

INTEGRATED MULTIMEDIA INSTRUCTIONAL PACKAGE AND STUDENTS' ACHIEVEMENT IN SEQUENCES AND SERIES IN MATHEMATICS

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Abstract

Mathematics is regarded as the cornerstone of all sciences, serving as the central axis around which other scientific disciplines orbit. However, students find some topics difficult. These include Sequences and Series, which demand attention to provide solutions, particularly with appropriate technology, which could engage learners sufficiently for improved learning outcomes. Therefore, this study developed and determined the effects of the self-developed Integrated Multimedia Instructional Package (IMIP) on senior secondary students' achievement in Sequences and Series in Mathematics in Ona-Ara Local Government Area of Oyo state, Nigeria. It further examined the moderating effects of perceived mathematics difficulty and gender on students' achievement. The study adopted the pre-test, post-test, control group quasi-experimental design and employed a purposive sampling method to select two Senior Secondary Schools. Forty students (20 for the experimental group and 20 for the control group) participated in the study. Four hypotheses were formulated and tested at 0.05 level of significance. Data collected were analysed using Analysis of Covariance. The results revealed that treatment and perceived mathematics difficulty have significant main effects on students' achievement in Sequences and Series, but gender does not. Also, treatment and perceived mathematics difficulty have an interaction effect on students' achievement in Mathematics. The study concludes that the Integrated Multimedia Instructional Package strategy is effective for enhancing students' achievement in Sequences and Series. Thus, teachers should adopt integrated multimedia instructional strategies for Mathematics instruction to enhance achievement in Sequences and Series regardless of students' gender.

Keywords: Achievement, Sequences and Series, Integrated Multimedia Instructional Package, Perceived Mathematics difficulty, Ona-Ara Local Government Area, Nigeria

Introduction

Mathematics is regarded as the cornerstone of all sciences, serving as the central axis around which other scientific disciplines orbit. The study of mathematics is highly beneficial for fostering creative thinking and self-confidence, playing a significant role in enhancing students' problem-solving skills. Mathematics strengthens an individual's power of presenting ideas in a logical way. The user of mathematical concepts feels comfortable relating with tasks that demand figures and numbers. It fosters boldness of handling precision-centred and engineering technology inclined tasks.

The significance of mathematics in nation-building has led the Federal Government of Nigeria to mandate it as a compulsory subject at all levels of education across the country (Udofia *et al.*, 2021). The study of mathematics encompasses many topics, some of which deal with abstract ideas that are difficult to connect to real-world situations. To guarantee students full comprehension, these abstract ideas, teachers are required to provide clear explanations and step-by-step guidance. Despite the crucial role of mathematics in the Nigerian education system, students' performances exhibit a consistent decline year after year. The persistent poor performance of students in mathematics during external examinations in Nigeria caused concern among mathematics educators and requires immediate attention.

In particular, concepts like Sequences and Series prove difficult for students to learn due to factors such as abstract notation, formula overload, weak foundation, word problem translation, and examination pressure (Kajander & Lovric, 2009). Researchers have identified several significant factors that contribute to students' failure in mathematics, including family background, peer group, lack of practice (Saha, *et al.*, 2024), students' poor mathematical background, parental influence on career choice, poor pedagogical approach or strategies, students' lack of participation in hands-on classroom activities, teachers' incompetence in teaching challenging mathematics concepts, students' poor study habits (Bosan, 2018), and teachers' failure to connect mathematical concepts to real-world activities (Usman, 2015). From these studies, these challenges are obviously mostly traceable to teachers' dependence on the traditional method of teaching. Study materials and resources could be developed to address the deficiencies generally reported in conventional teaching strategies. The possibilities of creating or developing appropriate learning packages abound in the era of digital technologies, especially those curated with such features that could provoke students' active participation in hands-on activities, support teachers' competency in teaching challenging math concepts, motivate students' study habits, and promote connecting mathematical concepts to real-world activities (Üredi & Doğanay, 2023) through the use of multimedia tools.

Multimedia is described as a combination of text, graphic art, sound, animation, and video delivered by a computer (Vaughan, 2014). Learning materials have, in recent times, gone digital through multimedia, the internet, and eLearning technologies, with fun and colours helping learners and improving learning styles (Achuonye, 2019). A multimedia instructional package consists of resources that are computer-based with text, pictures, sound, animation, video, or a combination of these media used in educational instruction to enhance learning outcomes (Mayer, 2013). Multimedia instructional packages promote sound, graphical and visual presentation of lesson to meet diverse learning needs of students in the classroom. Cyril (2016) noted that the use of multimedia instructional package provide opportunity for students experience the actual objects of study through sequences in motion. Multimedia instructional package can convey information in a stimulating situation that aids the brain to preserve information in the form of images, which can be easily retained and remembered. Mukherjee (2018) opined that multimedia should be interactive and controllable by the user. (2021) asserted that multimedia packages include: practice programmes and educational software such as Microsoft PowerPoint for making lesson presentations using a digital projector.

Multimedia in education encompasses three primary attributes: multiple media, delivery control, and interactivity. It utilizes various sensory formats such as videos, computers, and images to engage learners comprehensively, enhancing understanding and retention (Heinich *et al.*, 2002; Akude, 2004). This flexibility allows educators to convey information through different media elements, combining text, audio, video, and interactive features to cater to diverse learning styles and promote deeper learning (Cairncross & Mannion, 2000; Manjit *et al.*, 2003b). Moreover, multimedia offers learners control over their learning experience, enabling non-linear navigation and the ability to pause, replay, or explore supplementary materials independently, which fosters a sense of ownership and autonomy (Cairncross and Mannion, 2000). Lastly, interactivity in multimedia supports active student engagement through simulations and interactive exercises, facilitating better understanding and academic achievement across various educational levels and subjects (Murali & Jaise, 2016; Olasunkanmi & Salubi, 2023).

In this study, the Integrated Multimedia Instructional Package is an educational resource that embodies a holistic and intentional approach to mathematics instruction. It brings together a diverse range of media elements, such as text, images, audio, video, and interactive components, in a seamlessly integrated manner that could appeal to learners. The goal is to create a unified, cohesive, and engaging educational experience. By leveraging the strengths

of multimedia and adopting effective instructional strategies, this package aims to enhance learning, address diverse learning styles, and provide a comprehensive platform for effective education.

However, certain factors, including ease of use, content relevance, interactivity, flexibility, students' gender, and perceptions, tend to moderate the potential effects of integrating self-developed multimedia packages for instructional delivery. These factors could, in one way or another, affect the effectiveness of the Integrated Multimedia Instructional Package on students' learning of mathematical concepts, such as Sequences and Series. Gender is a term used to describe human beings based on sex and refers to male and female beings. Studies show that gender stereotypes can influence how students perceive subjects like mathematics and physics, sometimes discouraging female students from pursuing them. (Zalmon & Arokoyu, 2021). In Nigeria, WAEC Chief Examiners' Reports from 2018-2023 show no consistent pattern of one gender outperforming the other in overall mathematics, though item-level analysis is rarely published (Armah, *et al*, 2025). This suggests that if gender differences exist in "sequences and series," they are likely to be topic-specific and influenced by non-cognitive factors. Yet, this assertion needs to be re-examined for evidence of consistency. Similarly, it is important to investigate whether students' perception of Mathematics' Sequences and series as a difficult topic (Wigfield & Eccles, 2000; Fortunato, Ziab, and Fadlallah, 2026) could affect the use of multimedia instructional packages to teach it. The outcomes of the study would provide empirical evidence that should be able to provide insight to educators and educational technologists for further studies.

Statement of the Problem

Generally, Mathematics is regarded as the cornerstone of all sciences, serving as the central axis around which other scientific disciplines orbit. However, the global concern is that students find mathematics difficult. Especially at the secondary school level, students find some topics more challenging, including Sequences and Series, and this demands the attention of educators to proffer solutions, particularly with appropriate digital technology that could engage learners sufficiently for improved learning outcomes. Therefore, this study determined the effects of the Integrated Multimedia Instructional Package (IMIP) on senior secondary students' achievement in Sequences and Series in Mathematics in the Ona-Ara Local Government Area of Oyo State, Nigeria. It further determined the moderating effects of perceived mathematics difficulty and gender on students' achievement in the topic.

Objectives of the Study

The main objective of the study was to determine the effect of an Integrated Multimedia Instructional Package (IMIP) designed and developed by the researchers on senior secondary students' achievement in the Sequences and Series aspect of Mathematics in Ona-Ara Local Government Area of Oyo State, Nigeria. The specific objectives of the study are to:

1. determine the main effect of treatment (Integrated Multimedia Instructional Package) on Students' academic achievement in Mathematics Sequences and Series;
2. examine the main effect of perceived mathematics difficulty on students' academic achievement in senior secondary school Mathematics Sequences and Series;
3. find out if there is any effect of gender on students' academic achievement in Mathematics Sequences and Series when taught with Integrated Multimedia Instructional Package; and
4. examine the interaction effect of treatment and perceived mathematics difficulty on students' academic achievement in Mathematics Sequences and Series.

Hypotheses

The following hypotheses were formulated to guide this study:

1. There is no significant main effect of treatment on Students' academic achievement in Mathematics Sequences and Series.
2. There is no significant main effect of perceived mathematics difficulty on students' academic achievement in senior secondary school Mathematics Sequences and Series.
3. There is no significant main effect of gender on students' academic achievement in Mathematics Sequences and Series.
4. There is no significant interaction effect of treatment and perceived mathematics difficulty on students' academic achievement in Mathematics Sequences and Series.

Methodology

This study adopted a pre-test post-test control group, quasi-experimental design to examine the effects of the Integrated Multimedia Instructional Package (IMIP) on Senior Secondary School Two students' mathematics achievement in Sequences and Series. Purposive sampling was used to select schools for the research. The participants of this study were students in senior secondary school two (SS2) who were not preparing for any terminal examinations. Forty students (20 in experimental group and 20 in control group) participated in the study. The selection was based on the following criteria:

- i. The schools must be government-owned.
- ii. The schools must allow students to use technology (tablets, laptops and smartphones in schools),
- iii. The schools have facilities such as a well-articulated classroom structure, tables, and chairs that allow group-based learning.
- iv. The schools must have qualified Mathematics teachers with a minimum qualification of NCE.

This study employed a stimulus instrument named the Integrated Multimedia Instructional Package (IMIP), and two response instruments called Sequences and Series Achievement Test (SSAT) and Students' Perception of Sequence and Series Questionnaire (SPSSQ).

The ASSURE Instructional Design Model, which has the goal of producing more effective teaching and learning, is an acronym that stands for the various steps in the model (Heinich, *et al*, 2002). It was employed to design and develop the integrated multimedia instructional package and the lesson plan used in this study. The model provides a systematic framework for educators and instructional designers to plan, develop, and assess instructional experiences effectively. It comprises six phases, namely: Phase 1 - Analyze Learners (A), Phase 2 - State Objectives (S), Phase 3 - Select Methods and Media (S), Phase 4 - Utilize Materials (U), Phase 5 - Require Learner Participation (R), and Phase 6 - Evaluate (E).

Phase 1 - Analyze Learners (A)

Characteristics, prior knowledge, and learning styles of the learners who would use the IMIP for Sequences and Series were identified. Factors such as age, grade level, technological proficiency, and specific needs or challenges were considered. Multimedia elements aligned with learners' preferences and needs were determined, integrating visuals, animations, and interactive components catering to different learning styles and levels of understanding in Sequences and Series.

Phase 2 - State Objectives (S)

Learning objectives for Sequences and Series that the IMIP aimed to achieve were clearly defined. Specific goals and desired outcomes were outlined, ensuring alignment with the curriculum and educational standards. Multimedia elements directly addressing the stated

learning objectives were designed, with each component contributing to the mastery of specific concepts in Sequences and Series, fostering comprehensive understanding.

Phase 3 - Select Methods and Media (S)

Instructional methods and multimedia elements that best aligned with the learning objectives and the analyzed characteristics of the learners were chosen. Various media formats, such as videos, simulations, and interactive modules, were considered to enhance understanding. Multimedia formats optimizing the learning experience for Sequences and Series were selected, including animations to illustrate mathematical sequences and interactive simulations for hands-on exploration of series concepts.

Phase 4 - Utilize Materials (U)

The necessary materials and resources for the IMIP were gathered or created. Multimedia elements were well-integrated and seamlessly flowed within the instructional package for Sequences and Series. The multimedia elements were organized and structured cohesively within the IMIP, featuring a user-friendly interface facilitating easy navigation and access to relevant materials related to Sequences and Series.

Phase 5 - Require Learner Participation (R)

Activities actively engaging learners with the multimedia content were designed. Participation was encouraged through interactive exercises, discussions, or assessments related to Sequences and Series. Interactive features within the IMIP allowed learners to actively engage with the multimedia content, including quizzes, simulations, or collaborative elements reinforcing the understanding of Sequences and Series.

Phase 6 - Evaluate (E)

Assessment strategies to measure the effectiveness of the IMIP were developed. Formative and summative evaluations gathered feedback on learners' comprehension of Sequences and Series. Assessments aligned with the multimedia content evaluated how well learners grasped the concepts presented in Sequences and Series through the IMIP.

The second instrument, Students' Achievement in Sequences and Series (SSAT) with reliability index of $r = 0.75$ using KR-20 test, was self-developed based on the mathematics curriculum. It is made up of two sections A and B. Section A provides information on students' bio-data which consist of name of school, name of students, class, and gender. Section B consist of twenty (20) items to test the cognitive level of the students on Sequences and Series. Each correct answer was rewarded one mark to make a total of 20 marks. The third instrument, christened Students' Perception of Mathematics Questionnaire (SPDMQ), with a reliability index of $r=0.72$ using the Cronbach Alpha test considered that students' perception of mathematics could have an effect on achievement (Furinghetti and Pehkonen, 2000; Leder *et al*, 2002). It was used to measure students' perception of mathematics. The instrument has two sections; section A consists of bio-data information such as school type and gender, while section B comprises 10 items with a 4-Likert scale ranging from; Strongly Disagree, Disagree, Agree and Strongly Agree.

The experiment lasted for six weeks. Week 1: Training of research assistants. The instruments were administered to the students in the experimental and control groups for the pretest exercise; Week 2-5: The research assistants made use of conventional teaching method to teach Sequences and Series four times a week in the control group. Likewise, the research assistants made use of Integrated Multimedia Instructional Package (IMIP) to teach Sequences and Series four times in a week in the experimental group; and Week 6: Administration of posttest questionnaire. The data collected from the achievement test and questionnaires were subjected to inferential and descriptive statistics. The data were analyzed using frequency counts, percentage Pie and Cluster Bar Chart and Analysis of Covariance (ANCOVA) method were used to determine the relationship between groups' achievement mean scores of the pretest and the posttest.

Results

The results of the data analysed with tables depicting demographics and relationships that exist among the variables and the discussions are as follows:

Table 1: Demographic information of students

Gender	Frequency	Percentage
Male	19	48%
Female	21	52%
Total	40	100%

Table 1 shows the frequency distribution of students who participated in the study. A total of 40 students participated. By gender; out of 40 respondents, 19(48%) were male and 21(52%) were female.

Hypothesis One: There is no significant main effect of treatment on students' achievement in Mathematics

Table 2: Analysis of Covariance (ANCOVA) of Sequences and Series Achievement Test scores by Treatment, Perceived mathematics difficulty and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	583.621 ^a	8	72.953	94.312	0.000	.961
Intercept	213.716	1	213.716	276.290	0.000	.899
Pretest	.610	1	.610	.789	0.381	.025
Treatment	219.521	1	219.521	283.793	*0.000	.902
Perceived mathematics difficulty	69.734	1	69.734	90.151	*0.000	.744
Gender	.045	1	.045	.058	0.812	.002
Treatment * Perceived mathematics difficulty	3.171	1	3.171	4.099	*0.049	.117
Error	23.979	31	.774			
Total	6464.000	40				
Corrected Total	607.600	39				

R Squared = .961 (Adjusted R Squared = .950) * Denote significant difference at 0.05 level of significance

Table 2 shows that there is significant main effect of treatment on students Sequences and Series Achievement Test scores in ($F_{(1,31)} = 284.79$; $P < 0.05$, partial $\eta^2 = 0.90$). The effect size is 90%. This indicates that 90% of the variation in students' achievement is as a result of the significant main effect of the treatment. Thus, hypothesis 1 was rejected. Therefore, there is significant main effect of treatment on students' achievement in Mathematics.

Table 3: Estimated Marginal Means for Post-test by Treatment (Control and Experimental group)

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control (Conventional teaching method)	8.601 ^a	.215	8.164	9.039
Experimental (Integrated Multimedia Instructional Package)	14.550 ^a	.262	14.015	15.085

Table 3 revealed that the students in the Experimental group (Integrated Multimedia Instructional package) had the highest adjusted post- Sequences and Series Achievement Test mean score (14.55) while the Control group (Conventional teaching method) had the least adjusted post- Sequences and Series Achievement Test mean scores (8.60). The magnitude of the significant main effect of treatment across groups is depicted by the graph in Figure 1.

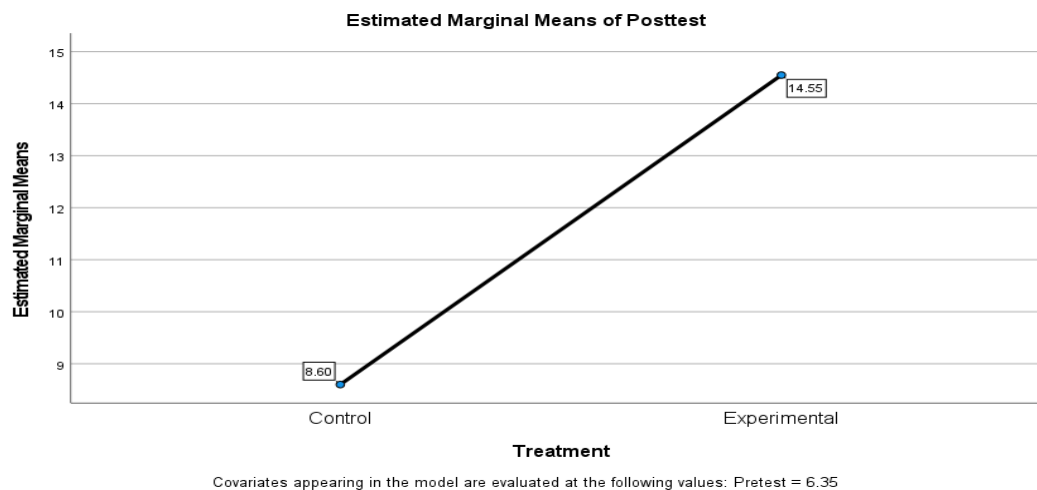


Figure 1: The magnitude of the significant main effect of treatment across groups

Hypothesis Two: There is no significant main effect of perceived mathematics difficulty on students' achievement in Mathematics

Table 3 shows that there is significant main effect of perceived mathematics difficulty on students Sequences and Series Achievement Test scores in ($F_{(1,31)} = 90.15$; $P < 0.05$, partial $\eta^2 = 0.74$). The effect size is 74%. This indicates that 74% of the variation in students' achievement is as a result of the significant main effect of their level of perceived mathematics difficulty. Thus, hypothesis 2 was rejected. Therefore, there is significant main effect of perceived mathematics difficulty on students' achievement in Mathematics.

In order to determine the magnitude of the significant main effect across perceived mathematics difficulty groups, the estimated marginal means of the perceived mathematics difficulty groups (high and low) was calculated and the result was presented in Table 4.

Table 4: Estimated Marginal Means for Post-test by Perceived mathematics difficulty (Positive and Negative)

Perceived mathematics difficulty	95% Confidence Interval			
	Mean	Std. Error	Lower Bound	Upper Bound
Low	10.008	.268	9.462	10.554
High	13.143	.188	12.759	13.527

Table 4 revealed that the students with a positive perception had the highest adjusted post-Sequences and Series Achievement Test mean score (13.14) while students with a negative perception had the least adjusted post-Sequences and Series Achievement Test mean scores (10.01).

Hypothesis Three: There is no significant main effect of Gender on students' achievement in Mathematics.

Table 3 shows that there is no significant main effect of gender on students' Sequences and Series Achievement Test Scores ($F_{(1,31)} = 0.58$, $p > .05$, partial $\eta^2 = 0.002$). This means that gender has no significant effect on students' achievement in Mathematics. Thus, hypothesis 3 was not rejected.

Hypothesis Four: There is no significant interaction effect of treatment and perceived mathematics difficulty on students' achievement in Mathematics

Table 3 shows that there is significant interaction effect of treatment and perceived mathematics difficulty on students Sequences and Series Achievement Test scores in ($F_{(1,31)} = 4.10$; $P < 0.05$, partial $\eta^2 = 0.12$). The effect size is 12%. This indicates that 12% of the variation in students' achievement is as a result of the significant interaction effect of treatment and their level of perceived mathematics difficulty. Thus, hypothesis 4 was rejected. Therefore, there is significant interaction effect of treatment and perceived mathematics difficulty on students' achievement in Mathematics.

In order to determine the magnitude of the significant main effect across perceived mathematics difficulty groups, the estimated marginal means of the perceived mathematics difficulty groups (positive and negative) was calculated and the result was presented in Table 5.

Table 5: Estimated Marginal Means of Treatment and perceived mathematics difficulty on Students' Post Achievement score

Perceived mathematics difficulty	Treatment	95% Confidence Interval			
		Mean	Std. Error	Lower Bound	Upper Bound
High	Control	10.737	.603	9.515	11.958
	Experimental	13.738	.377	16.976	18.500
Low	Control	8.798	.406	10.976	12.620
	Experimental	12.082	.711	10.642	13.523

From Table 5, it can be deduced that students with a positive perception had higher achievement score in experimental group (13.74) than the control group (10.74). Also, students with a negative perception had higher achievement score in the experimental group (12.08) than those in the control group (8.80).

Discussion of Findings

The findings of the study revealed significant differences in the achievement scores of students in the experimental and control group. Students exposed to the Integrated Multimedia Instructional Package had higher achievement scores than students in the control group. The findings showed that the experimental strategy (using integrated multimedia instructional package) is more effective than the conventional teaching method in improving students' academic achievement in Mathematics. The result is in support of the findings of his agrees with the view of Ibrahim (2012), Gambari, Yaki & Olowe (2013) and Dubey (2012). Their findings of their study revealed that the experimental group that received experimental treatment of integrated multimedia instructional package performed significantly better than those taught using the conventional teaching method.

Using multimedia instructional package can convey information in a stimulating situation that aids the brain to preserved information in the form of images which can be easily retained and remembered, this however influences their academic achievement. Also, the study of Murali & Jaise (2016) asserted that multimedia allows teachers to address various levels of students in a classroom due to the fact that it enables students to see, hear, and imagine what is being taught thereby help increase students' academic achievement in any subject. The result proves that by leveraging the strengths of multimedia and adopting effective instructional strategies, the package will enhance the learning process, address diverse learning styles, and provide a comprehensive platform for effective education which will have a positive impact of students' academic achievement.

The study revealed that significant differences existed in the achievement of between students with a positive and negative perception. Students with a positive perception particularly had the highest adjusted post achievement mean score of (13.14), while students with a low level of perceived mathematics difficulty had the least adjusted post-achievement mean score of (10.01). This denotes that perceived mathematics difficulty of students has an influence in the academic achievement of students in Mathematics. This result is in line with the findings of (Anne, Ndurumo & Kisilu., 2013). Their study revealed significant difference in the academic achievement of students in the groups. Students with a positive perception had higher achievement than their counterparts with a negative perception. This tends to suggest that students' performance will largely be shaped by their perceived mathematics difficulty to Mathematics, However, good academically the student is, the perceived mathematics difficulty creates an impetus into the student's mind which creates a culture to like or dislike the subject. When these students' perceptions are not strengthened towards an undertaking, they often don't do quite well academically, even though they can do well under conducive environment.

Gender was found to have no significant effect on students' achievement in Mathematics. The finding is in support of Akinbadewa (2020) which reported that gender has no significant effect on students' achievement in Mathematics. From all his findings, it was revealed that there was no difference in the mean achievement and interest of male and female students taught Mathematics. It was therefore concluded that gender does not influence the achievement of students in Mathematics. Finally, findings of the study revealed that there was a significant interaction effect of treatment and perceived mathematics difficulty on the academic achievements of students in Mathematics. Students with a positive perception in the experimental group did better than students with a positive perception in the control group. Also, student with a negative perception did better in the experimental group than those in the control group. This proves that the perceived mathematics difficulty of students, coupled with the right instructional strategy such as integrated multimedia interactive package can improve the academic achievement of students in Mathematics.

Conclusion

Based on the results of the finding, the Integrated Multimedia Instructional Package (IMIP) has significant beneficial influence on the learners of the mathematics topic, Sequence and Series than the conventional lecture method. The use of Integrated Multimedia Instructional Package (IMIP) does not discriminate between genders in academic achievement. The IMIP as an instrument was found more interesting, interactive and engaging. It also assisted the students to master learning contents at their own pace. Hence, IMIP is found to be effective for the improvement of students' academic achievement in Sequences and Series in schools when used by teachers to mediate mathematics instruction.

Recommendations

Hence, the following recommendations were made:

- i. Mathematics teachers should use IMIP strategy as one of the strategies to be employed in classroom teaching and learning.
- ii. Government should provide well equipped computer laboratories and power supply in public senior secondary schools to facilitate effective use of Integrated Multimedia Instructional Package (IMIP) strategy.
- iii. Parents should provide computers and animated instructional packages on mathematics topics for their children to use at home after school hours.
- iv. Seminars and workshops should be organized by State and Federal Ministries of Education for mathematics teachers to enable them to learn how to use IMIP to teach series and sequence in mathematics.
- v. Curriculum planners should embrace and include IMIP strategies that will bring about improvement in learning, acquisition of creative thinking, problem solving and performance skills in students into the curriculum.

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