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Effect of Intelligent Tutoring Systems On Academic Performance and Interest of Physics Students in Makurdi Metropolis

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Abstract: *The study investigated the effect of Intelligent Tutoring Systems on the academic performance and interest of physics students in Makurdi Metropolis. Two research questions and two hypotheses were answered, formulated and tested. A quasi-experimental design was used for the study. The population of the study made up of all the physics students in government approved secondary schools in Makurdi metropolis. The sample size consisted of 120 physics students. Physics Performance Test (PPT) and Physics Interest Inventory (PII) with the reliability coefficients of 0.80 and 0.86 respectively were the instrument used for data collection. Simple Mean was used to answer the research questions. While ANCOVA was used to test the hypotheses at 0.05 level of significance. The findings revealed that, students taught physics concepts using Intelligent Tutoring Systems (ITS) performed better than those taught with Conventional Teaching Methods (CTM). Students taught Physics concepts using Intelligent Tutoring System (ITS) were more interested in the subject than those taught with conventional Teaching Method (CTM), among others. It was therefore recommended that the government through the Ministry of Education and Ministry of Science and Technology should ensure that; (ITS) should be used by teachers to enhance academic performance and interest of students in physics.*
Keywords: physics, intelligent tutoring systems, academic performance, interest and teaching methods.

INTRODUCTION

Education is universally acknowledged as the cornerstone of national development, as it equips individuals with the right knowledge, skills, and attitudes required for meaningful participation in society and the global economy (UNESCO, 2002). Science education, in particular, hold a crucial role in fostering innovation, problem-solving, and technological advancement, which are critical for sustainable development in the 21st century. In Nigeria, the educational system is designed to provide learners with a strong scientific foundation from the Basic Education level, where Basic Science is taught as a compulsory subject. At the Upper Basic level (Basic 7–9), students are introduced to fundamental concepts in Physics, Chemistry, Biology, and Earth Science. In particular, Physics-related topics such as force, motion, energy, electricity,

magnetism, heat, light, and simple machines help learners understand natural phenomena and develop scientific reasoning and problem-solving skills. These foundational concepts prepare students for the study of Physics at the senior secondary school level and equip them with the knowledge and competencies required for careers in science, technology, engineering, and mathematics (STEM) (Federal Government of Nigeria, 2013; Nigerian Educational Research and Development Council, 2020). Furthermore, a solid grounding in Physics at the basic education level contributes to technological innovation and national development by fostering critical thinking, creativity, and practical application of scientific principles.

Despite the importance of Physics in scientific and technological development, students' achievement and interest in the subject remain a major concern in Nigeria. Many secondary school students consistently perform poorly in Physics, a situation often linked to the use of teacher-centred instructional methods, inadequate laboratory facilities, and the abstract nature of many Physics concepts. These challenges make it difficult for learners to understand and apply fundamental principles, resulting in low motivation and weak academic performance (West African Examinations Council, 2024; National Examinations Council, 2024). In many public secondary schools, including those in Makurdi Metropolis, these persistent challenges have raised concerns about the effectiveness of conventional teaching approaches in preparing students with the scientific knowledge and problem-solving skills required in today's technology-driven society.

The ongoing emphasis on lecture-based instruction, in which students take a passive role in the learning process, is one of the main causes of students' low performance in physics. Learners frequently find it difficult to relate classroom theories to real-world situations since many physics topics are abstract, which lowers their interest and comprehension. In order to increase student achievement and interest in physics, learner-centered teaching strategies that actively involve students in scientific investigation, experimentation, and critical thinking are becoming more and more necessary. This situation has raised concerns about the effectiveness of existing pedagogical practices in achieving national educational goals and preparing students for active participation in a science-driven world (Vieriu & Petrea, 2025) thereby weakening its competitiveness in the global knowledge economy (Hwang et al., 2020; Krause et al., 2024).

The emergence of Intelligent Tutoring Systems (ITS) in education provides a new frontier for addressing these challenges. ITS platforms such as GeoGebra, Mathway, ChemDraw, BioLab, and PhET simulations have been shown to simplify abstract concepts, provide real-time feedback, and personalize learning experiences according to students' abilities and progress (Orim & Egwo, 2025). Based on additional research, these methods can maximize learning effectiveness, reduce time, enhance students' understanding of difficult subjects, and boost engagement (Vieriu & Petrea, 2025). These benefits are especially pertinent to physics, as students frequently need interactive practice, step-by-step instructions, and visualization to build both proficiency and long-term interest.

Globally, ITS integration in education has gained momentum, with evidence showing improvements in students' academic outcomes and motivation (Luckin et al., 2016; Hwang et al., 2020). However, in Nigeria, and particularly in Makurdi Metropolis, empirical research on the use of ITS in physics classrooms remains limited. Most schools still rely on conventional

methods with minimal adoption of technology-enhanced pedagogies, despite the widespread availability of ITS-supported applications on common digital devices. This creates a research gap on how ITS might impact the learning experiences of physics students in the Nigerian context.

Teaching strategies play a pivotal role in shaping students' academic performance, particularly in subjects like physics that require both conceptual understanding and practical application. Effective instructional approaches determine how well learners grasp abstract concepts, retain knowledge, and develop problem-solving skills. Conventional methods in Nigeria, which are largely teacher-centered, have often been criticized for contributing to poor performance due to their emphasis on rote memorization rather than inquiry, collaboration, and active learning (Orim & Egwo, 2025). Research has shown that innovative strategies such as technology-assisted and learner-centered methods significantly improve students' comprehension, motivation, and outcomes (Vieriu & Petrea, 2025). Within this context, Intelligent Tutoring System (ITS) teaching strategies offer a unique opportunity to personalize instruction, provide real-time feedback, and create interactive learning environments that address individual learners' needs. For physics students in Makurdi Metropolis, where persistent underachievement has been linked to ineffective pedagogical practices, the integration of ITS has the potential to enhance both performance and sustained interest in science learning.

Students' interest is a critical factor in learning physics, as it influences motivation, engagement, and willingness to persist in problem-solving tasks. When teaching strategies fail to capture learners' curiosity, students are more likely to disengage, perform poorly, and even abandon science-related pathways in later schooling. Conventional, teacher-centered approaches have often been associated with declining interest because they provide limited opportunities for active participation and exploration (Orim & Egwo, 2025). In contrast, interactive and technology-driven strategies stimulate learners' curiosity by making abstract concepts concrete and relatable. Intelligent Tutoring Systems, in particular, create adaptive and engaging learning environments where students receive instant feedback, experience personalized learning, and interact with simulations that make science concepts meaningful (Vieriu & Petrea, 2025).

This study is anchored on the Constructivist Learning Theory by Jean Piaget (1970) and the Cognitive Apprenticeship Theory by Collins, Brown, and Newman (1989). The Constructivist emphasizes that learners actively construct their own understanding and knowledge of the world through experiences and interactions with their environment. Piaget introduced the concepts of assimilation and accommodation to describe how learners adapt to new information. And The Cognitive Apprenticeship Theory emphasizes that learning occurs most effectively when students are guided by experts or systems that make thinking processes visible and accessible. Empirically Akombo and Iorliam (2025), study gender differences in student interest in basic science taught using intelligent tutoring systems, Okoh and Umeh (2022) which also study gender and method as determinants of science achievement among student exposed to intelligent tutoring system.

Statement of the problem

Although physics is essential to scientific and technological advancement, many secondary schools in Nigeria, especially those in Makurdi Metropolis, continue to have serious concerns about their students' academic performance and interest in the subject. Poor comprehension of physics ideas, low achievement, and waning student enthusiasm have all been caused by the continued use of teacher-centered teaching approaches and the lack of possibilities for personalized learning. Although Intelligent Tutoring Systems (ITS) have developed as novel technologies that enable adaptive education, quick feedback, and tailored learning experiences, empirical information on their usefulness in Nigerian secondary schools remains sparse. This gap in the literature emphasizes the need to look into whether integrating Intelligent Tutoring Systems might boost students' interest in physics and help them perform better academically.

Purpose of the Study

The main purpose of this study is to investigate the effect of Intelligent Tutoring Systems on the academic performance and interest of physics students in Makurdi Metropolis.
Specifically, the study seeks to:

1. Determine the academic performance of students taught Physics using Intelligent Tutoring Systems and those taught with the Conventional Teaching Method.
2. Determine the mean interest of male and female students taught physics with Intelligent Tutoring Systems compared to those taught with the Conventional Teaching Method.

Research Questions

1. What is the academic performance of students taught Physics using Intelligent Tutoring Systems compared to those taught with the Conventional Teaching Method?
2. What is the difference in the mean interest of male and female students taught Physics using Intelligent Tutoring Systems compared to those taught with the Conventional Teaching Method?

Hypotheses

1. There is no significant difference in the academic performance of students taught Physics using Intelligent Tutoring Systems and those taught with the Conventional Teaching Method.
2. There is no significant difference in the mean interest of male and female students taught Physics with the Intelligent Tutoring Systems Strategy and those taught with the Conventional Teaching Method.

METHODOLOGY

This study adopted a quasi-experimental, non-equivalent control group pretest-posttest design to examine the effect of an Intelligent Tutoring System (ITS) on the academic performance and interest of Physics students in Makurdi Metropolis, Benue State. The population comprised 2,460 physics students enrolled in public and private secondary schools within the metropolis. A sample of 120 students (60 males and 60 females) was selected from four purposively chosen secondary schools using a multi-stage sampling technique. Two schools were assigned to the experimental group and taught using the Intelligent Tutoring System, while the remaining two

schools served as the control group and received instruction through the Conventional Teaching Method (CTM). Data were collected using two instruments: the Physics Performance Test (PPT), consist of 30-item multiple-choice test, and the Physics Interest Inventory (PII), a 20-item four-point Likert scale designed to measure students' interest in Physics. The instruments were subjected to face and content validation by experts in Science Education and Measurement and Evaluation to ensure their suitability for the study. The study followed three stages: pretest, treatment, and posttest. Both groups completed the pretest before the intervention. The experimental group then received instruction through the Intelligent Tutoring System, while the control group was taught the same content using the Conventional Teaching Method over a one-week period. At the end of the treatment, both groups completed the posttest using the same instruments. Data were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at the 0.05 level of significance, with pretest scores used as covariates to control for initial group differences.

RESULTS

The result of this study is presented in table 1- 4 in the order of the research questions and the null hypotheses as follows:

Research Question One: What is the academic performance of students taught Physics using Intelligent Tutoring Systems (ITS) compared to those taught with the Conventional Teaching Method (CTM)?

Table 1: Pretest and Posttest Mean Achievement Scores of Students who were taught using Intelligent Tutoring System and those taught with Conventional Teaching Method

Group	N	Pretest Mean	Posttest Mean	Mean Difference	Remark
ITS	58	59.00	65.25	6.25	More Effective
CTM	62	40.20	44.10	3.09	

Table 1 shows that pretest mean score of 59.00 and posttest mean score of 65.25 with mean difference of 6.25 for the students taught with (ITS), while those taught using (CTM) recorded pretest mean score 40.20 and posttest mean score of 44.10 with mean difference of 3.09. Therefore, (ITS) is more effective in enhancing academic performance of students in Physics.

Research Question Two: What is the difference in the mean interest of male and female students taught Physics using Intelligent Tutoring Systems compared to those taught with the Conventional Teaching Method?

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Table 2: Pretest and Posttest Mean Difference in the Interest Scores of Male and Female Students who were taught using (ITS) and those taught with (CTM)

Group	N	Pretest Mean	Posttest Mean	Mean Difference	Remark
ITS	58	60.00	72.30	12.03	More Effective
CTM	62	52.25	59.19	06.94	

Table 2 shows the pretest and posttest mean score of 60.00 and 72.30 with the mean difference of 12.03 for the male and female students taught physics using (ITS) as against pretest and posttest mean score of 52.25 and 59.19 with the mean difference of 06.94 for the male and female students taught with (CTM). Therefore, (ITS) is more effective in enhance students' performance in Physics irrespective of gender.

Hypothesis One: There is no significant difference in the academic performance of students taught Physics using Intelligent Tutoring Systems and those taught with the Conventional Teaching Method.

Table 3: ANCOVA on the Mean Performance Scores of Students taught Physics Intelligent Tutoring System and those taught with Conventional Teaching Methods

Source of variation	SS	Df	MS	Cal.F	Crit.F	DEC
Corrected Model	12616.129	2	6308.064			
Intercept	9959.681	1	9959.681			
Achievement 1	7681.066	1	7681.066			
Treated Model	5714.725	1	5714.725	125.30	2.54	Reject H_0
Error	10432.309	253	41.234			
Total	1466050.00	256				
Corrected Total	23048.437	255				

In Table 3, it was observed that at 0.05 level of significance, 1df numerator and 255df denominator, the calculated F 125.30 is greater than the critical F 2.54. Therefore, the first null hypothesis is rejected. Then (ITS) is significant in enhancing academic performance students in Physics when compared with CTM.

Hypothesis Two: There is no significant difference in the mean interest of male and female students taught Physics with the Intelligent Tutoring Systems Strategy and those taught with the Conventional Teaching Method.

Table 4: ANCOVA on the Mean Difference in Performance Scores of Male and Female students taught Physics with Intelligent Tutoring System and those taught with Conventional Teaching Method.

Source of variation	SS	Df	MS	Cal.F	Crit.F	DEC
Corrected Model	28316.394	2	14158.197			
Intercept	12.357	1	12.357			
Achievement 1	15062.628	1	15062.628			
Treated Model	2049.176	1	2049.176	235.25	2.07	Reject H_0
Error	2198.606	253	8.690			
Total	130064.400	256				
Corrected Total	30515.0000	255				

Table 4: shows that at 0.05 level of significance, 1df numerator and 255df denominator, the calculated F 235.25 is greater than the critical F 2.07. Therefore the third null hypothesis is rejected. Then, the interest of male and female students taught Physics using ITS differ significantly when compared with those taught with the CTM.

DISCUSSION OF FINDINGS

The effect of intelligent tutoring system and conventional teaching method on student's performance and interest scores in Physics. Result from table 1 showed that the gained mean achievement scores of students in the process-based group were higher than that of the gained mean achievement scores of students in the conventional method group. This was further confirmed by the ANCOVA result in table 3 which revealed that teaching method was a significant factor on students' achievement in Physics. Thus it was confirmed that students taught with ITS performed better than those taught with CTM. This implies that ITS was more effective in enhancing and facilitating students' performance in Physics concepts than the CTM. The finding of the study is in support of the finding of previous findings by Akombo and Iorliam (2025), Okoh and Umeh (2022) which confirmed that appropriate Intelligent Tutoring systems leads to students' improved performance in science subjects. This improved and significant achievement must have been as a result of the variety of activities which characterized ITS, where every learner must fully be involved in all fun-like, practical and interesting activities. These hands-and minds-on activities must have empowered and enabled all learners with different characteristics and abilities to benefit from the variety of the learning experiences provided by this approach.

Results in table 2 and 4 showed that despite gender, the students taught Physics with ITS performed better and more interested in the subject than those taught with CTM. The high lost mean scores obtained by the conventional method group showed that they had low performance and are not very interested compared to those taught with ITS. This was further confirm by the ANCOVA result in table 4 which revealed that method was a significant performance and interest demonstrated by students in physics concept. Thus both male and female students using Intelligent Tutoring Systems (ITS) were more interested in the subject than those taught with

Conventional Teaching Methods (CTM). The finding agrees with that of Akombo and Iorliam (2025) who also found significant difference in the effectiveness of ITS.

CONCLUSION

Going by the findings of this study, it is concluded that: Intelligent Tutoring System is more effective in enhancing academic performance students in Physics than conventional method. Intelligent Tutoring System is more effective in enhancing both male and female students' performance and interest in Physics than the conventional method.

Recommendations

1. The government through the Ministry of Education and Ministry of Science and Technology should ensure that: Intelligent Tutoring System is used by teachers in enhancing academic performance students in Physics.
2. Intelligent Tutoring System is used in enhancing student's interest in Physics.
3. Intelligent Tutoring System is used by teachers in Physics to boost the interest of both male and female students.

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