

## **Hybrid E-Learning for Rural Secondary Schools in Uganda: Co-Evolution in Triple Helix Processes**

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### **ABSTRACT**

Rural secondary schools in Uganda perform poorly in Science and Mathematics due to lack of functional science laboratories and libraries. Furthermore, it is difficult for such schools to attract and retain good, committed and qualified Science and Mathematics teachers. Arua is one such District. It has two advanced level girls' secondary schools- Muni and Ediofe. Hybrid e-learning was introduced in both schools for the benefit of 29 students who were taking either Mathematics or Physics or both. Local content for the production of interactive multimedia CD-ROMs were developed based on the national syllabus using senior teachers from Makerere College School in Kampala. The students effectively used the CDs for six months in 2007 and were repeatedly externally examined by Makerere College teachers, Arua District Examinations Committee and the Uganda National Examinations Board. The longitudinal data collected were analysed using multilevel methods. The results showed that 41% of the students passed and were eligible for university admission. However, after extrapolation of the performance of the students over twelve months, up to 72% of the students would have passed. The paper is discussed by linking the study to its contribution towards the achievement of international and national obligations of Uganda. Co-evolutions of the study into triple helix processes and 'Mode 2' knowledge production are also discussed. The paper concludes that it is possible to implement hybrid e-learning financially constrained rural secondary schools. However, when carrying out research in the context of the problem, co-evolutions in triple helix processes and Mode 2 production of knowledge are likely to happen.

**Keywords:** Co-evolution; Hybrid E-Learning; Mode 2; Rural Secondary Schools; Triple Helix; Uganda.

### **1.0 INTRODUCTION**

#### **1.1 Background**

From 1991/2 academic year, a number of policies aimed at increasing participation of female students in higher education have been implemented by Uganda Government. This has led to the dramatic increase in the female students' enrolment in Makerere University for 24% in 1989, 45.8% in 2008 and approximately 51% in 2010. However, according to Lating (2006, 2009), enrolment of female students in Faculty of Technology has remained between 17% to 20% only. Furthermore, over 90% of the female engineering students are from the 'elite' and advantaged urban schools located in the capital city, Kampala, and its surrounding Districts of Mukono and Wakiso. Rural secondary schools perform poorly in Physics and Mathematics- the key technology and engineering subjects. One rural District, which has failed to send female students to Makerere University for engineering training on merit, is Arua- a remote, poor and insecure District in the West Nile Region of Uganda. There are two advanced level senior secondary schools in Arua that are Government-aided. They are St Marys' Ediofe Girls Senior Secondary School and Muni Girls' Secondary School (hereafter referred to as Ediofe and Muni respectively).

## 1.2 Problem Statements

During a number of fieldwork visits to Ediofe and Muni in 2004, it was found that the schools perform poorly in Physics and Mathematics subjects due to acute financial constraints resulting in lack of functional science laboratories and libraries. Furthermore, rural schools do not attract and retain good, committed and qualified Physics and Mathematics teachers.

## 1.3 Research Question

The above scenario presents a research question that needed to be addressed as regards rural Advanced -level secondary Physics and Mathematics education in Uganda:

- *What effects will application of hybrid e-learning in rural Advanced-level secondary education in Uganda have on the performance of female students in Mathematics and Physics?*

Hybrid e-learning in the context of the project means e-learning, where the main course delivery platform is the interactive multimedia CD-ROM and the face-to-face traditional classroom teaching remains.

## 1.4 Main Research Objective

The main research objective of this study was to improve performance of disadvantaged Ugandan advanced-level rural secondary school female students in Mathematics and Physics so that they could pass national examinations and get admitted into universities and other tertiary institutions.

## 2:0 METHODOLOGY

### 2.1 Research Approaches Used

To understand the difficult school contexts under which the participants study, qualitative research methods were used. However, the longitudinal data collected were quantitative. Consequently, this study adopted both research approaches hence the use of qualitative and quantitative methods.

### 2.2 Research Design

Participatory theories were used to produce the interactive multimedia CD-ROMs for Physics and Mathematics. Multilevel methods were used to analyse the data.

### 2.3 Sampling Method

Multi-stage sampling was done to identify the participants in the project. Participating schools were identified first, followed by selection of science classes in each of the schools before identifying the project students who were taking subject combinations containing either Mathematics or Physics or both.

### 2.4 Participants in the Study

In March, 2006 the participants were identified during a *field visits* to the schools- Muni and Ediofe. Twenty nine students were identified: 17 from Ediofe and 12 from Muni.

## 2.5 Procedure

### 2.5.1 Local Content Development

At the Local Content Creation Workshop organized in Arua town from 5<sup>th</sup> to 10<sup>th</sup> September, 2005, thirty three out of 51 teachers from 14 schools attended. They were advanced level Mathematics and Physics from schools situated in the current Districts of Arua, Koboko and

Nyadri. Mvara SSS in Arua town hosted the event. The manual content that was developed by these teachers was found to be shallow and lacked the necessary depth and breadth required by the examination syllabus.

### ***2.5.2 Collaboration with Makerere College School in Local Content Development***

Makerere College School (MACOS) is one of the advantaged senior secondary schools in Kampala and is on the same hill with Makerere University. The school attached three experienced teachers to develop all the relevant local content in the digital format for Physics Papers 1, 2 and 3 and Mathematics Papers 1 and 2. Later, the digital content was used to produce interactive multimedia CD-ROMs for A-Level Physics and Mathematics.

All the inferior computers of Muni and Ediofe were upgraded to higher multimedia capacities: hard disk drives (40 MB), memory (256 MB), and processing speed of 512 MHz. They were fitted with CD drives and sound cards. This enabled the students to access content from CD-ROMs from their respective schools.

### ***2.5.3 Co-Evolution in Triple Helix***

It was known early in the project that none of the schools could sustain Internet connectivity. To let students and their teachers have access to Internet, a decision was made to set up an ICT Centre with VSAT Internet connectivity in Arua town within the vicinity of the two schools. The District Council provided buildings for the Centre. The Faculty of Technology equipped the Centre with financial support from Sida/SAREC. The Centre was connected to broadband VSAT Internet in December 2005. The business community of Arua agreed to use the services at the Centre to make it sustainable- hence co-evolution in triple helix. The Center was opened for public use in June 2006. Subject teachers of Muni and Ediofe and their students were allowed free access to resources from the Internet and project website, <http://www.aruaeduc.com>.

### ***2.5.4 Rolling Out of the Hybrid E-learning Tools to Students in Muni and Ediofe***

The participants interacted with the interactive multimedia CD-ROMs and Internet resources effectively from May 2007 to November 2007. During that period, they were repeatedly examined externally by Makerere College School, Arua District Council and UNEB in June, July, September and November 2007. The longitudinal performance results were collected from the Schools.

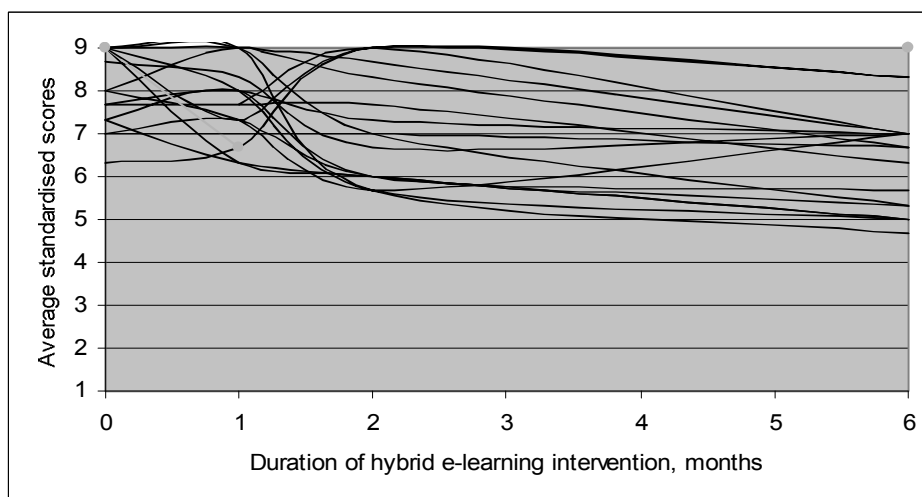
## **3.0 PRESENTATION OF RESULTS**

### **3.1 Analysis of Trends in the Longitudinal Data**

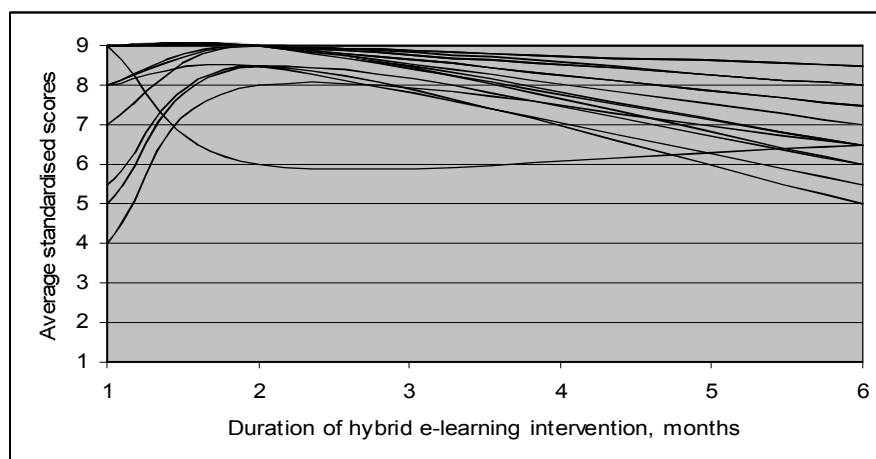
To determine the broad trends in the longitudinal data collected, smooth splines of individual performance trajectories with increasing duration of the hybrid e-learning intervention in months were drawn. These trajectories are shown in figures 3.1 and 3.2 for Physics and Mathematics respectively. Note that a standard score of “9” represents a failure while “1” represents the best score.

From the smooth splines in figures 1 and 2, it was observed that there was generally a linear relationship between individual performance scores and duration of hybrid e-learning intervention. The implication was that the data could be modelled as linear relationship between the outcomes and predictors.

The trajectories also showed that there was a general improvement in performance with increasing duration of the intervention. It could also be seen that variability in individual performance was increasing with time.



**Figure 1** Individual smooth splines for performance in Physics



**Figure 2** Individual smooth splines for performance in Mathematics

### 3.2 Data Analysis

#### 3.2.1 Modelling the Data

The longitudinal data collected was analysed using multilevel analysis methods using the model the *fully conditional growth model* (1) with predictors at both levels of the hierarchy: DURATION (level-1) and SCHOOL (level-2)

$$Y_{ij} = [\gamma_{00} + \gamma_{01} * SCHOOL_i + \gamma_{10} * DURATION_{ij} + \gamma_{11} * SCHOOL_i * DURATION_{ij}] + \quad (1)$$

$$+ [\zeta_{0i} + \zeta_{1i} * DURATION_{ij} + \varepsilon_{ij}]$$

where  $Y_{ij}$  denotes the score of student  $i$  at measurement occasion  $j$ .  $\varepsilon_{ij}$  are residual errors of student  $i$  during measurement occasion  $j$ .  $\pi_{0i}$  is the student  $i$ 's true initial average standardized score (at baseline when  $DURATION_{ij}=0$ ). It is the intercept.  $\pi_{1i}$  is the monthly rate of change of the student  $i$ 's score in a particular subject. This is the slope or gradient. It shows the monthly rate of change in performance of a student participating in the project as the duration of the hybrid e-learning intervention increases.  $\gamma_{00}$  and  $\gamma_{10}$  are Level-2 intercepts while  $\gamma_{01}$  and  $\gamma_{11}$  are Level-2 average rates of change or slopes. The slopes are of great interest because they show the effect of predictors on the individual growth trajectories. The variation in individual change parameters ( $\pi_{0i}$  and  $\pi_{1i}$ ) is to be taken as a function of the differences between individuals in the Level-2 predictor variable  $SCHOOL_i$  and the coefficients  $\gamma_{01}$  and  $\gamma_{11}$  stand for the average effect of variable  $SCHOOL_i$  on the individual development parameters. Level-2 residuals  $\zeta_{0i}$  and  $\zeta_{1i}$  are also assumed to be independent and identically (multivariate normally) distributed with zero expected mean values and variances  $\sigma_0^2$ ,  $\sigma_1^2$  and covariance  $\sigma_{10} = \sigma_{01}$ . These residuals are deviations of individual change trajectories

around the population averages, where  $\begin{bmatrix} \zeta_{0i} \\ \zeta_{1i} \end{bmatrix} \sim iidMVN \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{10} & \sigma_1^2 \end{bmatrix} \right)$ . It is further

assumed that Level-2 residuals  $\zeta_{0i}$  and  $\zeta_{1i}$  are independent of Level-1 errors  $\varepsilon_{ij}$  for all  $i$  and  $j$ . Since there are two Level-2 residuals, *multivariate* normality is assumed. To be specific, this is a *bivariate* normality assumption. There are eight parameters to be determined from the models above:  $\gamma_{00}$ ,  $\gamma_{10}$ ,  $\gamma_{01}$  and  $\gamma_{11}$  are called *fixed effects* while random error variances  $\sigma_e^2$ ,  $\sigma_0^2$  and  $\sigma_1^2$  and covariance  $\sigma_{10} = \sigma_{01}$  are called *random effects* parameters.

### 3.2.3 Results of the Analysis

The results showed that 41% of the students passed and were eligible for university admission. However, after extrapolation of the performance of the students over twelve months, up to 72% of the students would have passed and be eligible to join higher institutions of learning.

## 4.0 DISCUSSIONS

This study is significant in that it directly addresses the requirements of the following international and national development agenda: the Millennium Development Goal No. 3: elimination of gender disparity at all levels by 2015; the World Summit on the Information Society (WSIS, 2003, 2005): ICT to be mainstreamed in order to accelerate achievement of MDGs; the New Partnership for Africa's Development: the NEPAD e-schools project which aims at introducing e-learning and e-health in basic schools in Africa; the Poverty Eradication Action Plan of the Government of Uganda: pillar 5 which deals with human development (The Republic

of Uganda, 2004); the Uganda Vision 2035: prosperous people, harmonious nation and a beautiful country; the National Development Plan (2010) of Uganda; the Constitution of Uganda (article 32 on 'affirmative action in favour of marginalised groups' and article 32 on 'rights of women' The Republic of Uganda, 1995).

With one of the highest average population growth rates in the world, Uganda is under pressure to deliver social services to her citizens. In the education sector, the demands for formal education are so high that physical structures like science laboratories, libraries, classrooms and dormitories as well as qualified and competent teachers will never be enough. Education policies will have to be reviewed to encourage open education system. The introduction of hybrid e-learning would serve as the first step towards the realisation of an open education system.

By using mainly interactive multimedia CD-ROMs as a platform for delivering local content course materials for Physics and Mathematics, the rural students were able to perform well at national examinations. This finding is in line with that of Evoh (2007) who found that ICTs were the most feasible and economically sound means of expanding access to and improving the quality of secondary education in Africa.

This study co-evolved into triple helix processes between the academia, industry and government and mode 2 knowledge production. The setting up of Arua ICT/GIS Research Centre was not anticipated at the beginning of the study. However, it was a result of co-evolution that is always imminent while carrying out research in the social context of the problem. This co-evolution, which are in line with the thinking of Nowotny *et al.* (2001), sharply contrasts the traditional linear thinking of disciplinary researchers who are still dominant in the academia. More ideas about obsolescence of linear thinking can be found in the works of Gulbrandsen (2004) and Gibbons *et al.* (1994).

In their well known book 'The New Production of Knowledge', Gibbons *et al.* (ibid) introduced the concept of 'Mode 2', which is characterized by context of application and implication, transdisciplinarity, diversity of sites of knowledge production, highly reflexive, accountability, novel forms of quality control, socially robust knowledge. Michael Gibbons, in May 2003, explained that 'mode 2' processes have always been the case for universities since their beginning. According to him, 'Mode 1', which is based on linear thinking, started to develop during the Scientific Revolution (Merchant, 1980) and is a specialized part of mode 2. As a consequence perspectives of 'Mode 1' and 'Mode 2' are there to stay and the question is not to choose one mode before the other. The question is the most relevant mode for knowledge production to use in the specific situations and contexts. The repeatedly measured data that were collected in the study were multilevel in nature. Such data are correlated and traditional methods of analysis like Ordinary Least Squares methods are not appropriate for the analysis of such data. Raudenbush and Bryk (1986) are credited for introducing methodologies for the analysis of correlated data. However, in this study methods of analysis of longitudinal data using individual growth models recommended by Singer and Willett (2003) were used. The models were fitted to the data collected and deviance statistics was used for comparison of the three models: fully unconditional means model (Model A), unconditional growth model (Model B) and fully conditional growth model (Model C).

## 5.0 CONCLUSIONS:

The application of hybrid e-learning in the science and mathematics education of disadvantaged rural students can lead to improved performance. Triple helix interaction among the academia, local governments and the business community/industry can be useful in

looking for solutions to social problems of rural communities. Solutions to rural community problems can only be found in collaboration with a number of stakeholders with the target people taking ownership of the process. Participatory methods in creating the 'communities of practice' or alliances for purposes of solving social problems were found to be very helpful in the study.

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