

Effect of Artificial Intelligence Tutor System on Students' Achievement in Mathematics in Public Senior Secondary Schools of FCT, Abuja, Nigeria

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Abstract

The study examined the effect of the artificial intelligence tutor system on students' achievement in mathematics among public senior secondary school students of FCT, Abuja. Two objectives, two research questions and hypotheses were raised and tested for the study. The study adopted a quasi-experimental research design. The study population comprised 24,771 SS2 students from all public senior secondary schools in six Area Councils of the FCT Abuja. A sample of 102 students was selected using simple random sampling in which students from intact classes from two different schools were used. The instrument used for data collection was the Mathematics Achievement Test (MAT). The instrument was subjected to the validation of experts in mathematics and measurement and evaluation, and the results yielded a logical validity index of 0.72. The instrument was further subjected to a pilot study. Results obtained from the exercise were used to obtain a reliability index of 0.77 for the mathematics achievement test. The research questions were answered using mean and standard deviation, while the hypotheses were tested using analysis of covariance. The findings from the study showed there was a significant effect of the artificial intelligent tutor system on students' academic achievement in mathematics of public senior secondary schools in the FCT, Abuja, and there was no significant effect of the intelligent tutor system on students' academic achievement in mathematics of public senior secondary schools when segregated according to gender in the FCT, Abuja. The study recommended that teachers should be trained in the use of an intelligence tutor system to enhance students' academic achievement. The study concluded that the intelligence tutor system enhances students' achievement in the FCT, Abuja.

Keywords: Artificial intelligence, Achievement and Mathematics

Introduction

Education improves the development of any society, and the youths who occupy significant positions in that country should be properly educated to improve their society. Thus, it is a serious invasive instrument for bringing about social, economic and political inclusion and a durable integration of people. It therefore plays a crucial role in shaping the citizens of tomorrow, citizens

who are responsible, accountable, honest, healthy, emotionally strong and irrepressible. Over the years there have been reports of low achievement in secondary school students, as shown by poor academic achievement in WAEC results which have been confirmed by the standard measurement of academic achievement. Despite the claimed huge government investments towards enhancing the quality of education in the Federal Capital Territory, students' academic achievement has continued to decline at an alarming rate. According to the WAEC report (2024), students' failures in Mathematics were 51.39%, 57.84% and 55.71%, respectively, in the Nov/Dec Senior School Certificate Examination. This trend in achievement is worrisome due to the fact that mathematics is a core subject required, which is a prerequisite for admission into the universities in Nigeria. Academic achievement refers to the outcome of education. It is the amount of academic content a student learns in a specific time period which could be short-term or long-term (Barowsk, 2021). It is the extent to which a student, teacher or institution has achieved the educational goal (Melgosa and Melgosa, 2016).

Considering the widespread development of science and technology, especially computer technology, in the era of open world and paradigm globalisation, the need for improved teaching strategies is increasing. However, this goal may not become a reality without the input of experts in the field of artificial intelligence (AI) (Parnin, Siegmund and Peitek, 2017). Previous studies show that the need for artificial intelligence in the education industry is high. Therefore, the services of educationists proficient in the use of artificial intelligence tutor systems are a critical requirement. In order to meet the needs of the educational sector, an artificial intelligence tutor system must be considered an essential teaching strategy in enhancing the teaching and learning process (Jancheski, 2017). The world of teaching and learning processes has become more sophisticated such that the world is now talking about artificial intelligence where machines can now learn like humans. Bordia (2023) noted that artificial intelligence has revolutionised the world and is within the ambit of improving the teaching-learning process through the discovery of innovative teaching strategies such as the artificial intelligent tutor strategy. An artificial intelligence tutor system (AITS) is a computer system that initiates human tutors and provides immediate and customised instruction or feedback to learners, usually without requiring intervention from a human teacher. Artificial intelligence tutor systems aim to enable learning in a meaningful and effective manner by using a variety of computing technologies to enhance students' academic achievement (Holstein, McLaren and Aleven, 2017). It is therefore important to note that educators should employ the appropriate use of artificial tools such as the artificial intelligence tutor system because it is most likely to enhance students' achievement. It is also pertinent to note that learners' achievement through the application of an intelligent tutor system may be affected by the gender of the learner. Animasahun (2016) explained that there exists a gender difference in academic achievement in mathematics. Greenblatt (2020) concluded that males are more successful than females at solving mathematical problems. Thus, it was found that male students achieve better in mathematics than females. It is to this extent that gender as a factor affects the achievement of students in genetics.

In Nigeria (FCT, Abuja, included), teachers have persistently encountered challenges in enhancing mathematics achievement. Many students find mathematics to be abstract, challenging to understand, and monotonous (Grootenboer and Marshman, 2016). As a result, most learners are disadvantaged and are at risk of exhibiting poor mathematics achievement (Singh, 2015). Ediger and Lee (2017) observed that traditional teaching methods often pose challenges in engaging all students effectively and providing feedback. There is therefore a need to provide an artificial intelligence tool to help address these issues by providing access to high-quality educational content and allowing students to control their learning pace through online platforms. It is based on this realisation that the study is geared towards examining the effect of the intelligence tutor system on students' achievement in public senior secondary schools in the FCT, Abuja.

Objectives of the Study

The aim of the study is to examine the effect of the artificial intelligence tutor system on students' achievement in public senior secondary schools in the FCT, Abuja. Specifically, the study is geared towards achieving the following objectives:

1. determine the effect of an intelligent tutor system on students' academic achievement in mathematics in public senior secondary schools in the FCT, Abuja.
2. examine the effect of the intelligent tutor system on students' academic achievement in mathematics of public senior secondary schools when segregated by gender in the FCT, Abuja.

Research Questions

The following research questions guided the study:

1. What are the pretest and posttest achievement mean scores of students in mathematics in the experimental and control groups?
2. What are the pre-test and post-test achievement score of students in mathematics of senior secondary schools in the FCT, Abuja when segregated according to gender in the experimental group?

The following null hypotheses guided this study and will be tested at a 0.05 level of significance:

1. There is no significant difference in the pre-test and post-test achievement mean score of students in mathematics of public senior secondary schools in the FCT, Abuja
2. There is no significant effect of intelligent tutor system on students' achievement in mathematics of public senior secondary schools when segregated according to gender in the FCT, Abuja.

Review of Literature

Iyamu et al. (2024) examined the effect of the intelligence tutor learning system on students' academic achievement in brick/block laying and concreting programmes in technical colleges in Delta State. Specifically, three objectives, research questions, and hypotheses guided the study. Quasi-experimental research design was used for this study. The population for the study comprised 160 NTC II brick block laying and concreting students in the six technical colleges in Delta State selected for the study. A purposive random sampling technique was used to select the

two schools in Delta State. The instrument, lesson plans, and the Table of Specification/Test Blue Print were subjected to face and content validation by two experts. The instrument yielded a reliability index of 0.87. The instrument for data collection was brick block laying and concreting (BBLCT), which has five parts according to the topics outlined and was used for data collection. The finding of the study shows that the mean score for the experimental group is higher than the control group, indicating that those taught construction management with the intelligence tutor learning technique performed better than those who were taught using the lecture method in technical colleges in Delta State. The finding of the study shows that there is a significant difference between the mean scores of students taught building drawing and design using the intelligent tutor technique and those who were taught with the lecture method in technical colleges in Delta State. Based on the findings of the researcher, the following recommendations were made: The use of the intelligence tutor learning software should be encouraged, as this would help students to study at their own pace in technical colleges in Delta State. Philanthropists and stakeholders in technical colleges should create good content of intelligence learning software for students in brick/block laying and concreting programmes in technical colleges in Delta State. This could train the students on the current skills required in the industry.

Tsai et al. (2024) examined the effect of an intelligent tutoring system on student achievement in algebraic expression. Quasi-experimental research design was adopted for the study. In this experimental study, use of Computer-Assisted Instruction (CAI) followed by use of an Intelligent Tutoring System (CAI+ITS) was compared to the use of CAI (CAI only) in tutoring students on the topic of algebraic expression. Two groups of students participated in the study. One group of 32 students studied algebraic expression in a CAI learning environment, while the other group of 30 students was in a CAI and ITS (CAI+ITS) environment. Before the experimental treatment began, subjects were given a pre-test on algebraic expression. A post-test was also given at the end of the study. The experimental treatment was administered in eight sessions with one hour per session. For the first stage of the study, both groups of subjects studied algebraic expressions in a CAI environment. In the second stage, subjects from the CAI group continued with a tutoring session using the drill and practice section of the CAI package, whereas subjects from the CAI+ITS environment continued their learning using the ITS tutorial. The results of the study showed that there was a significant difference in the students' achievement in algebraic expression between students who learnt with CAI+ITS and who learnt with CAI only as the delivery system. The findings of the study indicated that CAI+ITS was more effective in helping students learn algebraic expressions as compared to using CAI alone. This study suggests that educators and software developers should focus on the development of ITS-based learning tools or integrate ITS elements in courseware development rather than developing a mere CAI tool.

Method

Quasi-experimental research design was used in this study. The population of the study comprises 24,771 SS2 students from all public senior secondary schools in six area councils. 102 students

were selected using purposive sampling by selecting students from intact classes in two selected secondary schools. The instrument used for data collection was a 40-item multiple-choice test tagged 'Mathematics Achievement Test (MAT) for SS2' for the study. The test items were subjected to the validation of experts in mathematics and measurement and evaluation. The scores emanating from the validation of experts yielded a validity index of 0.72. The test instrument was further subjected to a pilot study. The instruments were pilot tested on 30 students; the respondents were part of the population but not part of the sample for this study. The data obtained from the pilot test was used to compute the internal consistency of the instrument using Cronbach's Alpha reliability method. Results obtained from the exercise were used to obtain a reliability index of 0.77 for the Mathematics Achievement Test. Mean and standard deviation were used to answer the research questions developed for the study, while analysis of covariance was used to test the hypotheses at the 0.05 level of significance.

Results and Discussion

Research Questions One: What are the pretest and posttest achievement mean scores of students in Mathematics in the experimental groups?

Table 1: Mean and Standard of Students' Achievement in Mathematics in the Experimental and Control Groups

S/ N	Groups	N	Pretest		Posttest		Mean Gain	χ -Gain Difference
			Mean	Std Dev	Mean	Std Dev		
1	Experimental	48	42.65	11.20	64.92	8.68	22.27	4.03
2	Control	54	41.52	5.45	59.74	7.59	18.24	

Table 1 shows the mean and standard deviation of students' achievement in Mathematics in experimental and control groups in senior secondary schools of the FCT, Abuja. Results indicate that the pre-test mean and standard deviation scores for the experimental group were given as 42.65 and 11.20, respectively, while the post-test mean and standard deviation scores were 64.92 and 8.68. As for the control group, the pre-test mean and standard deviation scores were 41.52 and 4.54, respectively, while the post-test mean and standard deviation scores were given as 59.64 and 7.59, respectively. It is observed from the table that the mean gain for the experimental group was found to be higher at 22.27 than the mean achievement gain of the control group at 18.24, with a mean difference of 4.03. Hence, the artificial intelligence tutor system has an effect on students' achievement in mathematics in public senior secondary schools of the FCT, Abuja.

Research Questions Two: What are the pre-test and post-test achievement score of students in Mathematics of senior secondary schools in the FCT, Abuja when segregated according to gender in the experimental group?

Table 2: Students' Achievement in the Experimental Group based on Gender

S/N	Gender	N	Mean	Standard Deviation	Mean Difference
1	Male	26	61.26	2.11	2.82
2	Female	22	58.44	2.40	

Table 2 shows the pre-test and post-test of students' achievement in Mathematics of senior secondary schools in the FCT, Abuja, when segregated according to gender in the experimental group. Results indicate that the post-test mean and standard deviation scores for males were 61.26 and 2.11. As for the female students, the post-test mean and standard deviation mean scores were given as 58.44 and 2.40, respectively. It is observed from the table that the mean gain difference was found to be higher at 2.82, indicating that the achievement of males and females is almost the same after exposure to the intelligence tutor system in Mathematics in public senior secondary schools of the FCT, Abuja, when segregated according to gender.

Hypothesis One: There is no significant difference in the pre-test and post-test achievement mean score of students in Mathematics of public senior secondary schools in the FCT, Abuja

Table 3: Analysis of Covariance Variance Result on Students' Achievement in Mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	468.095 ^a	2	468.095	7.001	.011
Intercept	8490.034	1	8490.034	126.982	.000
Covariate	2628.045	1	2628.045	50.835	.000
Groups	468.095	1	468.095	7.001	.011
Error	3075.572	46	66.860		
Total	205824.000	48			
Corrected Total	3543.667	49			

a. R Squared = .866 (Adjusted R Squared = .861)

Table 3 reveals the analysis of covariance variance statistics showing the effect of the intelligent tutor system on students' achievement in Mathematics of public senior secondary schools in the FCT, Abuja. The results showed that the F-calculated value is (1.46) 7.001, and the p-value of 0.011 was found to be less than the 0.05 level of significance. The result further reveals an adjusted R-squared value of .861, which means that 86.1 per percent of the variation in the dependent variable, which is students' achievement, is explained by variation in the treatment of the artificial intelligent tutor system, while the remaining is due to other factors not included in this study. Hence, the result reveals that there is a significant effect of artificial intelligent tutor system students' achievement in Mathematics of public senior secondary schools in the FCT, Abuja.

Hypothesis Two: There is no significant effect of intelligent tutor system on students' achievement in Mathematics of public senior secondary schools when segregated according to gender in the FCT, Abuja.

Table 4: ANCOVA Statistics Showing the Effect of Artificial Intelligent Tutor System on Students' Academic Achievement in Mathematics when Segregated According to Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	288.741 ^a	2	288.741	4.675	.036
Intercept	1738.243	1	1738.243	28.142	.000
Achievement	.862	1	.862	.036	.852
Gender	288.741	1	288.741	4.675	.435
Error	2841.259	26	61.766		
Total	67078.000	28			
Corrected Total	3130.000	29			

Table 4 shows the analysis of covariance variance statistics showing the effect of the intelligent tutor system on students' achievement in Mathematics of public senior secondary schools in the FCT, Abuja, when segregated according to gender. The results showed that the F-calculated value of 4.675 and the p-value of 0.435 were found to be greater than 0.05. The result reveals that there was no significant effect of intelligent tutor system students' achievement in Mathematics of public senior secondary schools in the FCT, Abuja, when segregated according to gender.

Discussion

Findings from the study on hypothesis one revealed there was a significant effect of intelligent tutor systems on students' achievement in mathematics in public senior secondary schools in the FCT, Abuja. This finding is in agreement with the findings from the study of Iyamu et al. (2024), which indicated there was a significant effect of the intelligence tutor learning system on students' achievement in brick/block laying and concreting programmes in technical colleges in Delta State. This entails that employing intelligent tutoring systems enhances students' achievement.

Findings from the study on hypothesis two revealed there was no significant effect of intelligent tutor system students' achievement in Mathematics of public senior secondary schools in the FCT, Abuja, when segregated according to gender. This finding does not agree with the findings from the study of Tsai et al. (2024), which indicated there was a significant effect of an intelligent tutoring system on students' achievement in algebraic expression irrespective of gender. This entails that employing an intelligent tutoring system does not enhance students' academic achievement when segregated according to gender.

Conclusion

Based on the findings of this study, it was concluded that there was a significant effect of intelligent tutor system students' achievement in mathematics of public senior secondary schools

in the FCT, Abuja. It further showed no significant effect of intelligent tutor system students' achievement in mathematics of public senior secondary schools in the FCT, Abuja when segregated according to gender.

Recommendations

Based on the findings of the study and conclusion, the following recommended were made:

1. Schools should be equipped by the Federal ministry of Education with intelligent tutor system software tools for the purpose of creating an enabling environment that will enhance students' academic achievement in mathematics.
2. Periodic trainings and seminars should be organized by the Federal Ministry of Education for teachers in order to facilitate the effective use of intelligent tutor system software tools that will enhance students' academic achievement in mathematics irrespective of gender.

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