

Statistical Modelling of the Academic Performance of Pre-service Teachers of Regular and Distance Education in Ghana

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Abstract

Almost all pre-service teachers from colleges of education in Ghana, whether from the regular mode or distance mode end-up in the basic schools. This research employed statistical modelling in investigating the academic performance of pre-service teachers in the regular and distance modes of teacher education in Ghana. A total of four hundred and fifty-five (455) students were selected for the study. Pre-service teachers' scores were considered as dependent variables, whereas the category of learning mode with two levels-regular and distance was treated as the main independent variable. Descriptive statistics and Multivariate Analysis of Variance (MANOVA) were applied as statistical tools. Evidence gathered from the study indicated that there are statistically significant differences in pre-service teachers' performance scores in English Language, Mathematics and Science content and methodology courses with regard to regular and distance learning modes in Ghana ($p < 0.001$). It is recommended that policy makers, including the Ministry of Education and the National Council on Tertiary Education, liaise with Ghanaian universities to give equal attention to distance education as regular pre-service teacher education programmes.

Keywords: Pre-service teacher, academic performance, distance education, regular education, MANOVA

Introduction

In Ghana, teachers for basic school level are trained by Colleges of Education (CoEs). All of the colleges of education are affiliated to most of the public universities in Ghana including the University of Cape Coast, University of Education, Winneba, University of Ghana, Kwame Nkrumah University of Science and Technology and University of Development studies. Pre-service teachers are selected into the colleges of education by virtue of their performance in the West Africa Senior Secondary Certificate Examination (WASSCE) and selection criteria set by the Teacher Education Division (TED) of the Ghana Education Service (GES). The pre-service teachers pursue Diploma in Basic Education (DBE) either via "regular education" or "distance and sandwich education" programme modes. The DBE course is meant to provide learning chances for pre-service teachers to advance in pedagogical content knowledge for teaching in the basic school. In recent times, there has been an increase in the enrolment of continuing educational programmes, particularly

on part-time bases in Ghana.

Continuing educational programmes are mostly on part-time, sandwich (summer school) and distance education bases. Continuing education provides an educational avenue for professional and other persons to further and upgrade their education while keeping their jobs and vocations. "Distance education", or "learning at a distance", is said to share many of the common characteristics of "traditional" or "face-to-face" courses, yet it is sometimes seen as new variables in teaching and education [1].

Distance, sandwich, and part-time learning programmes have increased participation of many teachers in higher education in Ghana in recent times. Sandwich programme, as a programme of study, is conducted outside the regular system of study by institutions of higher learning [2]. With the introduction of "distance education", "sandwich" programmes, there are expanded opportunities for both the initial training and later upgrading of teachers. For this reason, it is observed that the sandwich programme meets its objectives in that it has continually encouraged the academic growth of teachers and improved their

productivity and competence [2]. It is further indicated that, sandwich programme is encouraging continuous academic growth of serving teachers and other employees, improve their productivities and competencies and that the quality or products of sandwich programme are found not to be different from the quality and raises different opinions about distance learning as against traditional face-to-face education. Some say that distance education is viewed as being different from other forms of education. What is actually in the clash is not whether distance education is ideal, but whether it is good enough to merit a college or university degree, and whether it is better than receiving no education at all. The question is: is this really so? Does distance education work better for others as it is opposed to others? Do students' assessments in distance education differ from that in the traditional classroom? Although there are many empirical studies regarding the debate on this phenomenon worldwide [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15], there is very little or no existing study about it in Ghana. It is against this backdrop that this study examines the performance of both distance and regular pre-service teachers in English Language, Mathematics and Science (EMS) courses.

Empirically, several researchers [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15] conclude that "distance education" courses are as efficient as the traditional "face-to-face courses". These studies reported that students' attainment in distance education could be regarded as good as that of students in the "face-to-face" courses. Some studies have also affirmed that students' attainment in distance education settings will have a more positive drift than in the traditional face-to-face settings in the near future [7, 15]. It has also been proven that distance education students perform well when compared to on-campus face-to face students, either showing no significant differences or slight increase in class grades [13 14]. Some researchers found a statistically significant learning difference between distance education learners and traditional face-to-face learners in the following variables: reading comprehension with ($p < 0.04$) and academic

product of the full-time regular degree programme [2].

Learning occurs as much as in distance education as it does in traditional or regular education programmes. Notwithstanding, a serious argument has been waged as to which model of teacher education is better. This success with ($p < 0.03$) [6]. Two scholars investigated students' performance in an introductory statistic in two (2) learning modes (traditional and flexible learning environments) [8]. They observed that there were no differences in performance outcomes between the two learning modes with a p-value of 0.25 and 0.14 for traditional and flexible learning environments, respectively. A study compared students' final scores in "distance education" with those in traditional classes, resulted in an overall effect size of 0.37 [12]. They concluded that the final academic performance grades of students enrolled in distance education programs are lower than those enrolled in the traditional face- to face programs. Likewise, a number of researchers reviewed the literature of empirical studies between 1985 and 2002, which focused on investigating the effectiveness of distance education compared with its traditional classroom-based counterparts [4]. They found that there was a small but significant effect favouring traditional; face-to-face education conditions.

Materials and Methods

The analytical cross-sectional survey design was adopted for the study. The target population for this study was all Diploma in Basic Education (DBE) students who were pre-service teachers of Accra College of Education and the College of Distance Education at Papafio Hills, both of University of Cape Coast. A total of 455 students consisting of 299 regular (full-time) and 156 distance education students were selected through census, purposive and convenient sampling techniques for the study. Only pre-service teachers offering general courses were purposively sampled. Only second year group of colleges of education students were conveniently sampled for the study. Questionnaire with Cronbach's alpha reliability coefficient (α) of 0.81 was used to gather data from the 455

students. Students were requested to provide their index (ID) numbers on the completed questionnaires. The purpose of the ID on the questionnaires was to trace their scores in the examination. After collecting all the completed questionnaires, 455 ID numbers were obtained with 299 from regular students whilst 156 were obtained from distance students. The researcher purposely picked the examination scores of those students for analysis. Multivariate analysis of data collected. Thus, quantitative data which involved pre-service teachers' end of semester scores were used in this study. It involved the scores of

$$X_{ij} = \mu + \tau_i + \ell_{ij}, \quad j = 1, 2, \dots, n_i \text{ and } i = 1, 2, \dots, g$$

Where ℓ_{ij} are independent $N_p(0, \Sigma)$ variables. The parameter vector μ is an overall mean and τ_i represent the i^{th} interaction effect with

$$(\bar{X}_{\ell j} - \bar{X})(\bar{X}_{\ell j} - \bar{X})' = [(\bar{X}_{\ell j} - \bar{X}_{\ell}) + (\bar{X}_{\ell} - \bar{X})][(\bar{X}_{\ell j} - \bar{X}_{\ell}) + (\bar{X}_{\ell} - \bar{X})]' =$$

A "vector" of observations may be decomposed as below:

$$X_{ij} = \bar{X} + (\bar{X}_{\ell} - \bar{X}) + (\bar{X}_{\ell j} - \bar{X}_{\ell}) + \tau_{\ell ij}$$

$$\begin{pmatrix} \text{Observation} \\ \text{Observation} \end{pmatrix} = \begin{pmatrix} \text{overall sample mean} \\ \mu \end{pmatrix} + \begin{pmatrix} \text{estimated interaction effect} \\ \tau_{\ell} \end{pmatrix} + \begin{pmatrix} \text{residual} \\ \tau_{\ell ij} \end{pmatrix}$$

The decomposition in the equation above leads to the multivariate analogue of the univariate sum of squares.

Thus the product $(\bar{X}_{\ell j} - \bar{X})(\bar{X}_{\ell j} - \bar{X})'$ can be written as

$$\begin{aligned} (\bar{X}_{\ell j} - \bar{X})(\bar{X}_{\ell j} - \bar{X})' &= [(\bar{X}_{\ell j} - \bar{X}_{\ell}) + (\bar{X}_{\ell} - \bar{X})][(\bar{X}_{\ell j} - \bar{X}_{\ell}) + (\bar{X}_{\ell} - \bar{X})]' \\ &= (\bar{X}_{\ell j} - \bar{X}_{\ell})(\bar{X}_{\ell j} - \bar{X}_{\ell})' + (\bar{X}_{\ell j} - \bar{X}_{\ell})(\bar{X}_{\ell} - \bar{X})' + (\bar{X}_{\ell} - \bar{X})(\bar{X}_{\ell j} - \bar{X}_{\ell})' + (\bar{X}_{\ell} - \bar{X})(\bar{X}_{\ell} - \bar{X})' \end{aligned}$$

The sum of j of the middle two expressions is the zero matrix, because

$$\sum_{j=1}^{n_{\ell}} (\bar{X}_{\ell j} - \bar{X}_{\ell}) = 0$$

Hence summing the cross product over ℓ and j yields.

$$\sum_{\ell=1}^g \sum_{j=1}^{n_{\ell}} (X_{\ell j} - \bar{X})(X_{\ell j} - \bar{X})' = \sum_{\ell=1}^g n_{\ell} (\bar{X}_{\ell} - \bar{X})(\bar{X}_{\ell} - \bar{X})' + \sum_{\ell=1}^g \sum_{j=1}^{n_{\ell}} (\bar{X}_{\ell j} - \bar{X}_{\ell})(\bar{X}_{\ell j} - \bar{X}_{\ell})'$$

of squares and sum of squares and cross sum of squares and

The within cross products and cross products matrix can be expressed as

$$W = \sum_{\ell=1}^g \sum_{j=1}^{n_{\ell}} (X_{\ell j} - \bar{X})(X_{\ell j} - \bar{X})' = (n_1 - 1)S_1 + (n_2 - 1)S_2 + \dots + (n_g - 1)S_g$$

Where S_{ℓ} is the sample covariance matrix for the ℓ^{th} sample.

To test for interaction effects:

$$H_0: \text{all } \tau_i = 0$$

$$H_a: \text{not all } \tau_i \text{ equal zero}$$

Results

English contents, English methodology, Mathematics content, Mathematics methodology, Science content and Science methodology were considered as dependent variables whereas category of learning mode with two levels-regular and distance, was treated as the main independent variable. Variables like gender, age, were treated as concomitant (blocking) variables. Multivariate Analysis of Variance (MANOVA) was applied. The MANOVA was performed as a statistical model to measure differences in academic performance. The model is given below:

Table 1: Descriptive statistics of the scores for regular and distance modes (n = 455)

Learning mode		English content	Maths content	Science content	English methods	Math Methods	Science methods
Regular	Mean	55.91	60.54	63.76	63.78	70.18	54.58
	Std. Dev.	10.56	12.79	10.70	9.79	8.62	10.23
Distance	Mean	58.90	55.64	54.56	59.17	48.42	60.28
	Std. Dev.	14.83	14.88	14.55	14.14	17.08	12.33
Total	Mean	56.93	58.86	60.61	62.20	62.72	56.53
	Std. Dev.	12.26	13.73	12.90	11.66	15.98	11.31

In Table 1, the mean scores in English content are 55.91 and 58.90 for Regular and Distance, respectively. The means scores in mathematics content are 60.54 and 55.64 for Regular and Distance students respectively. In the same vein, the means scores in Science content are 63.76 and 54.56 for Regular and Distance. In the methodology courses for the English, Mathematics and Science, the mean scores

recorded for Regular were 63.78, 70.18 and 54.58, whilst the Distance mode recorded 59.17, 48.42 and 60.28. From the table, Distance Education pre-service teachers had very high standard deviations showing high variations between their scores. This indicates that the regular pre-service teachers had their scores with comparatively lower variations.

Table 2: Descriptive statistics of the scores by gender/sex for regular and distance modes (n = 455)

Gender		English content	Maths content	Science content	English methods	Maths methods	Science methods
Male	Mean	56.19	59.66	60.3	62.21	64.12	56.5
	Std. Dev.	12.11	13.21	13.11	10.73	15.37	11.28
Female	Mean	57.99	57.72	61.05	62.20	60.74	56.58
	Std. Dev.	12.42	14.38	12.62	12.90	16.64	11.38

The score for English content was 57.95 and 59.87 for male and female respectively, showing that the females performed a little better in the English content than the males. The mean scores for male and female students in Mathematics content recorded 54.93 and 56.36 respectively, also showing that the males performed a little better in the Mathematics content than the males. In Science content, it recorded 54.67 and 54.45 for male and female students respectively. With the methodology courses in English Language, Mathematics and Science, males recorded 60.06, 48.73, and 60.49 respectively whilst the females recorded 58.31, 48.10 and 60.05 respectively.

Generally, the mean scores in English Language, Mathematics and Science content for males recorded 56.19, 59.66 and 60.3 respectively whilst for females; it recorded 57.99, 57.72 and 61.05. In the methodology courses for English Language, Mathematics and Science, the mean scores recorded for males were 62.21, 64.12 and 56.5 whilst the females recorded 62.20, 60.74 and 56.58. From the Table 2, the females had a higher standard deviation in mathematics content showing that some of the females had higher marks whilst others also had very low marks. It could also be seen that in English language, the standard deviations were almost the same showing almost the same variations.

Table 3: Multivariate analysis (English Language) of examination scores of regular and distance students: Full model (n = 455)

Source of Variation	Dependent Variable	Degrees of freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept	ELC	1	139096.10	962.62	0.00
	ELM	1	136854.80	1115.72	0.00
Q6	ELC	1	17.89	0.12	0.73
	ELM	1	608.31	4.96	0.02*
Q1	ELC	1	50.11	0.35	0.56
	ELM	1	40.54	0.33	0.57
Q2	ELC	3	590.22	4.09	0.01**
	ELM	3	12.38	0.10	0.96
Q6*Q1	ELC	1	222.27	1.54	0.22
	ELM	1	16.87	0.14	0.71
Q6*Q2	ELC	2	565.46	3.91	0.02*
	ELM	2	63.23	0.52	0.60
Q1*Q2	ELC	3	304.96	2.11	0.10
	ELM	3	72.14	0.59	0.62**
Q6*Q1*Q2	ELC	1	82.77	0.57	0.45
	ELM	1	11.68	0.10	0.76

Note: * *p*-value for learning modes; ** *p*-value for learning modes by gender

Table 4: Multivariate analysis (English Language) of examination scores of regular and distance students: Full model (n = 455)

Source of Variation	Dependent Variable	Degrees of freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept	ELC	1	136236.51	927.77	0.00
	ELM	1	116852.70	962.32	0.00
Q6	ELC	1	325.34	2.22	0.14
	ELM	1	530.67	4.37	0.04*
Q7	ELC	1	266.51	1.82	0.18
	ELM	1	200.22	1.65	0.20
Q2	ELC	3	501.04	3.41	0.02*
	ELM	3	120.22	0.99	0.40
Q6*Q7	ELC	1	93.38	0.64	0.43
	ELM	1	160.15	1.32	0.25
Q6*Q2	ELC	2	114.61	0.78	0.46
	ELM	2	48.11	0.40	0.67
	ELC	2	108.86	0.74	0.48

Q7*Q2	ELM	2	101.57	0.84	0.43
	ELC	1	35.84	0.24	0.62
Q6*Q7*Q2	ELM	1	49.56	0.41	0.52

In Tables 3 and 4, the differences in final scores of English Language with regard to gender was statistically significant with p-value of 0.01 but with English methodology, it was not statistically significant with regard to gender ($p=0.62$). This means that the differences in final scores of English Language was significant for male and female whilst English methods for male and female students was not significant. For the final

scores of English Language and English methodology with regard to mode of learning, that is regular and distance, the differences in scores were statistically significant for the English Language ($p=0.02$) This is to say that, there were significant differences in final scores between regular and distance learning modes in the English Language examination scores.

Table 5: Multivariate analysis (Mathematics) of examination scores of regular and distance students: Full model (n = 455)

Source of Variation	Dependent Variable	Degrees of freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept	SMC	1	871596.4	4756.199	0.00
	SMM	1	940205.3	6300.731	0.00
Q6	SMC	1	998.961	5.451	0.02*
	SMM	1	32116.39	215.226	0.01*
Q1	SMC	1	3.122	0.017	0.896**
	SMM	1	13.341	0.089	0.765**
Q7	SMC	1	199.042	1.086	0.298
	SMM	1	36.656	0.246	0.62
Q6*Q1	SMC	1	77.637	0.424	0.515
	SMM	1	152.433	1.022	0.313
Q6*Q7	SMC	1	22.995	0.125	0.723
	SMM	1	18.541	0.124	0.725
Q1*Q7	SMC	1	16.074	0.088	0.767
	SMM	1	115.078	0.771	0.38
Q6*Q1*Q7	SMC	1	183.598	1.002	0.317
	SMM	1	397.493	2.664	0.103

Note: * p -value for learning modes; ** p -value for learning modes by gender

In Table 5, the differences in final scores of mathematics content and mathematics methodology with regard to gender were not statistically significant. The p -values are 0.896 and 0.765 for mathematics content and mathematics methodology, respectively. This means that the differences in final scores of mathematics content and mathematics methodology for male and female students were not significant.

For the final scores of mathematics content and mathematics methodology in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores were statistically significant with the following p -values: 0.02 and 0.01 for mathematics content and mathematics methodology respectively. This is to say that, there were significant differences in final scores between regular and distance learning modes.

Table 6: Multivariate analysis (Mathematics) of examination scores of regular and distance students by age distribution: Full model (n = 455)

Source of Variation	Dependent Variable	Degrees of freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept	SMC	1	140843.60	774.98	0.00
	SMM	1	150722.00	1017.25	0.00
Q6	SMC	1	12.63	0.07	0.79
	SMM	1	2397.24	16.18	0.01*
Q1	SMC	1	349.28	1.92	0.16
	SMM	1	306.00	2.07	0.15
Q2	SMC	3	83.11	0.46	0.71
	SMM	3	153.19	1.03	0.37
Q6*Q1	SMC	1	18.15	0.10	0.75
	SMM	1	280.37	1.89	0.17
Q6*Q2	SMC	2	143.05	0.79	0.45
	SMM	2	272.60	1.84	0.16
Q1*Q2	SMC	3	278.24	1.53	0.20
	SMM	3	297.43	2.01	0.11
Q6*Q1*Q2	SMC	1	61.65	0.34	0.56
	SMM	1	169.25	1.14	0.28

In Table 6, the differences in final scores of mathematics content and mathematics methodology with regard to age were not statistically significant. The p-values are 0.71 and 0.37 for mathematics content and mathematics methodology, respectively. This means that the differences in final scores of mathematics content and mathematics methodology for the various age groups of students were not significant. For the

final scores of mathematics content in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores were not statistically significant with the p-values: 0.79 but was significant for mathematics methodology with p-value 0.01. This is to say that, there were significant differences in final scores between regular and distance learning modes regarding mathematics methodology.

Table 7: Multivariate analysis (Science) of examination scores of regular and distance students: Full model (n = 455)

Source Variation	of	Dependent Variable	Degrees of freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept		SSC	1	136236.51	927.77	0.00
		SSM				
Q6		SSC	1	116852.70	962.32	0.00
		SSM	1	325.34	2.22	0.14
Q7		SSC	1	530.67	4.37	0.04*
		SSM	1	266.51	1.82	0.18
Q2		SSC	1	200.22	1.65	0.20
		SSM	3	501.04	3.41	0.02*
Q6*Q7		SSC	3	120.22	0.99	0.40
		SSM	1	93.38	0.64	0.43
Q6*Q2		SSC	1	160.15	1.32	0.25
		SSM	2	114.61	0.78	0.46
Q7*Q2		SSC	2	48.11	0.40	0.67
		SSM	2	108.86	0.74	0.48
Q6*Q7*Q2		SSC	2	101.57	0.84	0.43
		SSM	1	35.84	0.24	0.62
			1	49.56	0.41	0.52

In Table 7, the differences in final scores of Science content with regards to gender was significant with p-value of 0.01 but with Science methodology, it was not statistically significant with regard to gender with p-value of 0.96. This means that the differences in final scores of Science content was significant for male and female whilst Science content for male and female students was not significant.

For the final scores of Science content and

Science methodology in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores was also statistically significant for the Science content with the (p=0.03). Just like with gender, Science methodology, was not significant by recording a p-value of 0.56. This is to say that, there were significant differences in final scores between regular and distance learning modes with regards to Science content. For the final scores of Science content and Science methodology in connection

with category of learning mode, thus regular and distance, it can be seen that differences in scores

Discussions

The study found that distance education pre-service teachers had very high standard deviations showing high variations between their scores. This indicates that the regular pre-service teachers had their scores with comparatively lower variations. That notwithstanding, there was slightly significant difference in the performance in favour of the regular face-to-face mode which is in support with [4,12]. It came to light that females had a higher standard deviation in mathematics content showing that some of the females had higher marks whilst others also had very low marks. The results of the study also revealed that the standard deviations for English language were almost the same. There were statistically significant differences in scores for English Language by mode of learning, that is regular and distance ($p=0.02$). Similarly, there was statistically significant gender differences in final scores of English Language content ($p=0.01$) and methodology ($p=0.62$) courses with regard to mode of learning. For the final scores of mathematics content and mathematics methodology in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores were statistically significant with the following p-values: 0.02 and 0.01 for mathematics content and mathematics methodology respectively. This is to say that, there were significant differences in final scores between regular and distance learning modes. For the final scores of mathematics content in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores were not statistically significant with the p-values: 0.79 but was significant for mathematics methodology with a p-value of 0.01. This is to say that, there were significant differences in final scores between regular and distance learning modes regarding mathematics methodology. For the final scores of Science content and Science methodology in connection with category of learning mode, thus regular and distance, it can be seen that differences in scores was also statistically significant for the Science content with ($p < 0.02$).

was also statistically significant for the Science content with ($p < 0.02$).

Evidence gathered from the study indicated that there is statistically significant differences in pre-service teachers' performance scores in English Language, Mathematics and Science content and methodology courses with regard to regular and distance learning modes in Ghana. These findings are parallel to the views of several researchers who concluded that distance education courses are as effective and efficient as the traditional face-to-face courses [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15]. On running the full model of the data collected using "MANOVA", it was realized that the mean score for females in both English content and methodology were somehow higher than that of the males showing that the females performed a little better in the English than the males. Contrarily, the opposite occurred in the quantitative subjects like mathematics and science. Findings from this research have shown that differences in means of English content, English methodology, Mathematics content, mathematics methodology, Science content and science methodology with regard to mode of learning were statistically significant. Though, it has been known from the findings that female students on average performed better than male students in English language, the males averagely performed better in all the three subjects.

Conclusions

The study concludes that distance, part-time, sandwich (summer school) education programmes are equally effective and efficient means of education and training of pre-service teachers in Ghana just as the regular or traditional mode of teacher education and training though it recorded slight differences. Based on the findings of this research, it is recommended that policy makers including the Ministry of Education and the National Council on Tertiary Education in liaison with Ghanaian universities should give similar attention to distance education just as it is done to the regular pre-service teacher education programmes in Ghanaian colleges of education. The Ministry of Education should re-visit the national policy on science and mathematics education for females initiated by the Government

of Ghana so as to motivate female students to develop interest in quantitative courses like mathematics and science right from the basic level.

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