

Effect of Adaptive Learning Approach on Students' Achievement in Chemistry in Awka Education Zone of Anambra State

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Abstract

The study determined the effect of adaptive learning approach (ALA) on students' achievement in chemistry in Awka Education Zone. Two research questions guided the study and three hypotheses were tested at 0.05 alpha level. Quasi-experimental design was adopted for the study. The population of the study was 1, 942 senior secondary three (SS3) students offering chemistry in Awka Education Zone out of which a sample size of 109 students was drawn using purposive and random sampling techniques was involved in the study. The instrument for data collection was Chemistry Achievement Test (CAT) validated by three experts. The reliability of CAT was established using Kuder-Richardson Formula 20 to be 0.70. Research questions were answered using mean and standard deviation while analysis of covariance was used to test the null hypotheses. The result of the study showed that students taught using ALA had higher mean gain scores in achievement than those taught using conventional instructional method. The findings of the study revealed that there was a significant difference between mean achievement scores of students taught chemistry using ALA and conventional instructional method in favour of ALA. It was concluded that ALA is an effective instructional approach for improving students' achievement in chemistry. It was recommended among others that chemistry teacher should always form a pre-assessment test covering all such basic knowledge needed to understand the chemistry concept to be taught, so as to uncover areas where students need remedial instruction.

Keywords: *adaptive learning, achievement, chemistry, organic, conventional*

Introduction

Chemistry deals with the understanding into the world of matter, its occurrence, synthesis, and uses. Topics in chemistry education include understanding how students learn chemistry and determining the most efficient methods to teach chemistry. Teaching chemistry to students at a young age can increase student interest in STEM careers. Chemistry also provides students with many transferable skills that can be applied to any career. However, the abstract nature of the subject makes it difficult for students to understand.

Students offering chemistry manifest varied academic characteristics and each student prefer to use different learning resources in distinct ways. The students also have other aspects beside their peculiar academic preferences and needs such as goals and level of background knowledge. These characteristics bear certain effects on learning effectiveness and are particular for each individual student (Elena, Luisa, María, Juan & María, 2008).

Thus, the ideal learning system should be such that is adapted to the students according to their peculiarities.

The advocacy for adaptive learning approach dates back to antiquity; since educators have long known that learning is improved when instruction is personalized – adapted to individual learning styles. Adapting learning to students' needs and learning style addresses academic problems in a manner most personal to the student. Therefore, this could serve as an effective remedy to poor achievement. The incessant poor achievement of chemistry students in external examination clearly points out the necessity of adaptive instruction. Over the year, students' achievement in chemistry at the secondary school level has continued to be revisited with appalling notes. The West African Senior School Certificate Examination (WASSCE) Chief Examiners' Reports showed that students' achievement in chemistry has not improved as expected. Also, according to the Chief Examiner Report (2019) students as in other previous years manifested weakness in chemistry concepts such as organic chemistry. Students showed poor understanding of terminologies and International Union of Pure and Applied Chemistry (IUPAC) nomenclatures of organic compound. The report further revealed that students have very shallow understanding of molecular structure and formula of organic compounds and stereochemistry.

The problems of poor achievement in chemistry have been attributed by researcher to a number of factors. Studies (Nwanze & Okoli, 2021, Konyefa & Okigbo, 2021) have shown that lack of laboratory facilities and instructional materials, students' phobia for the science subjects and non-availability of adequate consumable and over-the-counter chemicals for practical exercises contribute to students' poor achievement. The commonest factor however adduced to students' poor achievement was the teaching method adopted by the teacher (Nwanze, Konyefa & Ezeanya, 2021). Nwanze *et al.* noted that chemistry teachers adopt the use of conventional instructional method and this has continued to pose serious challenges for students in the learning of chemistry.

Conventional instructional method is teacher-centred method of instruction in which the teacher is seen as an authority that dispenses knowledge with the students at the receptive end. Students in the conventional classroom are known to be passive and have lessened participation in their learning process. Despite these disadvantages of conventional instructional methods, chemistry teachers either employ its usage because it can be used to cover large content areas or to reach large number of students in small amount of time. Conventional instructions unlike student-centred instructions do not allow students to take responsibility for their own learning. Student-centred instructional approaches like adaptive learning approach reveals students' learning style and academic needs thereby enabling the teacher to diagnose students' weaknesses and address them by adapting instruction to meet the students' needs.

Adaptive learning approach is an instructional approach aimed at achieving a common instructional goal with learners whose individual differences such as prior achievement, aptitude, or learning styles differ (Ikumelu, Oyibe & Oketa, 2015). According to Borich (2011) it is the application of different instructional strategies to different groups of learners so that natural diversity prevailing in the classroom does not prevent any learner from achieving success. Adaptive learning according to Elena, Luisa, María, Juan and María (2008) provides students with individual and personalized learning wherein students' satisfaction and the effectiveness of the learning process could be improved. Adaptive teaching strategy involves remediation and compensatory approach (Adeyemi, 2017). Therefore, adaptive learning approach is conceived in the present study as an instructional approach in which purposeful effort is made by the teacher to accommodate individual differences in learners' characteristics for designing effective instruction.

According to Adeyemi (2017) the first approach in adaptive learning is proactive in nature where learners are provided with the basic or prerequisite knowledge or skill necessary for them to benefit from the planned instruction, such as student centred discussion and question and answer session. The second approach (compensatory) is reactive in nature where the choice of an instructional method is based on its efficacy in compensating for lack of basic knowledge or skill among the learners. The application of adaptation has been shown to provide a better learning environment given that students perceive and process information in very different ways peculiar to them.

In the present study, adaptive learning approach involved the creation of an inventory of named requisite knowledge for each content area in organic chemistry to be taught. On evaluation and analysis of students' adaptive test, instructions are given to students to remedy their knowledge deficiencies and preparations made using any suitable instructional plans to teach students who manifested similar needs. The teacher during the whole process of instruction differentiated instruction for different groups of students who show similarity in their academic needs and learning styles in order to improve academic achievement of the learners.

Academic achievement is the outcome of instruction. According to Konyefa and Okigbo (2021) it is the grade obtained through achievement test through which the teacher evaluates the extent to which instructional objectives have been achieved. Academic achievement is often an expression of what the students have gained from an educational programme or lesson. Students' achievement refers to performance in a school subject as designated by a score or mark obtained in an achievement test (Abd, Andi & Muhammad, 2020). Achievement is measured by standardized achievement test developed for school subjects. Achievement is conceived in the present study as the students score on a standardized test from a given instructional content.

Achievement in the view of Nwankwo (2020) is often time a function of how much the students are able to remember the learning material. This is because students who engage in rote learning, unlike those who indulge in meaningful learning have poor understanding and find it difficult in applying the knowledge gained in the solution to outlined chemistry problems. Meaningful learning according to Borich (2011) is an important factor that can be achieved when teachers adapt instruction to meet male and female students' varied academic needs irrespective of their gender

Gender is the sexual assignment or identity of an individual. The influence of gender and its interaction with instructional strategies have remained inconclusive. Studies had shown that certain instructional methods favour males more than females and others reported otherwise. Some teaching methods tend to be gender sensitive (Izuegbunam, 2018, Konyefa, 2018) while others are more gender bias or specific (Nwanze, 2016). Effective instructional strategies however, must have the potency to positively enhance achievement irrespective of students' gender. Since the influence of gender of students when learning is adapted is not widely known, investigating how adaptive learning interacts with gender to affect achievement will be a worthwhile exercise.

Purpose of the Study

The purpose of the study determined the effect of adaptive learning on students' achievement in chemistry. Specifically, the study seeks to determine the:

1. difference between the mean achievement scores of students taught chemistry using adaptive learning approach (ALA) and those taught using conventional instructional method (CIM);
2. difference between the mean achievement scores of male and female students taught chemistry using ALA.

Research Questions

The following research questions guided the study.

1. What is the difference between the mean achievement scores of students taught chemistry using adaptive learning approach (ALA) and those taught using conventional instructional method (CIM)?
2. What is the difference between the mean achievement scores of students taught chemistry using ALA and those taught using CIM?

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the mean achievement scores of students taught chemistry using adaptive learning approach (AL) and those taught using conventional instructional method (CIM).
2. There is no significant difference between the mean achievement scores of male and female students in chemistry.
3. There is no interaction effect of instructional approaches and gender on students' achievement in chemistry.

Method

The study adopted the quasi-experimental design. The area of study was Awka Education Zone of Anambra State. The population of the study was made up of 1,942 (1,331 males and 611 females) senior secondary school year three (SS3) chemistry students offering chemistry in Awka Education Zone. The sample of the study is 109 (60 males and 49 females) SS3 chemistry students. The sampling involved a multi-staged procedure. The coeducational schools in Awka South were listed and two schools were chosen purposively. The rationale for choosing the schools will be because they are far apart to avoid class interaction and they are coeducational to help take care of the gender variables. The schools also have similar characteristics. In each of the schools selected, one intact class of chemistry SS3 students were chosen at random for the study. The intact classes were assigned to experimental and control groups using the toss of a coin. The experimental group has 59 students (32 males, 27 females) and the control group has 50 students (28 males, 22 females).

The instrument for data collection was Chemistry Achievement Test (CAT). CAT 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. CAT is a 50 items multiple choice test question with four answer options lettered A-D. The questions were on the concepts on organic chemistry and its compounds. The questions were chosen for each content using a table of specification.

Lesson plans were also prepared by the researcher on the concepts of chemistry 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 centre of the instruction. Requisite Knowledge Inventory (RKI) was prepared for each week's lesson. The inventory contains a list of all requisite/entry chemistry knowledge needed for the proper understanding of the concepts. It also contains a brief outline of instructional objectives for which the teacher could use any instructional strategy she deems fit to teach any student or group of students who manifest deficiency in that area of knowledge.

The instrument and intervention were validated by experts from Department of Science Education and Educational Foundations, Nnamdi Azikiwe University, Awka and Department of Measurement and Evaluation, Federal College of Education Technical,

Umunze. The reliability of CAT was established using Kuder-Richardson 20 (KR-20) to be 0.77.

The treatments were done in two stages. In the first stage, regular chemistry teachers in the intact classes involved in the study were 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. Students in the experimental group received instructions from the teacher on the concepts of organic chemistry and its compounds in the first period of every week of the treatment. The treatment was done using instructions organised into unit contents to ensure that the lesson is broken down to modules to which weaknesses or requisite knowledge is identifiable and contained in the requisite knowledge inventory. After every lesson, the teacher administers the LPT for that module. The LPT was analysed to identify students who have similar weaknesses in learning the concept and the lacking requisite chemistry knowledge needed to learn the concept. Using the information from the LPT score analysis, the teacher groups the students who have similar weakness or lacking requisite knowledge and select from the requisite knowledge inventory the instructions to be received by the students to remedy their knowledge deficiencies. The teacher denoted what unit of the instructions received was revisited for proper understanding.

In the second period of the same week, the teacher arranged the students according to the group formulated and teach the class the selected chemistry concepts from the requisite knowledge inventory. The remedial instructional was done in the general class but with particular focus on each group according to their identified knowledge deficiency. Questions will only be taken from the group focused on for any remedial instruction with other students learning and waiting for their own turn for remedial instruction to ask any question(s). After attending to the different group needs, the teacher quickly revisited the units of instruction which the students did not do well in and other such units for which the students as individuals may request further instruction. The teacher employed different instructional procedure necessary to ensure understanding of the contents of the lessons. The lesson in the second period was followed with an assignment on the next topic.

The control group was taught using conventional method. The same content was taught but no remedial instructions were given neither did the teacher adapt instructions to meet individual student's needs. Students' questions were attended to during the lesson without any further diagnostic exercise to identify and meet academic needs. Data relating to the research questions and analysis of FAT were answered using mean and standard deviation while those relating to the hypotheses were tested using Analysis of covariance (ANCOVA). The Decision rule was to reject the null hypotheses where the Pvalue is less than or equals 0.05 ($P \leq 0.05$) and accept the null hypotheses where the Pvalue is greater than 0.05 ($P > 0.05$).

Results

Research Question 1: What is the difference between the mean achievement scores of students taught chemistry using adaptive learning approach (ALA) and those taught using conventional instructional method (CIM)?

Table 1: Mean Achievement Scores of Students Taught Chemistry Using Adaptive Learning Approach (ALA) And Conventional Instructional Method (CIM)

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
ALA	59	25.54	9.73	73.75	8.41	48.21
CIM	50	21.56	9.34	69.72	6.63	48.16

Mean Difference	3.98	4.03	0.05
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Table 1 reveals that the students taught chemistry using ALA has pretest mean achievement score of 25.54 and posttest mean achievement score of 73.75 with gained mean achievement score of 48.21, while those in the control group taught with conventional instructional method has pretest mean achievement score of 21.56 and posttest mean score of 69.72 with gained mean 48.16. Students taught chemistry using ALA had a less homogeneous score in their posttest (8.81) than those taught using CIM (6.63). The difference between the between the mean gained achievement scores of the students is 0.05 in favour of ALA.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught chemistry using ALA?

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

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
Male	32	25.34	9.63	79.41	5.44	54.07
Female	27	25.78	10.02	67.04	6.02	41.26
Mean Difference		0.44		12.37		12.81

Table 2 reveals that the male students taught chemistry using ALA has pretest mean achievement score of 25.34 and posttest mean achievement score of 79.41 with gained mean achievement score of 54.07, while those the female students had pretest mean achievement score of 25.34 and posttest mean score of 67.04 with gained mean 41.26. Male students taught chemistry using ALA had a more homogeneous score in their posttest (5.44) than the females (6.02). The difference between the mean gained achievement scores of the male and female students is 12.81 in favour of males.

Hypothesis 1: There is no significant difference between the mean achievement scores of students taught chemistry using adaptive learning approach (AL) and those taught using conventional instructional method (CIM).

Table 3: ANCOVA Test of Significance of Difference between the Mean Achievement Scores of Students taught Chemistry using ALA and CIM

Source	Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	2842.978 ^a	4	710.745	19.215	.000	
Intercept	72279.511	1	72279.511	1954.053	.000	
Pretest	47.627	1	47.627	1.288	.259	
Method	300.331	1	300.331	8.119	.005	Sig.
Gender	1631.363	1	1631.363	44.103	.000	Sig.
Method * Gender	554.780	1	554.780	14.998	.000	Sig.
Error	3846.912	104	36.990			
Total	570163.000	109				
Corrected Total	6689.890	108				

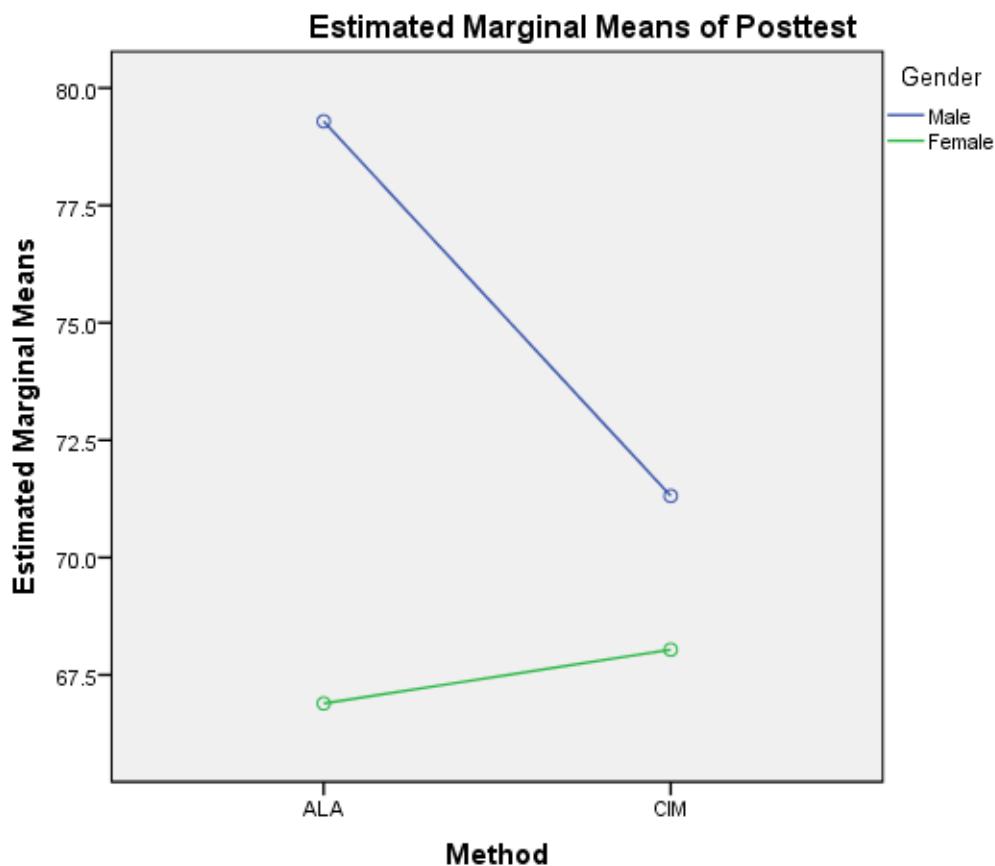
Table 3 shows that there is a significant main effect of the treatment on students' achievement in chemistry $F(4, 104) = 8.119, P = 0.005 < 0.05$. Therefore, the null hypothesis was rejected meaning that there is a significant difference between the mean achievement scores of students taught chemistry using adaptive learning approach (AL) and those taught using conventional instructional method (CIM) in favour of ALA.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students in chemistry.

Table 3 also shows that there is a significant influence of gender students' achievement in chemistry $F(4, 104) = 44.103, P = 0.000 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant difference between the mean achievement scores of male and female students in chemistry in favour of the males.

Hypothesis 3: There is no interaction effect of instructional approaches and gender on students' achievement in chemistry.

Table 3 further shows that there is a significant interaction of instructional approaches and gender on secondary school students' achievement in chemistry $F(4, 104) = 14.998, P = 0.000 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant interaction effect of instructional approaches and gender on students' achievement in chemistry.



Covariates appearing in the model are evaluated at the following values: Pretest = 23.72

Figure 1: Plot of interaction effect of instructional approaches and gender on secondary school students' achievement in chemistry

The plot of interaction effect of instructional approaches and gender on students' achievement in chemistry is significant and ordinal. This shows that effect of the instructional approaches did not change when gender was put into consideration. Thus, the teaching methods were gender biased with respect to achievement.

Discussion

The student showed that there was a significant difference between the mean achievement scores of students taught chemistry using ALA and those taught using CIM in

favour ALA. The observed result is attributed to the fact that students exposed to adaptive learning had their academic needs met. They received remedial instructions on those chemistry concepts that were required for their proper understanding of what was being taught. To do so, the teacher differentiated instruction for students and taught them in a way that the learning is meaningful for the students.

Again by exposing the students to varied instructional style with a view to ensuring that they learn the concepts and master the learning materials, the students were engaged in a rich learning experience. Again, the use of adaptive learning help the students to learn at their own pace giving students opportunity to interact with the teacher over the learning materials in as much as they learn the material. By adapting learning, students had sufficient opportunity to learn the concept through learning of other related concept, thus, learning adaptation became an incentive that motivated the students to study more.

The findings of the study contradicts the findings 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. The finding of the study supports the finding of Clair (2015) that students taught using adaptive learning system had higher final grades than students who did not use the system. The finding of the study is in line with the finding 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 finding of the students showed that there was a significant difference between the mean achievement scores of male and female students in chemistry. Significant interaction effects of instructional approaches and gender was observed on students' achievement in chemistry. Adaptive learning favoured the males more than the females in their achievement. The finding of the study is not in line with the finding of Neboh (2009) and Rafiee, Pazhakh and Gorjian (2014) that there was no significant difference in the achievement of males and females when individualized instructional approach (LAP) was used. The finding of the study supports the finding of Abungu, Okere and Wachanga (2014) that in the Experimental Group, the boys obtained higher mean score than the girls in the CAT pre-test, and after the treatment however, there was statistically significant difference in the mean scores between boys and girls in the experimental groups.

Conclusion

The findings of this study showed that students taught chemistry using ALA had significantly higher achievement scores than those taught using CIM. It is concluded that ALA is an effective instructional approach for improving students' achievement in chemistry. Again, gender had significant influence on students' achievement in chemistry. The conclusion drawn from the finding is that adaptive learning approach affects male and female students differently.

Recommendations

The following recommendations are made in the light of the findings of the study:

1. Chemistry teachers should adopt ALA in teaching chemistry making sure that students' knowledge deficits in chemistry concepts needed as important entry knowledge to their present lesson are revisited.
2. Chemistry teacher should always form a pre-assessment test covering all such basic knowledge needed to understand the chemistry concept to be taught, so as to uncover areas where students need remedial instruction.

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