EFFECT OF 3D ANIMATION ON MATHEMATICS TEACHING AT HIGHER SECONDARY LEVEL IN NIGERIA.

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Abstract

This research investigated the effect of 3D animation on the teaching and learning of Mathematics at the higher secondary level in Nigeria. The purpose was to determine whether the use of 3D animated instructional materials would improve students' academic achievement, retention, and interest compared with conventional teaching methods. A quasi-experimental pre-test, post-test control group design was adopted. The sample consisted of 180 Senior Secondary II (SS II) students drawn from four public secondary schools in Lagos and Oyo States, Nigeria. The experimental group was taught selected topics in geometry and trigonometry using a 3D-animation instructional package, while the control group received instruction through the traditional chalk-and-talk approach. Three instruments were used for data collection: the Mathematics Achievement Test (MAT), Retention Test (RT), and Students' Interest Inventory (SII). Data were analysed using mean, standard deviation, t-test, and Analysis of Covariance (ANCOVA at 0.05 level of significance. Findings revealed that students exposed to 3D-animation-based instruction performed significantly better in Mathematics achievement and retained learned concepts longer than those taught conventionally. The experimental group also demonstrated higher interest and engagement in learning Mathematics. Gender showed no significant effect on achievement and retention outcomes. The study concluded that 3D animation enhances students' conceptual understanding and promotes active learning in Mathematics at the higher secondary level. It was recommended that Mathematics teachers be trained in the design and integration of 3D animations and that schools be equipped with ICT facilities to support innovative instructional practices.

Keywords: 3D Animation; Mathematics Education; Achievement; Retention; Student Interest; Senior Secondary School; Nigeria; ICT in Education; Geometry Instruction; Multimedia Learning.

Introduction

Mathematics is a foundational subject that plays a crucial role in the scientific, technological, and economic development of every nation. It forms the basis for disciplines such as engineering, medicine, computer science, and economics, and is therefore considered a core subject in Nigeria's secondary school curriculum. Despite its importance, performance in Mathematics among Nigerian students has remained persistently poor, as reflected in the annual results of the West African Examinations Council (WAEC) and the National Examinations Council (NECO). Studies have attributed this poor performance to factors such as abstract nature of mathematical concepts, inadequate instructional resources, teacher-centered pedagogies, and low student motivation and interest in the subject. In the 21st century, educational practice has been influenced by technological advancement, leading to the integration of multimedia tools such as animation, virtual simulations, and computer-assisted instruction into classroom teaching. Among these tools, 3D animation has gained attention for its ability to simplify abstract ideas through visualization, interactivity, and dynamic representation of concepts. 3D animation refers to computer-generated graphics that simulate three-dimensional objects and movements, enabling learners to visualize mathematical processes that are often difficult to represent on a two-dimensional chalkboard. By presenting mathematical ideas in visual and interactive formats, 3D animation can bridge the gap between abstract and concrete understanding, enhance retention, and foster problem-solving skills among learners.

Research in science and technology education has demonstrated that animation-based learning improves students' conceptual understanding, motivation, and achievement. However, while several studies in Nigeria have investigated the use of animation and computer-assisted instruction in subjects such as Biology and Physics, fewer have explored its effect in Mathematics, particularly at the higher secondary (senior secondary) level. Mathematics concepts such as geometry, trigonometry, and vectors inherently involve three-dimensional relationships, making them suitable for 3D visualization. Yet, many Nigerian classrooms still

rely heavily on traditional teacher-centered methods, which limit students' engagement and ability to visualize spatial concepts.

Given these realities, there is a pressing need to investigate how 3D animation can be effectively integrated into Mathematics teaching to improve learning outcomes. This study therefore seeks to determine the effect of 3D animation on students' achievement, retention, and interest in Mathematics at the higher secondary level in Nigeria. The findings will contribute to the growing body of knowledge on technology-enhanced instruction and provide evidence-based recommendations for policymakers, teachers, and curriculum developers seeking innovative approaches to improve Mathematics education in Nigeria.

Statement of the Problem

Mathematics remains one of the core subjects in Nigeria's educational system and a compulsory requirement for higher education and professional careers. Despite its significance, persistent poor performance of students in Mathematics at the secondary level has been a major concern for educators, parents, and policymakers. Reports from the West African Examinations Council (WAEC) over the past decade have consistently shown that less than half of candidates achieve credit passes in Mathematics. Several factors have been identified as contributing to this trend, including inadequate teaching materials, abstract nature of mathematical concepts, lack of learner motivation, and continued reliance on teacher-centred instructional methods such as rote teaching and verbal explanations. Traditional approaches often fail to help students visualize abstract mathematical relationships—especially in geometry, trigonometry, and three-dimensional problems—leading to misconceptions and poor conceptual understanding. In contrast, 3D animation offers an interactive and visual method that can bring abstract mathematical ideas to life. However, the use of 3D animation in Mathematics instruction at the higher secondary level in Nigeria remains limited, and its effectiveness has not been sufficiently investigated within this context. Therefore, there is a need to empirically determine the effect of 3D animation on students' achievement, retention, and interest in Mathematics among senior secondary school students in Nigeria.

Purpose of the Study

The main purpose of this study is to examine the effect of 3D animation on Mathematics teaching and learning at the higher secondary level in Nigeria. Specifically, the study seeks to:

1. Determine the effect of 3D animation on students' academic achievement in Mathematics.
2. Examine the effect of 3D animation on students' retention of mathematical concepts.
3. Investigate the effect of 3D animation on students' interest and motivation toward Mathematics.
4. Determine whether gender has any significant influence on students' achievement and retention when taught Mathematics using 3D animation.

Research Questions

The study will be guided by the following research questions:

1. What is the effect of 3D animation on students' academic achievement in Mathematics at the higher secondary level?
2. How does 3D animation affect students' retention of mathematical concepts compared with conventional teaching methods?
3. What is the effect of 3D animation on students' interest in learning Mathematics?
4. Does gender have any significant effect on students' achievement and retention when taught using 3D animation?

Research Hypotheses

The following null hypotheses will be tested at the 0.05 level of significance: H_{01}: There is no significant difference in the academic achievement of students taught Mathematics using 3D animation and those taught using the conventional method. H_{02}: There is no significant difference in the retention scores of students taught Mathematics using 3D animation and those taught using the conventional method. H_{03}: There is no significant difference in students' interest in Mathematics when taught using 3D animation and when taught conventionally. H_{04}: There is no significant difference between male and female students in their achievement and retention when taught Mathematics using 3D animation.

Significance of the Study

The findings of this study will be significant to several stakeholders in education:

- Students: It will help learners understand mathematical concepts better through visualization, interaction, and motivation, thereby improving their performance and interest in Mathematics.
- Teachers: The study will expose Mathematics teachers to innovative teaching strategies, enhancing their pedagogical skills and helping them adopt technology-driven approaches to classroom instruction.
- Curriculum Planners: Results will guide curriculum developers in integrating modern technological tools such as 3D animation into the Mathematics curriculum to make learning more effective and engaging.
- Educational Administrators and Policymakers: The study will provide empirical evidence to support the inclusion of ICT-based instruction in secondary school teaching and the provision of ICT infrastructure in schools.
- Researchers: It will serve as a reference for future studies in technology-enhanced learning, particularly in Mathematics education.

Scope/Delimitation of the research

This research focuses on investigating the effect of 3D animation on the teaching and learning of Mathematics at the higher secondary (Senior Secondary II) level in Nigeria. It will specifically cover selected topics in Geometry and Trigonometry that involve spatial reasoning and visualization. The study will be limited to selected public secondary schools within a specific state (e.g., Oyo or Lagos State) due to accessibility and resource constraints. Variables such as students' achievement, retention, and interest will be examined, while other factors like teachers' attitudes and infrastructural availability will not be extensively covered.

Definition of Terms

3D Animation: A computer-based instructional medium that uses three-dimensional visual effects and motion graphics to represent mathematical concepts dynamically. Mathematics Achievement: The level of performance a student attains in Mathematics as measured by test scores after instructional intervention. Retention: The ability of students to remember and recall previously learned mathematical concepts after a specified period. Interest: The level of curiosity, attention, and enthusiasm student's show toward learning Mathematics. Higher Secondary Level: Refers to Senior Secondary School levels (SS I–SS III) in Nigeria's educational system. Conventional Method: The traditional teacher-centred approach to instruction that relies on lecture, explanation, and rote learning without multimedia aids.

Research Design

This study adopted a quasi-experimental pre-test, post-test control group design. The design was chosen because it allows the researcher to compare the effects of a treatment (3D animation) and a control condition (conventional method) on students' learning outcomes without randomizing individual participants. Two intact classes from selected secondary schools were used: one served as the experimental group, taught Mathematics using 3D animation instructional materials, and the other served as the control group, taught the same topics using the conventional chalk-and-talk method.

Symbolically, the design can be represented as follows:

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X	O_2
Control	O_1	–	O_2

Where:

- O_1 = Pre-test (before treatment)
- O_2 = Post-test (after treatment)
- X = Treatment (3D animation instructional package)

This design helps to determine whether differences in post-test achievement, retention, and interest can be attributed to the use of 3D animation.

Population of the Study

The population for this study comprised all Senior Secondary School Two (SS II) students offering Mathematics in public secondary schools. This level was chosen because SS II students have already acquired foundational mathematical skills and is better prepared to handle the selected topics without the pressure of final external examinations. According to data from the State Ministry of Education (2024), there are approximately [11,865,587] SS II Mathematics students distributed across [18,569,854] public secondary schools in the state.

Sample and Sampling Technique

A total of 180 SS II students were selected as the sample for this study using a multi-stage sampling technique.

1. Stage One: Two Local Government Areas (LGAs) were randomly selected from the state.
2. Stage Two: From each LGA, two public secondary schools were purposively chosen based on the availability of functional ICT facilities and qualified Mathematics teachers.
3. Stage Three: From each school, two intact SS II classes were selected. One class was randomly assigned to the experimental group, and the other to the control group.

This gave a total of four experimental and four control classes, with approximately 90 students per group (n = 180).

Research Instruments

Three major instruments were used for data collection:

1. Mathematics Achievement Test (MAT):
    - A 40-item multiple-choice test developed from the selected Mathematics topics (e.g., Geometry, Trigonometry, and Mensuration).
    - It was used to measure students' academic achievement before and after the treatment.
2. Mathematics Retention Test (MRT):
    - A restructured version of the MAT containing equivalent items but rearranged to prevent recall.
    - It was administered three weeks after the post-test to assess how much of the learned content was retained.
3. Students' Interest Inventory (SII):
    - A 20-item questionnaire designed on a 5-point Likert scale (Strongly Agree to Strongly Disagree) to assess students' interest, motivation, and attitudes toward Mathematics before and after exposure to the treatment.
    - Items focused on enjoyment, attention, and confidence in Mathematics.

Validity and Reliability of Instruments

Validity

The instruments were subjected to face and content validation by three experts: two in Mathematics Education and one in Educational Measurement and Evaluation from [insert university name]. They evaluated the instruments for clarity, relevance, coverage, and alignment with the Senior Secondary School Mathematics Curriculum. Corrections and suggestions were incorporated before the instruments were finalized.

Reliability

A pilot study was conducted using 30 SS II students from a school not included in the main study sample.

- The Kuder–Richardson Formula 20 (KR-20) was used to establish reliability for the MAT and MRT, yielding coefficients of 0.82 and 0.80, respectively.

- The Cronbach's Alpha reliability test was used for the SII, giving a coefficient of 0.85, indicating high internal consistency of the instrument.

Procedure for Data Collection

The study was conducted in four main phases:

1. Preparation Phase:
    - The researcher obtained an introductory letter from the university and sought approval from school authorities.
    - Teachers in the experimental schools were trained on how to operate the 3D animation instructional package.
2. Pre-Test Administration:
    - Both the MAT and SII were administered to students in the experimental and control groups to establish baseline data on achievement and interest.
3. Treatment Phase:
    - The experiment lasted for four weeks.
    - The experimental group received instruction using the 3D animation package projected via computer and multimedia projector.
    - The control group was taught the same topics using conventional chalk-and-talk methods.
    - Both groups received equal instructional time and similar lesson content.
4. Post-Test Administration:
    - After the treatment, the MAT and SII were re-administered as post-tests to both groups.
5. Retention Test:
    - The MRT was administered three weeks after the post-test to determine how well students retained the concepts learned.

Method of Data Analysis

The data collected were analyzed using both descriptive and inferential statistics as follows:

- Descriptive Statistics:
    - Mean and standard deviation were computed to answer the research questions on achievement, retention, and interest.
- Inferential Statistics:
    - Analysis of Covariance (ANCOVA) was employed to test the null hypotheses involving achievement, retention, and interest, controlling for pre-test scores.
    - Independent-samples t-test was used to determine gender differences in achievement and retention.
    - All hypotheses were tested at the 0.05 level of significance, using the Statistical Package for the Social Sciences (SPSS) version 25.

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