department and the Student Affairs Unit of Bolgatanga Polytechnic. The multivariate analysis of variance technique was used to complement the Hotelling's T^2 to compare the mean vectors of k random samples for significant difference among the levels of Departments, Entry Requirements and Gender. Profile analysis of the data indicated at 5% level of significance that the average GPA scores of the Male and Female students were parallel, level and deviated significantly from flatness whereas the various Departments had their own subject-specific mean response. The Entry Qualifications of students admitted into the Polytechnic were not similar.
Keywords: Profile Analysis, Academic Performance, MANOVA, Ghana

1. Introduction

The Ghanaian Tertiary Education system is composed of the Universities and Polytechnics (including Colleges of Education). The Polytechnic sector emphasizes Technical and Vocational Education by training students in Scientific and Technical subjects. Since 1992, when Government directed Polytechnics in Ghana to run Tertiary programmes, significant gains have been made in the output of the Polytechnic graduate. The Polytechnics provides the bulk of our people with technical education that is relevant, up-to-date in technology, and forward looking in approach (Owusu-Agyeman, 2006). For this reason, Polytechnic graduates play a momentous function in the development of the nation.

Many researchers (Abledu, 2012; Gyekye, 2002; Irfan *et al.,.,* 2012; Blazenka *et al.,.,* 2009; Hijazi *et al.,.,* 2006; DeBerard *et al.,.,* 2004; Hansen *et al.,.,* 2003; Deepak *et al.,.,* 2011; Chinwuba *et al.,.,* 2011; Liver *et al.,.,* 2002; Kyei *et al.,* 2011) seem willing to leap from cross-sectional data that describes differences among students' academic achievements to making generalisations about change over time. Change is pervasive in everyday life. Beyond the natural changes, targeted interventions can also cause change; test scores or students' GPA might rise after coaching, increased learning facilities or student's self reported interest in their area of study. By measuring and charting changes like these we uncover the temporal nature of development in terms of students' academic performances. This study, however, seeks to describe the changes in the average academic performance of students over time and how these changes are related to student segments, choice of program and entry qualifications.

2. Materials and Methods

The study used a cohort of students admitted into Bolgatanga Polytechnic during the 2009/2010 academic year as the study sample. A profile plot on the Grade Point Average (GPA) of students was conducted to establish the growth trajectory and determine the link of its distribution to the exponential family of distributions.

2.1 MANOVA

Multivariate analysis of variance evaluates differences among centroids for a set of dependent variables when there are two or more levels of independent variables (groups). This technique provides a multivariate test to compare the mean vectors of k random samples for significant difference when the levels of the grouping variable are more than two. For k independent random samples of size n obtained from p–variate normal populations, the model for each observation is:

$$\begin{aligned} y_{ij} &= \mu + \alpha_i + \varepsilon_{ij} \\ &= \mu_i + \varepsilon_{ij}, \quad i = 1(1)k; \quad j = 1(1)p \end{aligned} \tag{1}$$

In terms of the p variables in y_{ij}, (1) becomes

$$\begin{pmatrix} y_{ij1} \\ \vdots \\ y_{ijp} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \vdots \\ \mu_p \end{pmatrix} + \begin{pmatrix} \alpha_{i1} \\ \vdots \\ \alpha_{ip} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij1} \\ \vdots \\ \varepsilon_{ijp} \end{pmatrix} = \begin{pmatrix} \mu_{i1} \\ \vdots \\ \mu_{ip} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij1} \\ \vdots \\ \varepsilon_{ijp} \end{pmatrix}$$

This model leads to a multivariate hypothesis of the form

$$H_{01} : \begin{pmatrix} \mu_{11} \\ \mu_{12} \\ \vdots \\ \mu_{1p} \end{pmatrix} = \begin{pmatrix} \mu_{21} \\ \mu_{22} \\ \vdots \\ \mu_{2p} \end{pmatrix} = \cdots = \begin{pmatrix} \mu_{k1} \\ \mu_{k2} \\ \vdots \\ \mu_{kp} \end{pmatrix}$$

using the likelihood ratio test

$$\Lambda = \frac{\sup_{H_0} L\left(\mu_1, \mu_1, \cdots \mu_1, \Sigma / x_{11}, \cdots, x_{1n_1}, \cdots, x_{k1}, \cdots, x_{kn_k}\right)}{\sup_{H} L\left(\mu_1, \mu_1, \cdots \mu_1, \Sigma / x_{11}, \cdots, x_{1n_1}, \cdots, x_{k1}, \cdots, x_{kn_k}\right)}$$

where

$$H_0 = \left\{\left(\mu_1, \cdots \mu_k, \Sigma\right) : \mu_1 = \cdots = \mu_k \in \Re^p, \Sigma > 0\right\} \text{ - - - - - Restricted parameter space}$$

$$H = \left\{\left(\mu_1, \cdots \mu_k, \Sigma\right) : \mu_1 = \cdots = \mu_k \in \Re^p, \Sigma > 0\right\} \text{ - - - - - Unrestricted parameter space}$$

For the case of two levels of the independent term (group) in the model, the Hotelling's T^2 was used to test the equality of the mean vectors between the two samples using the following hypotheses:

1. $H_{01} : \mu_j^{(1)} - \mu_j^{(2)} = \mu_{j-1}^{(1)} - \mu_{j-1}^{(2)}, \quad j = 2,\ 3, \cdots, p$
2. $H_{02} : \sum \mu_j^{(1)} = \sum \mu_j^{(2)}, \quad j = 1,\ 2, \cdots, p$
3. $H_{03} : \mu_1^{(1)} = \cdots \mu_p^{(1)} = \mu_1^{(2)} = \cdots \mu_p^{(2)}$

3. Results and Discussion

The mean Grade Point Average (GPA) and standard deviations at each measurement location for a random subset of 402 students, broken down by Gender are presented in Table 1. The mean response in the baseline (year one, semester one) was similar across Gender. However, there were discernible differences in the patterns of change in the mean GPA of students over time. As shown in Table 1, the Female students registered the least standard deviation in all semesters except the third semester.

According to Table 2, the average GPA for various Departments differed across semesters with the Department of Statistics having the highest mean GPA at the beginning of the first semester and Marketing Department with the least GPA for that semester. In terms of spread across Departments, the Department of Statistics recorded the highest standard deviation for all but the fifth semester whilst the variability of the other departments varied from semester to semester.

It was obvious from the descriptive statistics in Table 3 that students who were admitted based on Direct Qualification (DQ) had the highest GPA across all semesters except the third semester. Though, the mean GPA of students who were admitted based on a Decisive factor (NQ) did not change much across semesters, they had a much higher variability as compared to the other two categories.

3.1 Mean Response Profiles of gender

Figure 1 indicated a gain in the mean GPA scores for both Male and Female students in the second semester. There was a dramatic drop in the mean GPA scores among Male students in the third semester compared to their Female counterparts. However, each profile had a nonlinear trend as shown in Figure 1.

The test of parallelism for the two groups estimated a Hotelling's T^2 value of 10.4043 with a p-value of 0.0696 which was statistically not significant. Using the MANOVA technique to complement the Hotelling's T^2, the results indicated at the 5% level of significance that the mean profiles of Male and Female students were parallel

(Table 4), level (Table 5) and deviated significantly from flatness (Table 6).
The evidence of female students performing better than their male counterparts was not seen in this study. This is consistent with the findings of some studies: Chinwuba *et al.,* (2011) established that there was no difference in academic performance between male and female undergraduate Accounting students. Similarly, Ding *et al.,* (2008) in a related study established that ethnicity, but not gender, distinguished two types of change profiles. However, contrary to the results of this study, Deepak *et al.,* (2011) and Hijazi *et al.,* (2006) showed that females performed better than their male counterparts in the field of Medicine and Agricultural Science respectively. The results supporting female dominance in academic performance in subject-based research were done in the developed countries whereas the findings consistent with this study were done in the developing countries.

3.2 Mean Response Profiles of Departments

A profile plot of Departments suggested that each Department had their own subject-specific mean response and the observations varied (Figure 2). The results of the multivariate test of parallelism, assuming heterogeneity, indicated at 5% level of significance that the null hypothesis of similar profiles was rejected as shown in Table 7. Hence, the pattern of change of students' academic performance differed by departments. The levelness (significance of separation of profiles) and similarities of the response to all the dependent variables, independent of groups were not of much interest once the profiles were not similar.

3.3 Mean Response profiles of Mode of Entry

At the beginning of the first academic assessment, students who were admitted with Direct Qualification proved to be much better in terms of academics than those who entered the institution through Matured Entrance Examination (QM) and those that were admitted based on a Decisive Factor (Figure 3). Apart from QD and QM, students who were admitted based on a decisive factor seemed to have a linear trend across all semesters as shown in Figure 3. The matured students, on the other hand, registered the lowest GPA score at all measurement occasions except the second semester. From Table 8, all four multivariate tests rejected the null hypothesis, indicating that the profile of the means were likely different between the three categories of Mode of Entry of the student into the institution. This implies that at least one of the three groups was necessarily not flat. Though it is conceivable that the non-flatness could cancel each other to produce, on average, a flat profile, this result was not of interest to this study.

4. Conclusion

The analysis revealed an unsteady linear trend in the mean GPA scores of students in the Bolgatanga Polytechnic. The profiles of the Male and Female students were statistically similar, level and deviated from flatness. However, although the mean GPA score of the Female students was generally higher than their Male counterparts, suggesting a slightly better academic performance in favor of the Female students, this was not statistically significant..

Though the profiles of the various Departments and Mode of Entry were not similar, students admitted on the basis of a decisive factor did not change much across semesters as compared to the non-linear trend showed by students admitted directly and through the Matured Entrance Examination.

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Table 1: Mean GPA (and standard deviation) at each measurement occasion by Gender

Gender	*Semester 1*	*Semester 2*	*Semester 3*	*Semester 4*	*Semester 5*
Female	2.60 (0.59)	2.67 (0.60)	2.53 (0.75)	2.72 (0.61)	2.60 (0.73)
Male	2.60 (0.63)	2.68 (0.62)	2.36 (0.73)	2.56 (0.71)	2.45 (0.80)
Total	2.60 (0.62)	2.67 (0.61)	2.41 (0.74)	2.61 (0.68)	2.50 (0.78)

Table 2: Mean GPA (and standard deviation) at each measurement level by Departments

DEPARTMENT	*S1**	*S2**	*S3**	*S4**	*S5**
ACT	2.75 (0.52)	2.85 (0.56)	2.03 (0.67)	2.43 (0.70)	2.28 (0.83)
CVE	2.67 (0.63)	2.22 (0.50)	2.39 (0.43)	2.40 (0.46)	2.56 (0.64)
EAG	2.33 (0.73)	2.65 (0.59)	3.31 (0.45)	2.85 (0.68)	2.81 (0.73)
HCIM	2.38 (0.58)	2.35 (0.70)	2.84 (0.90)	2.85 (0.69)	2.36 (0.88)
IA	2.88 (0.51)	2.90 (0.45)	2.86 (0.49)	3.24 (0.58)	2.55 (0.62)
MKT	2.28 (0.53)	2.52 (0.56)	2.63 (0.57)	2.65 (0.65)	2.44 (0.58)
SMS	2.64 (0.71)	2.61 (0.56)	2.41 (0.59)	2.62 (0.51)	2.95 (0.63)
STA	2.96 (0.77)	2.79 (0.75)	2.73 (0.91)	2.95 (0.71)	3.08 (0.84)

* S1, S2, S3, S4 & S5 represent semester1, semester2, semester3, semester4 & semester5

Table 3: Mean GPA (and standard deviation) at semester by Mode of Entry

Entry Remark	**Semester 1**	**Semester 2**	**Semester 3**	**Semester 4**	**Semester 5**
QD	2.85 (0.64)	3.00 (0.64)	2.49 (0.75)	2.82 (0.66)	2.68 (0.82)
NQ	2.56 (0.66)	2.57 (0.67)	2.57 (0.80)	2.62 (0.75)	2.60 (0.79)
QM	2.53 (0.58)	2.59 (0.55)	2.35 (0.72)	2.54 (0.67)	2.41 (0.76)

Table 4: Multivariate test of parallelism by Gender

Test Statistic	**Estimate**	**df**	**F**	**p-value**
Wilks' lambda	0.9775	1, 4, 385	2.22	0.0667
Pillai's trace	0.0225	4, 385	2.22	0.0667
Lawley-Hotelling trace	0.0230	4, 385	2.22	0.0667
Roy's largest root	0.0230	4, 385	2.22	0.0667

Table 5: Multivariate test of levels by Gender

Test Statistic	Estimate	df	F	p-value
Wilks' lambda	0.9938	1, 1, 400	2.48	0.1161
Pillai's trace	0.0062	1, 400	2.48	0.1161
Lawley-Hotelling trace	0.0062	1, 400	2.48	0.1161
Roy's largest root	0.0062	1, 400	2.48	0.1161

Table 6: Multivariate test of flatness by Gender

Test Statistic	Estimate	df	F	p-value
Wilks' lambda	0.8140	1, 4, 398	22.74	0.0000
Pillai's trace	0.1860	4, 398	22.74	0.0000
Lawley-Hotelling trace	0.2285	4, 398	22.74	0.0000
Roy's largest root	0.2285	4, 398	22.74	0.0000

Table 5: Multivariate test of parallelism by Department

Test Statistic	Estimate	df	F	p-value
Wilks' lambda	0.2928	7, 28, 1411.2	20.46	0.0000
Pillai's trace	0.9271	28, 1576.0	16.98	0.0000
Lawley-Hotelling trace	1.7261	28, 1558.0	24.01	0.0000
Roy's largest root	1.2649	7, 394.0	71.20	0.0000

Table 6: Multivariate test of parallelism by Mode of Entry

Test Statistic	Estimate	df	F	p-value
Wilks' lambda	0.9389	2, 8, 788	3.16	0.0016 e
Pillai's trace	0.0613	8, 788	3.12	0.0018 a
Lawley-Hotelling trace	0.0650	8, 788	3.19	0.0014 a
Roy's largest root	0.0628	8, 788	6.20	0.0001 u

e = exact, a = approximate, u = upper bound on F

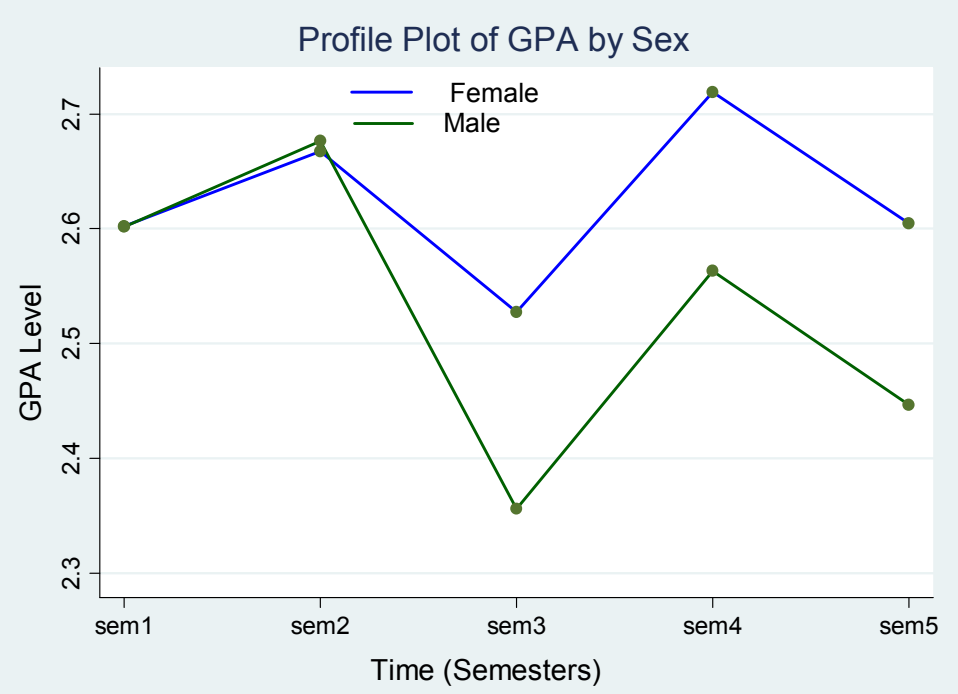

Figure 1: Plot of mean GPA at semester1 to semester 5 in the Male and Female groups

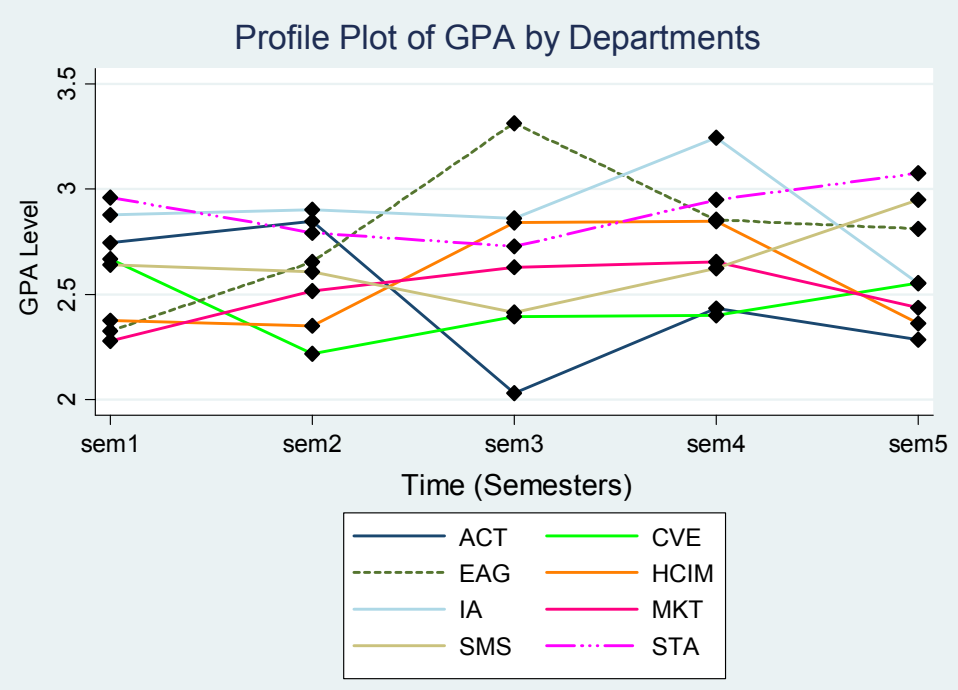

Figure 2: Plot of mean GPA at semester 1 to semester 5 by Departments

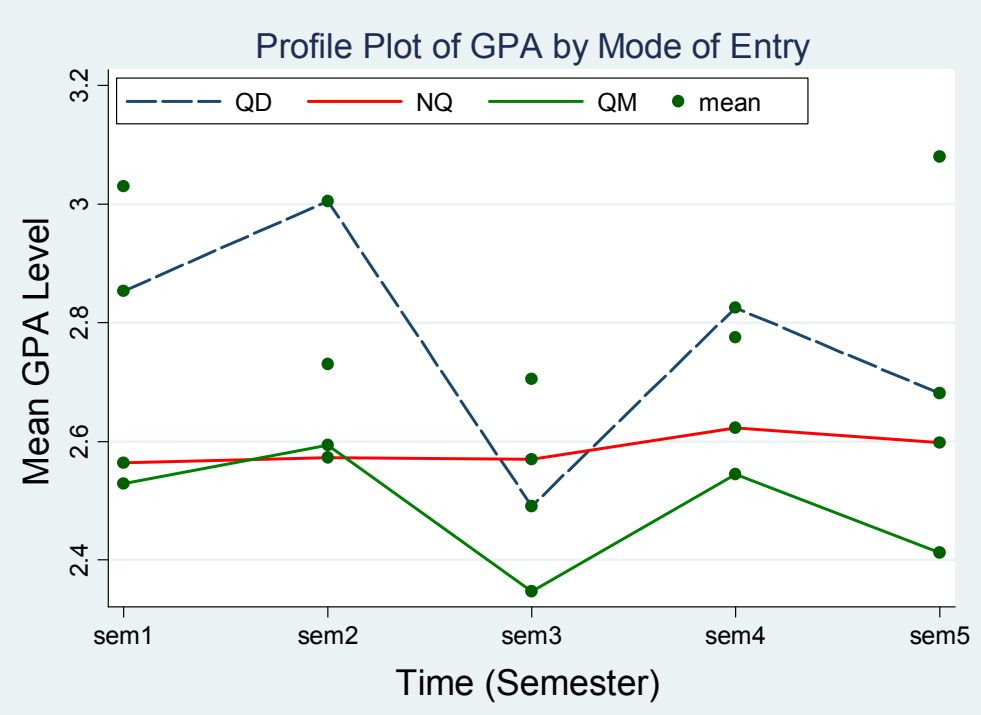

Figure 3: Profile plot of mean GPA levels by Mode of Entry