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Research Article

Multinomial Regression Analysis of Patronage of Online Learning by Teacher Trainees: The Case of a College Education in Ghana

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ABSTRACT

The outbreak of the COVID-19 pandemic has necessitated the shift from face-to-face lecture delivery to online mode of delivery in most countries across the world including Ghana. There is the growing need to study the patronage of the students in online learning to improve practice. The data of 323 observations consisting of first and second year students was collated by virtual learning team of Ada College of education, Ghana. Multinomial regression was used for the analysis. The dependent variable had 3 levels and the predictor variables were sex and programme of study with 2 and 3 levels respectively. Female students were found to be 0.784 times more likely than males to have smart phone but with no access to online lectures. Primary education students were found to be 1.287 times less likely to belong to the category of students with no smart phone to access online lesson than the reference category of students with smart phone that have access online lesson. Students who offer visual arts programme were found to be 1.420 times less likely to belong to the category of students with no smart phone to access online lesson than the reference category. It was also found that students who study degree in mathematics as a major were 1.423 time less likely to have a smart phone but no access to online lessons than the reference category. The study recommended for the management of the college to consider the findings of this research to offer hard copy notes, exercises and assignments to the identified students with low patronage of online learning.

Keywords: Online learning; Multinomial regression; College of education; Ghana

INTRODUCTION

In order to forestall the disruptions and interruptions in students' learning and assessment arising from global lockdown of educational institutions due to the COVID-19 pandemic, Ghana's universities which hitherto mainly offered face-to-face teaching have now shifted to online teaching learning as an interventionary measure. This mode of teaching and learning, although untested and unprecedented in some countries such as Ghana seem to be the only alternative [1].

Developed nations such as Korea and China, have reported that their implementation of internet-based learning was marred with problems such as insufficient proper course monitoring, inadequate feedback to learners; poor instructional design; poor training for instructors; lack of necessary technology; poor Internet accessibility; inadequate online resources; high costs and lack of credibility for online degrees, in general [2]. Scott, found that mobile learning method (rather than internet-based learning) which involve use of cell-phones for both formal and informal learning will be most appropriate for African countries. This is because the technology is more affordable; learners are familiar with it and with proper instructional design it promises educational opportunities with an increased flexibility for learners, satisfying the 'anytime/anywhere' component of distance education for thousands if not millions of learners [3].

Asampana, et al., in employed multinomial logistic regression model in the analysis of the determinants of students' academic performance in mathematics. They found sex of students to be a significant predictor of good performance in mathematics.

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To that end, male students outperform their female counterparts in the subject of mathematics. They also found age to be another significant predictor; where younger students outperform older ones [4]. Naderi, et al., used multinomial logistic regression to examine the relationship of gender and self-esteem variables in academic achievement of undergraduate students. Their findings suggested a strong significant relationship between self-esteem and academic achievement when gender is controlled [5].

Bosson-Amedenu, et al., used multinomial logistic regression to examine district level health insurance data in Ghana. As part of their findings, pregnant women were five (5.400) times significantly more likely to renew their NHIS compared to the reference category. The informal category was found to be seven (7.400) times significantly more likely to renew their NHIS than the reference category. Children aged four and below were also found to be two times (2.067) significantly more likely to renew their NHIS than the reference category [6].

Ari, et al., also examined the factors affecting the types of domestic violence against women using multinomial logistic regression model. In terms of odds ratios, the variables of "education level of woman" and "husband's work sector" were statistically significant in only comparison one; the variables of "agnation with husband, "education level of husband", "frequency of seeing drunk husband" and "frequency of gambling of husband" were statistically significant in both comparison one and three; the variables of "region", "deceived by husband", "common-law female for husband" were statistically significant in all comparisons [7].

MATERIALS AND METHODS

The data of 323 observations was collated by virtual learning team of Ada College of education. The data consisted of first and second year students and information on their access to online lectures. Multinomial logistic regression was used for the analysis. The dependent variable (condition) had three levels (smart phone with access, smart phone with no access and no smart phone with no access). The independent variables were gender (male or female) and programme (primary education, science related degree, visual arts degree, maths degree and technical degree levels). IBM SPSS Statistics version 25 was used for the analysis [8].

Multinomial logit model

Consider the response variable of three levels with say A, B and C and predictor variables x_1, x_2 and x_3, the multinomial logit model is in effect simultaneously estimating binary logits among all pairs of outcome categories, including:

$$In\left[\frac{\Pr(A|x)}{\Pr(C|x)}\right] = \beta_{0,A|C} + \beta_{1,A|C}x_1 + \beta_{2,A|C}x_2 + \beta_{3,A|C}x_3$$

$$In\left[\frac{\Pr(B|x)}{\Pr(C|x)}\right] = \beta_{0,B|C} + \beta_{1,B|C}x_1 + \beta_{2,B|C}x_2 + \beta_{3,B|C}x_3$$

$$In\left[\frac{\Pr(A|x)}{\Pr(B|x)}\right] = \beta_{0,A|B} + \beta_{1,A|B}x_1 + \beta_{2,A|B}x_2 + \beta_{3,A|B}x_3$$

Three more equations could be listed, comparing C to A, C to B and B to A. Given that the sum of the probabilities for the outcomes must be equal to 1, there is implicit constraints on the three logits. Specifically,

$$In\left[\frac{\Pr(A|x)}{\Pr(C|x)}\right] - In\left[\frac{\Pr(B|x)}{\Pr(C|x)}\right] = In\left[\frac{\Pr(A|x)}{\Pr(B|x)}\right]$$

In terms of parameters,

$$\beta_{k,A|C} - \beta_{k,B|C} = \beta_{k,A|B}$$

RESULTS AND DISCUSSION

Table 1 show that 323 respondents were used as sample. From this output, 16.4% had no smart phone to access online lecture. Another 45.5% had smart phone but did not partake in the lecture due to mobile network related issues and lack of internet bundle. Only 38% of the respondents who had smart phones could partake in the lecture [9].

Approximately 42% of the respondents were female and 58% were male. The respondents belonged to five (5) programme categories including primary education (24.5%), bachelor of science education (41.2%) and bachelor of mathematics education (6.5%). Others were bachelor of technical education (16.1%) and bachelor of visual arts education (11.8%).

Table 1: Case processing summary.

Variables		N	Marginal percentage
Condition	No smart phone	53	16.4%
	No access	147	45.5%
	Smart phone with access	123	38.1%
Gender	Female	135	41.8%

	Male	188	58.2%
Programme	Primary	79	24.5%
	Science	133	41.2%
	Visual	38	11.8%
	Math	21	6.5%
	Tech	52	16.1%
Valid		323	100.0%

The difference between the -2 log-likelihoods of the null and final models is represented by the *chi-square* statistic. Since the significance level of the test is less than 0.05, we reject the null hypothesis and conclude that the final model is outperforming the null model (Table 2) [10].

Table 2: Model fitting information.

Model	Model fitting criteria-2 log likelihood	Likelihood ratio tests		
		Chi-square	**df**	**Sig.**
Intercept only	113.078	-	-	-
Final	73.23	39.849	10	0

Table 3 is the goodness-of-fit table which tests the null hypothesis that the model adequately fits the data against the alternative hypothesis that the model does not fit the data adequately. The null hypothesis is true since the Pearson and Deviance statistics have significant values (*i.e.*, p>0.05).

Table 3: Goodness-of-fit.

Variables	*Chi-square*	df	Sig.
Pearson	11.371	8	0.182
Deviance	12.884	8	0.116

The Nagelkerke pseudo R-Square value of 0.133 is an indication that the model accounts for about 13% of the variance. This means there are more factors that affects students turning up for online lessons which have not been captured in this study (Table 4) [11].

Table 4: Pseudo R-square.

Variables	Pseudo R square value
Cox and Snell	0.116
Nagelkerke	0.133
McFadden	0.060

The likelihood ratio tests represent the product of -2 and the log likelihoods of the null model and "final" fitted model. It helps to ascertain whether all predictors' regression coefficients in the model are simultaneously zero and in tests of nested models. From Table 5, programme offered by students and their gender are significant contributors to the final model (p<0.05). Table 5, again shows the intercept cannot be tested in this model since the removal of the intercept would make redundant factor levels to become non-redundant [12].

Table 5: Likelihood ratio tests.

Effect	Model fitting criteria-2 log likelihood of reduced model	Likelihood ratio tests		
		Chi-square	df	Sig.
Intercept	73.230	0	0	0
Programme	93.66	20.43	8	0.009
Sex	87.381	14.151	2	0.001

No smart phone and no access

In Table 6, we treated the students who have smart phone and have online access to lecture as the referent category and so estimated a model for students with no smart phone who could not access lectures online relative to the reference category. Again, we estimated for students who have smart phone but could not access lectures online relative to the reference category. To this end, since the parameter estimates compared to the reference category, the standard interpretation of multinomial regression is that for a unit change in the predictor variable, the logit of outcome relative to the reference category is expected to change by its respective parameter estimate (which is in log-odds units) given the variables in the model are held constant.

Programme 1 (B.Ed primary education students) with estimated multinomial logistic regression coefficient of B=-1.287 means that for one point increase in B.Ed primary education students, the multinomial log-odds of having no smart phone to access online lectures compared to the reference category would be expected to decrease by 1.287 points while holding all other variables in the model constant. The Wald statistic for the predictor programme 1 was 6.124 with an associated p-value of 0.013. With alpha level at 0.05, we would reject the null hypothesis and conclude that the regression coefficient for B.Ed primary education students has been found to be statistically different from zero for students with no access to smart phone (for online lessons) to the reference category given that programme 2, programme 3, programme 4 and female are in the model [13].

Considering programme 2 (Science related programmes such as agricultural, home economics, etc.) with estimated multinomial logistic regression coefficient of B=-7.33 showed that for one point increase in enrollment from science related programmes, the multinomial log-odds of having no smart phone to access online lectures compared to the reference category would be expected to decrease by 7.33 points while holding all other variables in the model constant. The Wald statistic for the predictor programme 2 was 2.207 with an associated p-value of 0.137. With alpha level at 0.05, we would fail to reject the null hypothesis and conclude that for students with no access to smart phone (for online lessons) relative to the reference category, the regression coefficient for programme 2 has not been found to be significantly different from zero given programme 1, programme 3, programme 4 and female are in the model.

A one-unit increase in number of students offering programme 3 (visual arts) is associated with 1.420 decrease (B=-1.420) in the relative log odds of having no smart phone to access online lectures versus the reference category of having a smart phone with access to online lectures. The Wald statistic for the predictor programme 3 was 5.036 with an associated p-value of 0.025. With alpha level at 0.05, we would reject the null hypothesis and conclude that the regression coefficient for B.Ed visual arts has been found to be statistically different from zero for students with no access to smart phone (for online lessons) to the reference category given that programme 1, programme 3, programme 4 and female are in the model.

A one-unit increase in number of students offering programme 4 (mathematics majors areas) is associated with 0.869 decrease (B=-0.869) in the relative log odds of having no smart phone to access online lectures versus the reference category of having a smart phone with access to online lectures. The Wald statistic for the predictor programme 4 was 1.715 with an associated p-value of 0.190. With alpha level at 0.05, we would fail to reject the null hypothesis and conclude that for students with no access to smart phone (for online lessons) relative to the reference category, the regression coefficient for programme 4 has not been found to be significantly different from zero given programme 1, programme 2, programme 3 and female are in the model.

The relative log odds of belonging to the category of students who have no smart phone and could not access lectures online versus the reference category of having a smart phone with smart phone and access to online lectures will decrease by 0.373 if moving from the female to male gender. The Wald test statistic for the predictor female is 0.916 with an associated p-value of 0.339. With alpha level at 0.05, we would fail to reject the null hypothesis and conclude that for students with no access to smart phone (for online lessons) relative to the reference category, the regression coefficient for female has not been found to be significantly different from zero given programme 1, programme 2, programme 3 and programme 4 are in the model.

Smart phone but no access

Programme 1 (B.Ed primary education students) with estimated multinomial logistic regression coefficient of B=-1.221 means that for one unit increase in B.Ed primary education enrollments, the multinomial log-odds of having a smart phone but no access to online lectures compared to the reference category would be expected to decrease by 1.221 points while holding all other variables in the model constant.

The Wald statistic for the predictor programme 1 was 7.916 with an associated p-value of 0.005. With alpha level at 0.05, we would reject the null hypothesis and conclude that the regression coefficient for B.Ed primary education students has been found to be statistically different from zero for students with smart phone but no access to online lessons to the reference category given that programme 2, programme 3, programme 4 and female are in the model.

For the case of programme 2 (Science related programmes such as agricultural, home economics, etc.), the estimated multinomial logistic regression coefficient of B=-0.278 is an indication that that for one point increase in students in science related programmes, the multinomial log-odds of having a smart phone but with no access to online lectures compared to the reference category would be expected to decrease by 0.278 points while holding all other variables in the model constant. The Wald statistic for the predictor programme 2 was 0.457 with an associated p-value of 0.499. With alpha level at 0.05, we would fail to reject the null hypothesis and conclude that for students with smart phone (but no access to online lessons) relative to the reference category, the regression coefficient for programme 2 has not been found to be significantly different from zero given programme 1, programme 3, programme 4 and female are in the model.

A one-unit increase in number of students offering programme 3 (visual arts) is associated with 1.201 decrease (B=-1.201) in the relative log odds of having a smart phone but no access to online lectures versus the reference category of having a smart phone with access to online lectures. The Wald statistic for the predictor programme 3 was 5.719 with an associated p-value of . 017. With alpha level at 0.05, we would reject the null hypothesis and conclude that the regression coefficient for B.Ed visual arts has been found to be statistically different from zero for students with smart phone but no access (for online lessons) to the reference category given that programme 1, programme 2, programme 4 and female are in the model.

A one-unit increase in number of students offering programme 4 (Mathematics majors areas) is associated with 1.423 decrease (B=-1.423) in the relative log odds of having a smart phone but no access online lectures versus the reference category of having a smart phone with access to online lectures.

The relative log odds of belonging to the category of students who have smart phone but could not access lectures online versus the reference category of having a smart phone with access to online lectures will increase by 0.784 if moving from the female to male gender.

Table 6: Parameter estimates.

Condition[a]		B	Std. error	Wald	df	Sig.	Exp (B)	95% Confidence interval for Exp (B)	
								Lower bound	Upper bound
No smart phone	Intercept	0.12	0.388	0.095	1	0.758	-	-	-
	(Programme=1.00)	-1.287	0.52	6.124	1	0.013	0.276	0.1	0.765
	(Programme=2.00)	-0.733	0.493	2.207	1	0.137	0.481	0.183	1.264
	(Programme=3.00)	-1.42	0.633	5.036	1	0.025	0.242	0.07	0.835
	(Programme=4.00)	-0.869	0.663	1.715	1	0.19	0.42	0.114	1.54
	(Programme=5.00)	0[b]	0	0	0	0	0	0	0
	(Sex=1)	-0.373	0.39	0.916	1	0.339	0.689	0.321	1.479
	(Sex=2)	0[b]	0	0	0	0	0	0	0
No access	Intercept	0.497	0.348	2.034	1	0.154			
	(Programme=1.00)	-1.221	0.434	7.916	1	0.005	0.295	0.126	0.69
	(Programme=2.00)	-0.278	0.411	0.457	1	0.499	0.757	0.339	1.695
	(Programme=3.00)	-1.201	0.502	5.719	1	0.017	0.301	0.112	0.805
	(Programme=4.00)	-1.423	0.644	4.881	1	0.027	0.241	0.068	0.852

(Programme=5.00)	0[b]	0	0	0	0	0	0	0
(Sex=1)	0.784	0.27	8.433	1	0.004	2.19	1.29	3.716
(Sex=2)	0[b]	0	0	0	0	0	0	0

Note: [a]The reference category is: Smart phone with access; [b]This parameter is set to zero because it is redundant

CONCLUSION

The main objective of this study was to examine the patronage of online teaching and learning by College of Education students in Ghana using multinomial regression. With reference to the studies in the introduction, it was evident that use of mobile phones as a medium of teaching and learning for African countries such as Ghana was apt; especially during these trying times of COVID-19 pandemic. To this end, the response variable had three levels, namely; 1) access to smart phone and able to participate in online lessons (reference category), 2) access to smart phone but unable to partake in online lectures and 3) no access to smart phone and unable to access lectures online. The predictor variables were sex and programme of enrolment. From the results, female students were found to be 0.784 times more likely than males to have smart phone but with no access to online lectures. Primary education students were found to be 1.287 times less likely to belong to the category of students with no smart phone to access online lesson than the reference category of students with smart phone that have access online lesson. Students who offer visual arts programme were found to be 1.420 times less likely to belong to the category of students with no smart phone to access online lesson than the reference category. It was also found that students who study degree in mathematics as a major were 1.423 time less likely to have a smart phone but no access to online lessons than the reference category.

RECOMMENDATION

The study recommended for the management of the college to consider the findings of this research to offer hard copy notes, exercises and assignments to the identified students with low patronage.

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