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Effect of Adaptive Learning Approach on Academic Achievement of Secondary School Physics Students in Ogidi Education Zone

OBIKWELU, Chinyere Cecilia[1] & ACHUFUSI-AKA, Nonye Ngozi[2]
1, 2-Department of Science Education, Nnamdi Azikiwe University, Awka, Anambra State.
n.n.Achufusi-aka@unizik.edu.ng

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Abstract
The study determined the effects adaptive learning approach on academic achievement of secondary school physics students in Ogidi Education Zone. Two research questions guided the study and three hypotheses guided the study. Quasi-experimental research design was adopted for the study. The population of the study was 3,113 senior secondary year two (SS2) students offering physics from which 138 students was obtained using purposive and simple random sampling techniques. The instrument for data collection was Physics Achievement Test (PAT) validated by three experts. The reliability of PAT was established using Kuder-Richardson Formula 20 to be 0.70. The experiment groups were taught physics using adaptive learning approach while the control group was taught using lecture method. CSAT was administered as pretest and posttest to generate data for the study. Research questions were answered using mean and standard deviation and analysis of covariance was used to test the null hypotheses. There was a significant difference between mean achievement scores of students taught physics using adaptive learning approach and lecture method in favour adaptive learning approach. Also, gender had no significant influence on students' achievement in Computer studies. It was recommended that seminars and workshops should be organized by educational administrators on how to employ and integrate ALA into the teaching and learning process of physics to make it easier for the students to understand the contents.

Keywords: *Adaptive, Physics, Achievement,*

Introduction

The actualization of the objectives of teaching Physics in senior secondary school however, has been a mirage as there has been a steady decline in students' achievement in Physics as observed by science education researchers (Nnaji, 2021; Ilo, 2022). Also evidence shown in the statistics of students "academic performance in West African Senior School Certificate Examination in physics purports poor students" achievement in the subject as Compared to other science subjects. In 2014, with an enrolled population of 635,729, only 60.76 percent of the students passed at credit level and above. In 2015, 60.1 percent of the students enrolled for the subject passed at credit level. From 2016 to 2017, 58.95 and 56.48 percent respectively passed at credit level and above, showing that there was a steady decline in the number of the students who passed. In 2018, 289,820 representing 60.24 percent of the

students enrolled for the examination passed. However, despite the increase in percentage, the number of students who passed the examination with respect to the number enrolled for the examination was below that of 2017. From 2019 to 2021, similar trend of poor and fluctuating academic achievement has been observed among students who enroll for physics in WASSCE.

The observed poor achievement could be due to methods of teaching and the overuse of the conventional teaching method used by physic teachers (Ilo, 2022). Nnaji (2021) observed that there is a serious disconnection between the ways of learning and methods of teaching in Physics and most teachers use the lecture method they were taught with for today's teaching thereby resulting in passive learning on the part of the students. The most common conventional methods which are often teacher centred, Nnaji (2021) asserted were lecture, teacher-demonstration and expository methods of teaching.

Lecture method are often used by physics teachers as it enables them to cover large Portions of the scheme of works especially for the over-populated classroom common in public schools. Lecture method has been reported by researchers as one of the contributing factors to the students poor performance in physics despite its advantages (Nnaji, 2021).

Lecture method is a teaching method in which the teacher gives out information to students who are at receiving end. It is therefore teacher-centered. The advantage is that it can accommodate large number of students at a time but it does not stimulate students "innovation, inquiry and scientific method (Konyefa and Okigbo, 2021). There is therefore the need for an innovative teaching methods such as: cooperative learning strategy, blended learning, multi-media integrated instructions, adaptive learning approach, discovery learning and metacognitive learning approach, that will promote excellence, motivate students to learn, give a transformative educational experience. Although many of these methods have been proven effective as reported in many research studies, little is known about the potency of adaptive learning approach for improving academi achievement in physics especially in the Nigerian conventional classroom like those in Ogidi Education zone of Anambra state. The innovative teaching approach considered in this research is Adaptive Learning Approach.

The adaptive learning approach is an instructional strategy that seeks to achieve a shared instructional objective with learners that have distinctive characteristics, such as prior achievement, aptitude, or learning styles (Ikwumelu, Oyibe & Oketa, 2015). Borich (2011) defines adaptive learning approach as the use of differentiated instruction such as the implementation of various teaching methods tailored to certain groups of students, ensuring that the inherent diversity in the classroom does not hinder any student from attaining success. According to Elena, Luisa, Maria, Juan, and Maria (2008), adaptive learning offers students individualised and personalised instruction, leading to enhanced student satisfaction and greater learning efficacy. The adaptive teaching style encompasses both remediation and compensating approaches (Adeyemi, 2017). In this study, the adaptive learning approach is defined as an instructional approach where the teacher actively adjusts the instructional approach to meet the particular needs and characteristics of each student, with the goal of creating effective instruction.

Adeyemi (2017) states that the initial approach in adaptive learning is proactive, involving the provision of fundamental knowledge or skills to learners. This enables them to effectively engage in planned instruction, such as student-centered discussions and question-and-answer sessions. The compensatory approach, which is the second approach, is characterised by a reactive nature. In this approach, the selection of an educational method is

determined by its effectiveness in compensating for the deficiency of fundamental knowledge or skills among the learners. Applying adaptability has been demonstrated to create an enhanced learning environment, as students individually receive and process information in unique manners (Alonso, Guzman, & Amescua, 2013).

Adaptive learning aims to be more individualised by constructing a model of each student's objectives, preferences, and knowledge level. This model is then utilised during the interaction with the students to tailor the learning experience to their specific needs. According to Ikwumelu et al. (2015), a significant number of adaptive learning systems prioritise adapting the assessment process, including tests and self-assessments, rather than focusing on how the content is presented. For instance, in the context of adaptive learning, oral examinations can be administered to assess students' knowledge, which can then be deduced by adaptive assessments. In addition to the self-assessment tests, adaptive learning can provide tips during the question or feedback after the response, with a specific emphasis on cognitive diagnostics.

The current study employed an adaptive learning technique that entailed developing a comprehensive list of essential knowledge for each specific content area in simple harmonic motion, which is the physics subject matter to be taught. After evaluating and analysing the adaptive test results of students, instructions are provided to address their knowledge gaps. Suitable instructional plans are then developed to teach students who have comparable needs. The teacher will employ differentiated teaching throughout the instructional process to cater to various groups of students who have comparable academic demands and learning styles, with the aim of enhancing the academic performance of the learners. Customising education to accommodate students' individual requirements and preferred learning methods effectively tackles academic challenges in a highly personalised manner. The active participation of students in the learning process might enhance their academic progress by stimulating their interest and enthusiasm to learn.

Academic achievement according to Udegbe and Okoli (2022) is a measure of knowledge gained in formal education. It is usually indicated by test scores, grade points, averages and degrees. This means that the achievement level of the students is judged by scores that the students acquired in an examination. In the context of this work which will be done using secondary school students, academic achievement will be taken as the students' score in a Physics Achievement Test (PAT).Achievement test helps the teacher and students to evaluate and estimate the degree of success attained in learning a given concept irrespective of gender (Akachukwu and Okoli, 2023).

Gender as a factor in students' achievement in science has been receiving research attention for many years. It is the biological, social and cultural identity by which an individual is known as male or female (Anafiza and Djukri, 2017). Sex-role stereotyping and masculine image of science are known factors influencing students‟ choice and achievement in science subjects generally. Nzewi (2015) however, found out that gender is not a significant factor in students "achievement and interest in physics. He further stated that the sex-role stereotyping and masculine image of science tend to place female students at a disadvantage in their choice relative of their male counterparts. In addition, various teaching-learning strategies have been developed to accelerate learning process of students but with little emphases on their biasness to gender. Ejeh and Akudolu (2021) found that innovative instructional strategies like problem-based learning affected male and female students differently. The male students had higher achievement than the female students. Emerhiona et al (2018) also found out that there was no

significant influence of gender on the students "achievement. Other authors like Barasa, Changeiywo and Okere (2015) found out that male students performed significantly better than female students in physics. The disparities in students' achievement in physics based on gender have continued to incite further research on gender. Thus, there is the need for further investigation into the achievement difference in physics based on gender.

Purpose of the Study

The purpose of the study is to investigate the effect of adaptive learning approach on academic achievement of secondary school physics students. Specifically, this study sought to determine the:

1 difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using lecture method.

2 difference between the mean achievement scores of male and female students taught Physics using ALA.

3 interaction effect of instructional approaches and gender on students' achievement in physics.

Research Questions

1 What is the difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using Lecture method (LM)?

2 What are the mean achievement scores of male and female students taught Physics using ALA and LM?

Hypotheses

1 There is no significant difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using Lecture method (LM).

2 There is no significant difference between the mean achievement scores of male and female students taught Physics using ALA and LM.

3 There is no significant interaction effect of instructional approaches (ALA and LM) and gender on students' achievement in Physics.

Method

A quasi-experimental design was adopted for the study, specifically, the non-randomized pre-test, post-test control group design. The study was carried out in Ogidi Education Zone, Anambra state. The population of the study comprised of 3,113 senior secondary school year two (SS2) students offering physics 2023/2024 academic session in the 37 senior government secondary schools in Ogidi Education zone in Anambra state. The sample size for the study consisted of 138 SS2 students offering physics. The sample will be obtained using multi-stage sampling procedure purposive and random sampling techniques. First, the researcher will use purposive sampling techniques in selecting two co-educational secondary schools in the zone. The rational for the selection of the schools is to ensure that they are miles apart to avoid subject interaction and contamination and also to take care of the gender variable in the study. Secondly, using the toss of a coin, the two co-educational schools will be assigned into experimental and control group. In each school, all the physics students

in SS2 will be involved in the study. The experimental group consists of 83 students (47 males and 36 females) while the control group comprises 55 students (35 males and 20 females).

The instrument that used for data collection was Physics Achievement Test (PAT). PAT was adapted from past WASSCE question items relating to the concept taught in this study. It has two sections namely section A and section B. Section A was designed to generate information of the students' biography while section B of the instrument contained the test items. PAT is a 50 items multiple choice test question with four answer options lettered A-D (Appendix D page 63). The questions were on the concept of simple harmonic motion. The questions were chosen for each content using a table of specification. Lesson plan was also prepared by the researcher on the concepts of Physics to be taught. The adaptive lesson plan has several instructional strategies designed to achieve the objective of instruction given the academic needs manifested by students during instructional process. The conventional lesson plan has the same content except that there is no remedial instruction and the teacher is at the center of the instruction. Entry knowledge lessons will be prepared for each week's lesson as is needed for the proper understanding of the concepts. It contained a brief outline of instructional objectives for which the teacher could use any instructional strategy she deems fit to teach any students or group of students who manifest deficiency in that area of knowledge.

The instrument was validated by to three experts, one from the Department of Science Education, one in the Department of Educational Foundations (Measurement and Evaluation) all from Nnamdi Azikiwe University, Awka and one experienced physics secondary school teacher. The reliability of PAT was established using Kuder-Richardson (KR-20). This is because the items are dichotomously scored with either right or wrong answers and KR-20 is a suitable reliability estimate for determining the internal consistency of dichotomously scores items. PAT was administered once to 40 SS2 Physics students in two schools not involved in the study. Their scores were obtained and the reliability index calculated which gave a coefficient value of 0.70.

The treatment was done in two stages. In the first stage, regular physics teachers in the intact classes involved in the study was trained on the objectives of the study and the experimental procedures. The training programme was done in one week. In the second stage, the pretest was administered and treatments commenced after the pretest in the same week. The experimental group of students were provided with weekly instructions from the teacher on the principles of simple harmonic motion during the first session of each week throughout the therapy. The treatment utilised instructions that are structured into unit contents, ensuring that the lesson is divided into modules where shortcomings or necessary information can be identified. Following each session, the teacher conducts the evaluation specifically designed for that module. The evaluation **was** examined to identify students who share common deficiencies in understanding the topic and are lacking the necessary physics expertise to grasp it. Based on the analysis of the evaluation scores, the instructor categorises students with comparable weaknesses or lacking necessary knowledge. The teacher then selects specific instructions from the requisite knowledge lesson to address these knowledge gaps and help the students improve. The teacher document**ed** which sections of the instructions were reviewed to ensure comprehension.

During the second session of the same week, the teacher organised the students into groups based on a predetermined criteria and instruct the chosen group on various physics concepts from the necessary knowledge inventory. The remedial education took place within the general class, with specific attention given to each group based on their identified areas of knowledge lack. Questions were exclusively entertained from the organisations who are anticipated to pose any question(s). Upon addressing the various requirements of the groups, the teacher promptly reviewed the instructional material of the unit in which the students performed poorly, as well as other units for which individual students may seek additional guidance. The teacher utilised several teaching methodologies to ensure comprehensive comprehension of the lesson subject. The lesson in the second period was succeeded by an assignment on the subsequent topic. The control group received instruction utilising traditional methodology. The content remained same, however, there was no additional support provided to address individual student questions or to tailor lessons to fit specific academic requirements.

The research questions were answered using mean and standard deviation while the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). ANCOVA was used because the design adopted for the study (pretest-posttest non-randomized group design) resulted in initial group difference. Thus, ANCOVA was used to take care of the initial differences that may exist between the groups.

Results

Research Question 1: What is the difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using Lecture method (LM)?

Table 1: Mean Achievement Scores of Students taught Physics using Adaptive Learning Approach (ALA) and Lecture Method (LM)

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
ALA	83	31.82	7.73	72.96	12.41	41.14
LM	55	27.20	5.77	55.45	13.23	28.25
Diff.		4.62		17.51		12.89

Table 1 shows that students taught Physics using adaptive learning approach had pretest mean achievement score of 31.82 and posttest mean achievement score of 72.96 with gained mean achievement score of 41.14, while those taught with Physics using Lecture method (LM) had pretest mean achievement score of 27.20 and posttest mean achievement score of 55.45 with gained mean achievement score of 28.25. Students taught Physics using ALA had a less homogeneous score in their pretest (7.73) than those taught using LM (5.77). In the posttest however, students taught Physics using PPSM had a more homogeneous score (12.41) than those taught using LM (13.23).

Research Question 2: What are the mean achievement scores of male and female students taught Physics using ALA and LM?

Table 2: Mean Achievement Scores of Students Male and Female Students taught Physics using ALA and LM

Method	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
ALA	Male	47	30.87	7.37	72.04	13.83	41.17
	Female	36	33.06	8.10	74.17	10.34	41.11
LM	Male	35	29.11	4.93	58.69	11.61	29.58
	Female	20	23.85	5.71	49.80	14.26	25.95

Table 2 shows that the male students taught Physics using ALA had pretest mean achievement score of 30.87 and posttest mean achievement score of 72.04 with a gain in mean achievement scores of 41.17 while the female students had pretest mean achievement score of 33.06 and posttest mean achievement score of 74.17 with gain in mean achievement scores of 38.11. Table 2 also reveals that the male students taught Physics using LM had pretest mean achievement score of 29.11 and posttest mean achievement score of 58.69 with a gain in mean achievement scores of 29.58 while the female students had pretest mean achievement score of 23.85 and posttest mean achievement score of 49.80 with gain in mean achievement scores of 25.95. Male students taught Physics using ALA had higher mean gain achievement score than those taught using LM and also, female students taught Physics using ALA had higher mean gain achievement score than the female students taught using LM.

Hypothesis 1: There is no significant difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using Lecture method (LM).

Table 3: ANCOVA Test of Significance of Difference in the Mean Achievement Score of Students taught Physics using ALA and LM

Source	SS	df	Mean Square	F	Sig.	Decision
Corrected Model	11408.051[a]	4	2852.013	18.219	.000	
Intercept	32405.975	1	32405.975	207.013	.000	
Pretest	169.737	1	169.737	1.084	.300	
Method	10639.520	1	10639.520	67.966	.000	Sig.
Gender	409.206	1	409.206	2.614	.108	Not Sig.
Method * Gender	1097.094	1	1097.094	7.008	.009	Sig.
Error	20819.920	133	156.541			
Total	633092.000	138				
Corrected Total	32227.971	137				

Table 3 shows that there is a significant main effect of the treatment on students' achievement in Physics, $F(1, 133) = 67.966$, $P = .000 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant difference between the mean achievement scores of students taught Physics using adaptive learning approach (ALA) and those taught using Lecture method (LM) in favour of ALA.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students taught Physics using ALA and LM.

Table 3 also shows that there is no significant main influence of gender on students' achievement in Physics, $F (1, 133) = 2.614$, $P = .108 > 0.05$. Therefore, the null hypothesis was

not rejected meaning that there is no significant difference between the mean achievement scores of male and female students taught Physics using ALA and LM.

Hypothesis 3: There is no significant interaction effect of instructional approaches (ALA and LM) and gender on students' achievement in Physics.

Table 3 further shows that there is significant interaction effect of the instructional approaches and gender on students' achievement in Physics, F (1, 133) = 7.008, P = .009 < 0.05. Therefore, the null hypothesis was rejected meaning that there is a significant interaction effect of instructional approaches (ALA and LM) and gender on students' achievement in Physics.

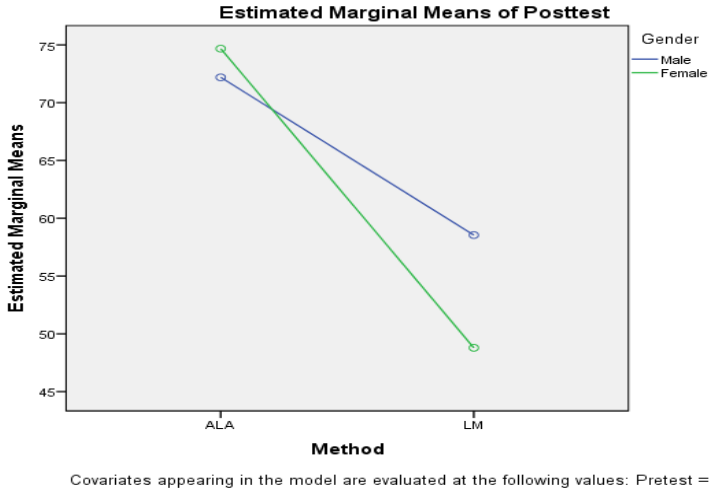

Figure 1: Plot of interaction effect of instructional methods (ALA and LM) and gender on students' achievement in Physics

The plot of interaction effect of instructional methods and gender on students' achievement in Physics is significant and disordinal. This shows that the instructional methods had different effect with respect to gender and are therefore gender sensitive. Male students taught Physics using ALA had higher mean achievement score than female students whereas male students taught using AGM had a lesser mean achievement score than the female students.

Discussion

The study showed that there was a significant difference between the mean achievement scores of students taught Physics using ALA and those taught using LM in favour ALA. The plausible explanation for the result of the study can be advanced from the fact that teaching students physics using adaptive learning approach meets their academic and physics learning needs. Getting to receive instructions on requisite knowledge or teaching to overcome deficient knowledge of concepts necessary to understand the new subject matter being taught, enabled students to grasp a proper meaning of what was taught. The students by integrating new knowledge with existing knowledge structure attained meaningful learning which had correspondent positive effect of students' academic achievement in Physics.

The teacher by differentiating instruction for the students to ensure that their needs are met also gave them rich learning experiences that ensured mastery learning. Thus, adaptive learning approach enabled the teacher to provide such a learning atmosphere where students proceeded with the learning of the instructional material contents at their own pace. The remedial instructions that are focused on students' weakness also gave students sufficient

motivation to understanding the contents of instruction leading to higher academic achievement.

The findings of the study is in line with the findings of Clair (2015) that students taught using adaptive learning system had higher final grades than students who did not use the system. The findings of the study lend credence to the findings of Wei and Khanh-Phuong (2019) that students achieved better performance using Yixue adaptive learning system than both traditional classroom instruction by expert teachers and another adaptive learning platform. The results of the study contradicts the finding of Murray and Pérez (2015) who compared adaptive learning to traditional learning and reported that student learning, gauged via two examinations, did not vary significantly across the courses based upon instructional delivery approach. Also, the findings of Bozhilov, Stefanov and Stoyanov (2009) that there was no statistically significant main effect for groups working under different adaptive scenarios and with traditional groups contravene the findings of the present study. The finding of the students showed that there was no significant difference between the mean achievement scores of male and female students in Physics. The observation can be explained from the fact that adaptive learning approach is well suited for both male and female students having adjusted for the needs of each individual student irrespective of their gender. Thus, students notwithstanding their gender were properly engaged in the lesson. The active participation from both male and female students resulted in greater interaction with the learning materials leading to good academic achievement on both parts.

Again, significant disordinal interaction effects of instructional approaches and gender was observed on students' achievement in Physics. The ordinal nature of the interaction effect suggests the idea that the gender of physics students has influence on their physics academic achievement, considering the instructional approach that is adopted. Thus, certain instructional approaches are therefore more suited for male students and others for female students. The finding of the study is in line with the finding of Aloa (2010) that gender has no significant influence on students' achievement in Physics. The findings of the study contradict the findings of Abu (2021) that significant difference exist between the performance of male and female students' academic achievement in physics.

Conclusion

The findings of this study showed that students taught Physics using ALA had significantly higher achievement scores than those taught using LM. The conclusion that can be drawn from the result is that ALA bears the potentials for helping students understand Physics concept well enough to reach high academic achievement. Thus, the use of ALA could help secondary school physics students to improve on their academic achievement in the subject. Again, gender had significant influence on students' achievement in Physics. It is established therefore that adaptive learning approach provides similar learning experiences for both male and female students, minimizing the gender gaps that could lead to male significantly outperforming the females or vice-versa.

Recommendations

Based the findings and conclusion of the study, the following recommendations are made:

1. Seminars and workshops should be organized by educational administrators on how to employ and integrate ALA into the teaching and learning process of physics to make it easier for the students to understand the contents.

2. Physics teachers should always give students pre-assessment test on concepts that are related to the new topic as a diagnostic tool to evaluate their entry knowledge for the new lesson and give remedial instruction on the observed weaknesses.
3. A pool of questions that can be used for pre-assessment of physics knowledge in relation to the spiral arrangement of topics in physics curriculum should be develop by evaluators to be used by secondary school teachers.

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