

Application of Locally Developed Smart Learning Environments in the Teaching of Mathematics in Public Secondary Schools in Osun State, Nigeria

**Temitope Oteyola, Oluyemisi Akintitan & Oyetola Oyeniran
Obafemi, Awolowo University, Ile Ife, Nigeria**

ABSTRACT

Challenges of teaching Mathematics include inadequate teachers, over reliance on the talk and chalk method of teaching and inadequate use of instructional materials. These resulted in poor academic performance among secondary school students in Osun State, Nigeria. This study therefore determined the effect of locally developed smart learning environments on secondary school students' academic achievement in Mathematics and if there is significant interaction between sex and the modes of teaching. The study employed pretest posttest control nonequivalent group design. Seventy five (75) students were selected across a randomly selected senatorial district in the state using a multistage sampling procedure. A Mathematics Achievement Test (MAT) was used at the pretest and the posttest. Items with IDI > 0.3 were removed during validation. Content Validity Ratio ($\alpha = 1$) was also obtained for the remaining 20 items in the achievement test. Analysis of data showed no significant difference in the academic achievement of students exposed to the SLE and those taught with the talk and chalk method ($F_{(1,74)} = 0.05$; $p = 0.83$). Results also showed that the interaction between sex and the mode of instruction is not significant ($F_{(1,74)} = 0.21$; $p = 0.65$).

Keywords: *Academic achievement; Mathematics; Smart Learning Environments*

INTRODUCTION

Mathematics is a language of communication in the sciences in general and Physics in particular. Considering this, Mathematic is an essential subject in Engineering, the physical sciences as well as some of the biological sciences. Analysis of data to draw empirical and predictable inferences requires adequate knowledge of mathematical processes. Mathematics is an important subject in nation building. A credit pass in Mathematics is required for students to secure admission into science and science related courses in higher education institutions in Nigeria.

Effective economic management requires mathematical skills. Scientific methods of information processing, critical thinking, problem identifications and problem solving require knowledge of mathematical operations. Mathematical skills are essential in preparing students for the 21st century challenges. AI algorithms, robotic engineering and the future of global inventions in IT all require mathematical manipulations. All scientific innovations and discoveries can be better and effectively explained through mathematical processes and mathematical skills are needed for both inductive and deductive reasoning. It is therefore important for the teaching of Mathematics from the preschool level to be given all the attention it deserves.

Akinoso (2011) posited that Mathematics is the basis for Science and Technology and that Mathematics is the tool for achieving scientific and technological development. Without adequate knowledge of Mathematics, diversifying Nigeria economy is simply a mirage: Mathematics is important right from the planning stage to the execution stage. Gathering of relevant data and processing of the data all require adequate mathematical knowledge. The Federal Government of Nigeria made Mathematics a core and compulsory subject at both the primary and secondary

school levels of education because of its contributions to national development (National Policy on Education (FGN., 2004).

However, it can be observed that despite all the significance attached to Mathematics in Nigeria's education system, poor performance is still being recorded in the subject especially in public examinations. Osun State for the past five years has been recording poor academic achievement in the examinations conducted by both West Africa School Certificate Examination (WASSCE) and National Examination Council (NECO). These are the two major recognized examination bodies that conduct the Senior Secondary schools Certificate Examination (SSCE) in Nigeria.

The students at all levels of education as observed in Nigeria and particularly in Osun State are superstitious and this is because of poor understanding of logic which is traceable to poor mathematical skills. These poor mathematical skills have also resulted in poor academic performance in Mathematics. Since Mathematics is a compulsory requirement for securing admission for Science and Technology related courses in higher institutions of learning in Nigeria, student enrolment in the related courses are always inadequate (Akintitan, 2023).

One of the major factors responsible for students' poor academic performance in Mathematics is the poor method of teaching. Teachers still adopt the teacher-centered drill and practice method of teaching Mathematics. This method is not only obsolete it is also weak. Students taught using this method always rely on rote learning and memorizing. Mathematics on the other hand is a procedural subject which should not be learnt by memorization. It is therefore necessary that an innovative strategy which can aid in acquisition of necessary mathematical skills be identified and experimented.

Akintitan (2023) referencing Asikhia (2010) categorized the major causes of poor academic performance in Mathematics among senior secondary school students into four areas:

- Causations resident of the child which includes basic cognition skills, physical and health factors, psycho – emotional factors, lack of interest in school programme;
- Causations resident in the family which are cognition stimulation/basic perception during the first two years, type of discipline at home, lack of role model and finance;
- Causations resident in the school which includes factors like school location and physical buildings, interpersonal relationship among the school personnel, and
- Causations resident in the society which are instability of educational policy, under-funding of educational sector, leadership and job losses.

All these can be drastically reduced through appropriate innovative Internet driven mode of instructions.

Internet-driven information technology modes of instruction provide opportunities for self-regulated, self-pacing individualized instructions. Students can learn at their own rate without the constraint of time and space. Learning through this mode can be made fun. Engagement and collaborations with other learners can also be greatly achieved through appropriate use of this mode of instruction. Smart learning environments provide a platform and opportunity for individualized, self-regulated and self-paced learning.

Smart learning environments, according to Chanminkin, Min & Lee (2013) based its foundation on the use of smart devices and intelligent technologies. Smart Learning Environment (SLE) is an environment involving artificial intelligence being built into a computer-based instrument. SLE is considered appropriate in the teaching of Mathematics and mathematical skills because it is efficient in making concepts that look abstract become real to the students.

A smart learning environment is an intelligent environment that offers students their needs by integrating them in one place with a structure and logical sense. It is not a mere space in the cloud, but an interactive environment in which content, reinforcement tools and virtual classrooms coexist to offer a complete experience to students. Spector (2016) reported that a smart learning environment is an effective, efficient and engaging mode of learning. Kim, Park & Joo (2014) also posited that learners are considered as the heart of a smart learning environment with the aim of providing self-learning, self-motivated and personalized instruction which will allow learners to attend courses at their own pace and also be able to access the personalized learning content according to their personal differences.

Gros (2016) also affirmed that the Smart Learning Environment enables the learner to access ubiquitous resources and interact with learning systems anytime and anywhere. It also provides necessary learning guidance, suggestions or supportive tools in the right form, at the right time and in the right place. The use of smart devices allows learning to take place anytime. A smart learning environment according to Gros (2016) aims to support learners to obtain new knowledge, even while they are engaged in leisure activities. SLE plays the role of a coach, or guide, who seeks opportunities to advise learners on their daily life by taking their needs and preferences into account. Gros (2016) summed up the goal of a smart learning environment as a learning environment to provide self-learning, self-motivated and personalized services.

Smart learning environments also provide opportunities for appropriate feedback to all the stakeholders in the student's education: parents, school management, class teacher, student, guidance and counselor, and so on. This will help in providing close monitoring of the students' academic activities. Through data analytics, student attrition as well as drop-out rate can be controlled (Akinbadewa, Oteyola & Sofowora, 2020). It is equally obvious that effective learner analytics requires a good knowledge of Mathematics. It is imperative that the teaching and learning of Mathematics be given the attention it deserves.

The SLE was developed based on the recommendations and the general features of smart learning environments as stated in Spector (2016), Gros (2016) and Kim et al. (2014). It was a software that can be installed on a computer. It can be used both online and offline. The limitation of using it offline is that stakeholders will not be able to monitor the student's activities until there is Internet access. All the information on the students' activities can only be sent to parents, teachers, school management and so on when there is Internet access, as the feedback is sent to their respective email addresses.

Saritas & Akdemir (2009) posited that the quality of teaching and learning Mathematics has been one of the major challenges and concerns of educators globally and that instructional design is an effective way to alleviate problems related to the quality of teaching and learning in Mathematics. It is in the light of this that SLE has been considered as a possible educational tool in ameliorating some of these challenges. The smart learning environment is one of the applications of AI technologies in developed nations of the world. Students in Nigeria are not culturally familiar with smart learning environments and Internet-driven educational platforms that have been invaluable to educational development across the globe. The smart learning environment was locally developed to create IT-driven learning environments that the students will be culturally familiar with while providing solutions to some of the challenges encountered by the students in their Mathematics class.

Akintitan (2023) citing Saritas & Akdemir (2009) argued that knowing the factors affecting Mathematics achievement is particularly important for making the best design decisions. Akintitan (2023) argued further that instructional strategies and methods, teacher competency in Mathematics education, and motivation or concentration were the three most influential factors that should be considered in the design decisions. The locally developed SLE therefore incorporated

motivations through feedback, and student concentration was secured through necessary hints and the use of a timer. The SLE was designed to ensure 100% mastery level of the subject matter.

Kariuki, et al. (2019) in Akintitan (2023) established that there was a strong positive relationship between the teachers' level of classroom preparedness, practice and instructional methods. All these were opined to influence students' academic performance in Mathematics. A well-prepared teacher who has practiced the use of an instructional method will be more efficient in delivering instructions through the method than a gatecrasher into the method. Kariuki et al. in Akintitan (2023) also established that teacher's experience affects the academic performance in Mathematics to a great extent. It was also pointed out by the same study that student-teacher ratio did not directly influence student performance in Mathematics. It can therefore be hypothesized that well-prepared smart learning environments for teaching Mathematics will aid students' academic achievement in the subject. Smart learning environments can also be used to provide effective and efficient individualized learning opportunities to students irrespective of the numbers.

This study determined the effect of locally developed smart learning environments on students' academic achievement in public senior secondary school in Osun State, Nigeria. There are arguments and counter arguments on the influence of gender on the effect of Internet driven technology tools on students' academic achievement. Reilly, Neumann & Andrews (2015) posited that there was a consistent mean difference in the academic performance of male and female students in Mathematics over a 10-years period. Whereas Skryabin, Zhang, Liu, & Zhang (2015) posited that individual-level of ICT use is a significant predictor of the influence of ICT on learning outcomes in Reading, Mathematics and Science, irrespective of students' sex and socioeconomic status. Emmanuel, Offiah, & Madichie (2018) posited that sex has no significant influence on the effect of computer-based simulation on senior secondary school students' academic performance in Chemistry.

The study therefore determined if there exist an interaction between sex and the effect of the smart learning environment on the students' academic achievement in Mathematics. This is to also add to the literature on the influence of sex on the effects of IT-driven instructional platforms on students' academic achievement in Mathematics. All these are to find empirical solutions to the challenges of poor student academic achievement in Mathematics in senior secondary schools in Nigeria in general and Osun State in particular.

HYPOTHESES

H₀₁: The smart learning environment has no significant influence on the secondary school students' academic achievement in Mathematics in Osun State, Nigeria.

H₀₂: The interaction between sex and the effect of the smart learning environment on academic achievement in Mathematics is not significant among senior secondary school students in Osun State, Nigeria.

METHODOLOGY

The study employed pretest posttest non-equivalent control group quasi experimental design. The population comprised all the senior secondary school students that attend the state government owned schools in Osun State. Seventy-five senior secondary II (SSII) schools were selected using a multistage sampling procedure. Four senior secondary schools with access to Internet and IT facilities were purposively selected from all the schools in a randomly selected senatorial district in the State. Two local government areas were randomly selected from all the local government areas in the selected senatorial district. The selected schools were also randomly assigned to

experimental and control groups with two schools in each of the groups. A full class of one arm of SSII students in each of the selected schools was randomly selected. The selection was done through balloting. There were 5 streams of SSII in the schools. The streams were labelled A – E with each stream having an equal chance of being selected. There were 36 students in the experimental group and 39 students in the control group. Twenty of the students were male while 55 were females. There were 11 male and 25 female students in the experimental group while there were 9 male and 30 female students in the control group.

The Mathematic Achievement Test (MAT) comprising 20 items of multiple choice questions was used to measure the students' academic achievement in Mathematics. The items in MAT were selected from past West African Senior Secondary School Certificate Examination questions. Three SSII Mathematics teachers appraised the relevance and suitability of the items in the achievement test for the study. The Item Difficulty Index of the items in the achievement test was determined and items with a difficulty index greater than 0.3 were discarded and found not suitable. Twenty items from the initial 50 items in the achievement test were selected for the study.

Ethical clarification of the study was done, and consent of the students was also obtained before the commencement of the study. Four Mathematics teachers in the selected schools were trained as research assistants. The pretest, exposure of students to the treatments and the posttest was done within six weeks. The participants were given personal identification numbers (PIN) on the first day of the meeting. The purpose of the study was also explained to them. The research instrument (MAT) was administered on both the students in the experimental group and the control in the first week as the pretest. The answer scripts were collected, marked and graded. The students in the experimental group were exposed to the SLE from the second week through to the fifth week.

The students were monitored and supervised by the Mathematic teacher who served as the research assistant. Internet access was provided, and feedback was provided for all the stakeholders. The students were guided and supervised as they interacted with the SLE. Those in the control group were also taught using the conventional talk and chalk method from the second week through to the fifth week. The posttest was conducted for both the experimental and the control in the sixth week after exposing the students to the treatments. Students in the experimental group were exposed to the SLE. They were given unrestricted access to interact with the locally produced SLE. Those in the control group were taught using the talk and chalk method. The pretest and the posttest were marked, graded and collated as appropriate and analyzed using mean, standard deviation and factorial analysis of covariance. The average learning gain of the students was also determined.

RESULTS AND DISCUSSION

H₀₁: The smart learning environment has no significant influence on the secondary school students' academic achievement in Mathematics in Osun State, Nigeria.

The hypothesis was tested at 95% significance level using pretest as covariate. ANCOVA was adopted in the analysis because for each level of the independent variable, there is a linear relationship between the dependent variable and the covariate. Also, there is no interaction between the covariant and the independent variable. There were no significant outliers in the data, the data were approximately normally distributed and there was homoscedasticity. The variances were equally homogeneous.

Table 1: Factorial ANCOVA of the effects of locally produced SLE on senior secondary school students' academic achievement in Mathematics**Tests of Between-Subjects Effects**

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	126.831 ^a	4	31.708	7.494	.000	.300
Intercept	1583.218	1	1583.218	374.213	.000	.842
Pretest	69.893	1	69.893	16.520	.000	.191
Group	.204	1	.204	.048	.827	.001
Sex	2.614	1	2.614	.618	.435	.009
Group * Sex	.882	1	.882	.209	.649	.003
Error	296.156	70	4.231			
Total	11247.000	75				
Corrected Total	422.987	74				

a. R Squared = .300 (Adjusted R Squared = .260)

Analysis of data showed no significant difference in the academic performance of students exposed to the SLE and those taught using the talk and chalk method ($F_{(1,75)} = 0.05$; $p = 0.83$). Since $p > 0.05$, the hypothesis which stated that the smart learning environment has no significant influence on the secondary school students' academic achievement in Mathematics in Osun State, Nigeria is not rejected. The students that were exposed to the SLE were guided on how to interact with the locally developed SLE. The SLE was designed in such a way as to provide immediate feedback to the students. It also motivated the students positively for questions they got correctly through the feedback mechanism built into it. Although the SLE cannot replace the teacher, it is one of the 21st century tools that will change teachers' role from being the sage on stage to a coach or a guide. Afolabi (2019) noted that the application of technology in classroom instruction changes classroom orientation from teacher-centered to learner-centered and that teachers are no longer the sage on stage as it is always seen in traditional classrooms. Kariuki, Njoka & Mbugua (2019) in Akintitan (2023) pointed out that student-teacher ratio did not directly influence student performance in Mathematics. Findings from the study agreed with Kariuki et al. (2019). Teacher – students' ratio does not influence the students' academic achievement when exposed to the locally developed SLE. The SLE was able to provide efficient and effective methodology for teaching Mathematics in the senior secondary schools. The average learning gain of those exposed to the SLE was 0.50. Thus, the locally developed SLE aided students' academic achievement in Mathematics. Spector (2016), Gros (2016) and Kim et al. (2014) all noted that SLE can enhance students' academic performance.

H_{02} : the interaction between sex and the effect of the smart learning environment on academic achievement in Mathematics is not significant among senior secondary school students in Osun State, Nigeria.

As shown in Table 1, there is no significant difference between sex and the SLE on students' academic achievement in Mathematics ($F_{(1,74)} = 0.62$; $p = 0.44$). Modes of teaching also make no significant difference as stated in H_{01} . It thus implies that the interaction between sex and students' academic achievement in Osun State public secondary schools irrespective of whether they were taught with the SLE or by the traditional talk and chalk method is not significant ($F_{(1,74)} = 0.21$; $p = 0.65$, partial $\eta^2 = 0.003$). Therefore, the hypothesis which state that the interaction between sex and the effect of the smart learning environment on academic achievement in Mathematics is not significant among senior secondary school students in Osun State, Nigeria is not rejected. These findings are aligned with that of Emmanuel, Offiah & Madichie (2018). It is also in accord with Skryabin, Zhang, Liu, & Zhang (2015) who affirmed that individual level of ICT use is a significant predictor of the influence of ICT on learning outcomes in Reading, Mathematics and Science

irrespective of students' sex and socioeconomic status. The students' ICT use arguably accounted for why there was no significant difference in the academic performance of the students in favour of the SLE. The students had limited skills in the use of computers. Some of them must be trained on how to perform some basic computer tasks that are necessary for learning with the SLE. As observed, the students were not given access to the computer laboratory prior to the commencement of the study in the selected schools. The students also do not have access to computers outside the school. Computer ownership was identified as one of the factors that influence computer literacy skills (Ogunkola, 2008; Tezci, 2011). It can therefore be inferred that the inadequate computer literacy skills inhibit the effectiveness and efficiency of the locally developed smart learning environments on the students' academic achievement in Mathematics.

CONCLUSION AND RECOMMENDATIONS

The study concluded that smart learning environments can be effectively used in teaching Mathematics in senior secondary schools in Nigeria. It can help in providing self-paced and self-regulated instructions to the students if students are properly guided and monitored. Individualizing instruction can also be effectively done with SLE. The feedback strategies provide an opportunity for effective monitoring of the students by all stakeholders. Thus, SLE can be effective in reducing dropout rates among secondary school students in Nigeria. A smart learning environment can also provide a platform for tutorials to assist the students' academic achievement in Mathematics, particularly where there are limited numbers of teachers. A smart learning environment also provides opportunities for the students to sharpen their computer skills in preparation for computer-based examinations which is the method for conducting entrance examinations to higher education institutions in Nigeria. It can also provide the opportunities for training newly admitted students in computer-based assessment which is currently in vogue in higher institutions of learning in Nigeria, more so in large classes. Training of teachers in the development of a smart learning environment would also be a way to facilitate the implementation of the "Use IT" policy of the Federal Government of Nigeria.

It is recommended that the use of smart learning environments in teaching Mathematics should be encouraged by all the stakeholders by providing necessary infrastructure for the adoption of the technology. Secondary school teachers should also be trained on how to develop a smart learning environment locally. Further studies on the influence of students' cognitive strategies as well as learning styles on the effect of smart learning environments on academic achievement in science-based courses should also be evaluated.

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