Longitudinal Analysis of the Differences in Performances of Telecommunications and Electrical Engineering Students of Makerere University

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***Abstract*—**Makerere University is one of the few leading institutions of higher learning in Africa. Engineering students are admitted to various degree programmes in the College of Engineering, Design, Art and Technology, CEDAT. In 2010, the university set up an ad-hoc committee to review and restructure all its degree programmes. The committee found that electrical and telecommunications engineering programmes in the Department of Electrical and Computer Engineering were the same. The purpose of the study was to establish if there were significant differences in the performances of a cohort of 2004/5 students admitted on the two degree programmes. Multistage random sampling was done to identify 33 telecommunications and 29 electrical engineering students. The objective was to track the changes in their performances, as measured by the Cummulative Grade Point Average (CGPA) attained at the end of every academic year. Multilevel data analysis methods were used for the analysis of the longitudinal data which were used for fitting three individual growth models: fully unconditional means model (Model A), fully unconditional growth model (Model B) and fully conditional growth model (Model C). The difference in deviances of the models was used for hypotheses testing. Results showed that by comparing Models B and C, it was found that there was a significant difference in performances between the two degree programmes (deviance difference 10.0647, 2df, $p < 0.005$). It was found that a cohort of 2007/8 telecommunications students were not taught 12 courses that were not related to their field. Yet these courses appeared in the curriculum.

While the contents of the two degree programmes were the same, the Department was teaching the telecommunication engineering students differently by ignoring some courses in the curriculum. Further analysis also revealed that the Telecommunications programme was approved by the University Council but the establishment was not approved. The staff who were employed to teach electricat engineering programme were overstretched to teach the new telecommunication engineering programme. Therefore, there were no dedicated staffs to teach telecommunication engineering students. The paper concludes by recommending that the University should do the following:

a) Strengthen its organs involved in approval of new degree programmes

b) improve supervision of delivery of curriculum and

c) approve new programmes together with their staff establishments.

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I. Introduction

A. Background

Makerere University is the most dominant tertiary institution in Uganda. The University admits engineering students into the College of Engineering, Design, Art and Technology- CEDAT. In CEDAT, the Department of Electrical and Computer engineering has three degree programmes- electrical, telecommunications and computer engineering. Each of these degree programmes was introduced at different stages of the development of the College. Electrical engineering programme was one of the traditional programmes introduced by the university in 1967 at the inception of the then Faculty of Technology (now CEDAT). Due to liberalization and privatization of the telecommunications sector in Uganda in the 1990s, the Telecommunications Engineering programme was started in 2004. The Bachelor of Science in Computer Engineering programme was approved in 2009.

In 2010, Makerere University set up an adhoc committee on academic programmes restructuring to study and recommend which degree programmes should be retained, restructured, merged or scrapped all together. In the ad-hoc committee report [1], one of the observations of the adhoc committee was that *'Every course in Bachelor of Science in Telecommunications Engineering existed in Bachelor of Science in Electrical Engineering'*. Consequently, the committee recommended that the telecommunications degree programme be suspended until it was revised to portray the content of telecommunications engineering.

B. The Problem Statement

No study had been done to establish if there were significant differences in performances between the telecommunication and electrical engineering students. If the two degree programmes were the same, then the differences in performances of the students should not be statistically significant.

C. Objective of the Study

The aim of the study was to investigate the changes over time in performances of telecommunication and electrical engineering students.

II. Theoretical Frameworks

Investigating the changes in performances of students through time means that multilevel analysis methods should be used. Performances of students are normally measured in Cumulative Grade Point Averages (CGPAs) at the end of every semester. Students are repeatedly examined eight times before successful ones are allowed to graduate at the end of the four years of engineering training. Repeated measures on the same subjects through time makes the study a longitudinal one. In longitudinal studies, there are two levels of analysis: level 1- the measurement occasions or (in this case -DURATION on the programme by a student measured in semesters) and level-2 the individuals (in this study –the PROGRAMME of a particular student).

A. Model Specification

Analysis of such longitudinal data is done by fitting the composite fully conditional individual growth model adopted from [2] and [3].

$$Y_{ij} = [\gamma_{00} + \gamma_{01} * PROGRAMME_i + \gamma_{10} * DURATION_{ij} + \gamma_{11} * PROGRAMME_i * DURATION_{ij}] + [\zeta_{0i} + \zeta_{1i} * DURATION_{ij} + \varepsilon_{ij}] \quad (1)$$

where Y_{ij} denotes the score of student i during semester j; ε_{ij} are residual errors of student i during semester j; π_{0i} is the student i's true initial average standardized score (at baseline when $DURATION_{ij}$=0). It is the intercept. While π_{1i} is the rate of change of the student i's score in a particular subject. This is the slope or gradient. It shows the rate of change in performance of a student with increasing number of semesters. γ_{00} and γ_{10} are Level-2 intercepts while γ_{01} and γ_{11} are differences in Level-2 average rates of change or slopes. Level-2 residuals ζ_{0i} and ζ_{1i} are also assumed to be independent and identically (multivariate normality) distributed with zero expected mean values and variances σ_0^2, σ_1^2 and covariance $\sigma_{10} = \sigma_{01}$. These residuals are deviations of individual change trajectories around the population averages, where $\begin{bmatrix} \varsigma_{0i} \\ \varsigma_{1i} \end{bmatrix} \sim iidMVN\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{10} & \sigma_1^2 \end{bmatrix} \right)$. It is further assumed that Level-2 residuals ζ_{0i} and ζ_{1i} are independent of Level-1 errors ε_{ij} for all i and j. Since there are two Level-2 residuals, *bivariate* normality is assumed.

There are eight parameters to be determined from the composite model above: γ_{00}, γ_{10}, γ_{01} and γ_{11} are called *fixed effects* while random error variances σ_e^2, σ_0^2 and σ_1^2 and covariance $\sigma_{10} = \sigma_{01}$ are called *random effects* parameters.

B. Model Fitting

The above composite model (1) can be fitted to data collected resulting in the following individual growth models:

a. Fully Unconditional Means Model (Model A) -a model with no predictors at either level.
b. Unconditional Growth Model (Model B) -a model with level-1 predictor variable DURATION added.
c. Fully Conditional Growth Model (Model C)- a model with variables at both levels; DURATION and PROGRAMME.

C. Hypothesis to be Tested

Deviance statistics is used for comparing nested models. For normally distributed errors, deviance is the Sum of Squares of residual errors.

$$Deviance = total\ variance.(n-1), \ldots\ldots (2)$$

where n is the average sample size per group of students. To answer the research question in this study, Model B can be obtained from Model C by invoking two constraints hence 2 degrees of freedom. The null hypotheses are

$H_0 : \gamma_{01} = 0;\ \gamma_{11} = 0$ where γ_{01} and γ_{11} are differences in Level-2 average intercepts and rates of change or slopes respectively.

The difference between the deviances of Models B and C has a chi-squared distribution with 2 df.

D. Research Ethics

To avoid disclosing the identities of the students, unique numbers were assigned to the participants in the study.

III. Methodology

A. Research Approach

During the four years of engineering training, the students were repeatedly examined at the end of every semester. Therefore, every academic year the students were examined twice since there are two semesters in an academic year. The performances of the students in terms of Cumulative Grade Point Average (CGPA) were recorded at the end of each semester. In this study, only results at the end of each academic year were recorded, see Annex I. Note that there were missing marks since some students dropped out before completing their four-year training. Therefore, this was a retrospective, observational, quantitative social science research.

B. Population

Records from CEDAT Academic Registrar's office showed that a cohort of 107 telecommunication and 86 electrical engineering students were admitted into Makerere University in 2004/5 academic year. However, 28 telecommunication and 23 electrical engineering students did not report and lost their positions in the Department. Furthermore, at the end of first year, 10 telecommunication students had dropped out of the programme. Therefore, the sample was randomly taken from the remaining total population of 132 students.

C. Sampling Method

Multistage sampling was done to identify the participants that consisted of 33 telecommunication and 29 electrical engineering students.

D. Variables

Response Variables- these are the CGPA of every student at the end of a semester.

Independent Variables: In longitudinal studies, there are two levels of independent variables.

Level 1 Predictor is the DURATION of a student on the degree programme.

Level 2 Predictor is whether the student is a BENEFICIARY of the affirmative action or not.

E. Data Collection Method

The annual CGPA of each of the participants in the study was collected from the Academic Registrar's office, CEDAT (see Appendix 1).

F. Statistical Data Analysis Method

Multilevel statistical data analysis method was used for specifying individual growth models. The collected data was used for fitting the models

IV. Results

The results of the calculations of the fixed and variance components of the three models were recorded in table 1.

TABLE 1
RESULTS OF FITTING THE MODELS TO DATA

Fixed Effects		**Parameter**	**Model A**	**Model B**	**Model C**
Initial status, π_{0i}	Intercept	γ_{00}	3.2934	3.236	2.8262
	Differences in intercepts between the two groups of engineering students	γ_{01}			-0.8763
Rate of change,	Intercept	γ_{10}		-0.0156	-0.0319
	Differences in rates of change between the two groups of engineering students	γ_{11}			-0.0348
Variance Components					
Level-1	Within-person	σ_{ε}^2	1.96045	7.1397	7.1397
Level-2	In initial status	σ_0^2	0.54081	0.5798	0.2264
	In rate of change	σ_1^2		0.0283	0.046
	Covariance	$\sigma_{10} = \sigma_{01}$		-0.0169	-0.0316
Goodness of fit statistics		Deviance	75.0378	232.434	222.37

Hypothesis testing using Deviance Statistics

Differences in deviances was calculated as

$\Delta Deviance = 232.434 - 222.3693 = 10.0647$ (2df, $p < 0.005$)

The null hypothesis was rejected. There was a highly significant difference in performances between the two groups of students.

V. Discussion

Hierarchical Linear Modeling (HLM) is a relatively new statistical procedure proposed by [4] which is suitable for the analysis of hierarchical or nested or correlated data. Different authors give this type of statistical methodology different names. Authors [5] call it Multilevel Analysis and define it as a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability. One example of multilevel data is the longitudinal data; these are repeated measurements done on the same unit through time. In this retrospective quantitative social science study, the same individuals or students were examined on multiple occasions, at the end of every academic year. Therefore, the results of the calculated CGPA for every student constituted longitudinal data. In longitudinal studies, the level-1 (repeated measurements) are nested within the higher level-2 subjects (individuals or students).

There are many methods for analyzing longitudinal data. However, this study adopted the procedure proposed by [3], the Individual Growth Modeling. Three models are usually fitted using this procedure:

a. The fully unconditional means model with no predictors at either level (Model A),
b. The unconditional growth model with only the time varying predictor added at level 1 (Model B)

c. and the fully conditional growth model with predictors added at all levels (Model C).

One of the advantages of multilevel analysis is that assumptions are less restrictive than when using the Ordinary Least Squares (OLS) methods. Authors of the article [4] recommend only three assumptions to be made when carrying out multilevel analysis: the error distribution, measurement metrics and variance-covariance structure. In this study normal distribution of the errors was assumed. The performances of the students were subjected to the same measurement metrics for calculating the CGPA. The unstructured variance-covariance structure was assumed, typical of all longitudinal studies.

The results of the hypothesis tests showed that there was a significant difference between the two programmes (2 df, $p < 0.005$). Many reasons may be advanced to justify this difference. When the curriculum was shown to the 2007/8 cohort of students on the telecommunications engineering programme, they admitted that the Department did not teach them the following courses:

ELE 1112 Introduction to Electrical Engineering and Society
ELE 1302 Electrical Engineering Drawing and Installation Practice
ELE 2112 Advanced Computer Programming
TEC 2202 Technology, Society and Ethics
TEC 3102 Law for Engineers
ELE 3217 Systems Engineering
TEC 3202 Principles of Economics and Accounts
ELE 4111 Digital Signal Processing
ELE 4116 Electrical Installation Design
ELE 4117 Project Management
ELE 4211 Very Large Scale Integrated Circuits (VLSIC) Design and Fabrication
ELE 4215 Broadband and Advanced Communications

This is a case of selective delivery of the approved curriculum. This brings into question whether the Quality Assurance unit of the university actually functions effectively. The gaps in teaching the courses on a particular programme should have been detected and addressed earlier. Furthermore, the telecommunications engineering programme was approved by the University Council but the staff establishment for teaching the courses was not approved in 2004. Staff that were recruited to teach the electrical engineering degree programmes are overstretched to teach all the three degree programmes in the Department. These lecturers may not be specialized in teaching the new degree programmes.

There may be a problem with the approval process for new programmes. It is not clear how the University Council approved the telecommunications programme in 2004 yet the curriculum was the same with that of electrical engineering programme. Curriculum approval starts from the Department, Faculty/School Board, Senate, Quality Assurance, University Council and the National Council for Higher Education. All these organs failed to detect that the curriculum for telecommunication engineering was the same as that of electrical engineering.

VI. Conclusion

A. Conclusion

Since the p-value ($p < 0.005$) < 0.05 (α) the null hypothesis was rejected at 5% level of significance. There was a significant difference in the performances between the two groups of students.

B. Recommendation

The study recommends that the University should strengthen its process of curriculum approval and delivery. The telecommunication engineering programme was approved without any organ of the University adding value. The same electrical engineering curriculum was approved by Council as a telecommunications engineering programme. Furthermore, the telecommunication engineering students were being taught without following the curriculum means that relevant organs of the University were non-functional. New degree programmes should be approved with their staff establishments.

C. Further work

It would be good to do a similar analysis of the performance of another cohort of both telecommunication and electrical engineering students to establish whether the University is adding value. One of the limitations of qualitative social sciences research is that the findings cannot be replicated to another group of students. The findings in this study are relevant to the 2004/5 cohort of students only.

References

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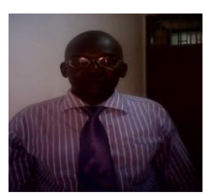

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Appendix

Performance of students as measured by their CGPAs

	ID/yr	1	2	3	4
Telecom	1	3,16	3,31	3,3	3,39

	2	2,58	1,62		
	3	1,99	1,74		
	4	2,81	2,45	2,45	2,56
	5	2,64	2,26	2,06	2,04
	6	3,04	2,99	3,11	3,2
	7	3,02	3,05	3,07	3,2
	8	3,66	3,58	3,51	3,67
	9	3,3	3,24	3,04	3,11
	10	2,3	2,21	2,07	
	11	1,78	1,86		
	12	2,08	1,88	1,9	
	13	2,91	2,78	2,88	3,06
	14	3,55	3,33	3,39	3,54
	15	2,95	3,01	3,16	3,43
	16	2,86	2,77	2,68	2,81
	17	3,22	2,83	2,48	2,2
	18	2,92	2,69	2,72	2,83
	19	3,29	3,31	3,34	3,42
	20	2,61	2,56	2,69	2,8
	21	2,7	2,97	3,23	3,38
	22	3,26	2,98	3,12	3,29
	23	2,5	2,82	2,98	3,22
	24	2,9	2,76	2,58	2,71
	25	3,24	3,13	3,33	3,55
	26	3,51	3,23	3,31	3,37
	27	2,4	2,05		
	28	3,09	2,94	2,91	3,08
	29	1,79	1,86		
	30	3,03	2,74	2,88	3,1
	31	2,83	3,07	3,06	3,31
	32	3,04	3,15	3,15	3,33
	33	2,7	2,5	2,65	2,81
Electrical	34	2,9	2,82	2,85	2,91
	35	4,58	4,35	4,28	4,4
	36	4,65	4,6	4,45	4,5
	37	3,2	3,21	3,16	3,22
	38	3,66	3,6	3,78	3,98
	39	4,16	3,87	3,82	3,98
	40	4,75	4,63	4,54	4,6
	41	3,13	3,47	3,6	3,54
	42	3,65	3,57	3,39	3,36
	43	3,46	3,19	3,18	3,37
	44	3,89	3,74	3,5	3,33
	45	3,12	3,17	3,29	3,34
	46	4,54	4,34	4,43	4,53
	47	4,53	4,43	4,43	4,53
	48	4,24	4,04	4,03	4,11
	49	3,55	3,71	3,61	3,48
	50	3,32	3,2	3,19	3,27
	51	4,42	4,45	4,55	4,59
	52	4,12	4,33	4,47	4,58
	53	4,74	4,62	4,6	4,68
	54	3,86	3,42	3,24	3,19
	55	3,45	3,38	3,32	3,33
	56	4,09	4,1	4,22	4,35
	57	1,19	1,25	1,17	
	58	3,87	3,93	3,97	4,09
	59	3,5	3,45	3,7	3,89
	60	2,71	2,55	2,65	2,64
	61	3,08	3,35	3,37	3,41
	62	3,88	3,99	4,06	4,11