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Effect of Adaptive Learning Approach on Students' Retention 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' retention in chemistry in Awka Education Zone. Two research questions and three hypotheses guided the study. The design of the study was Quasi-experimental design. 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 for 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 retention than those taught using conventional instructional method. The findings of the study revealed that there was a significant difference between mean retention 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' retention in chemistry. It was recommended among others that chemistry teachers 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, conventional, chemistry, retention*

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I. Introduction

Chemistry education is important because the field of chemistry is fundamental to our world. The universe is subject to the laws of chemistry, while human beings depend on the orderly progress of chemical reactions within their bodies. Described as the central science, chemistry connects physical sciences with the life sciences and applied sciences. Chemistry has applications in food, medicine, industry, the environment, and other areas. Learning chemistry allows students to learn about the scientific method and gain skills in critical thinking, deductive reasoning, problem-solving, and communication.

Chemistry students at the secondary school level have over the years continued to show poor achievement in chemistry, evident in their appalling achievement at external examinations. One of the factors implicated for the poor achievement is the teaching method adopted by the chemistry teachers which do not enable the students to retain what they have learnt no more than a term. A lot of innovative instructional strategies that have been empirically proven to improve or enhance students' retention of chemistry concepts are not easily implementable at the secondary school chemistry classes. In most cases, the school either lack the necessary facilities needed to adopt such instructional strategies or the chemistry teachers lack the know-how and motivation. Other considerations such as age, maturity and level of knowledge prevent the chemistry teachers from their usage.

There is the need therefore, to seek redress in approaches of instruction that could make-up for students' learning weaknesses, knowledge deficiencies and academic needs with a view to avoid rote learning and ensure proper understanding of chemistry concepts to the point of retaining learning materials over a fair period of time. To achieve this aim, attention need to be directed by chemistry teachers on how to adopt adaptive learning approach in teaching chemistry. The present study therefore, sought to find out whether such learning adaption could improve retention of chemistry concepts.

Retention is the ability to remember or recognize the content that has been learned or experienced. It is an importance issue in teaching and learning. Learning is complete when knowledge can be transferred into a new situation and studies on type of learning tools that promote students' retention is yet to be concluded (Anunobi, Gambari, Abdullahi & Alabi, 2016). However, active engagement of students in the learning process

has been known to facilitate retention (Neboh, 2009). This is because students' engagement in the learning process exposes them to individual learning experience and varied practice tools which may facilitate transfer and enhance retention process. More importantly, students who have proper in-depth understanding of the learning materials tend to associate them with real life situations and thereby making learning meaningful. One of the innovative instructional strategy that possess the potential to enhance retain as shown in literature is adaptive learning.

Adaptive learning approach (ALA) according to Jonsdottir (2015) is an instructional approach that uses software as an intelligent interactive teaching mechanism that combines provision of resources according to the unique and essential learning requirements of each student. In adaptive learning experience, each student literally sees a different course based on his/her individual learner profile and demonstrated progress. In adaptive teaching strategy, different content is presented to different learners, which can be determined by a pre-test or formative knowledge check but will more likely be based on his or her performance during learning time. Franzoni and Assar (2009) described adaptive learning approach as the design of a personalized teaching method that is based on an adaptive taxonomy using Felder and Silverman's learning styles and which is combined with the selection of the appropriate teaching strategy and the appropriate electronic media.

Adaptive learning attempts to be more adaptive by building a model of the goals, preferences and level of knowledge of each student, and using the model throughout the interaction with the students in order to adapt learning to the students' need. Many adaptive learning systems focus the adaptation efforts on the assessment (both exams and self-assessments) instead of on content presentation (Ikwumelu *et al.*, 2015). For example, in adaptive learning, oral examinations may be conducted and students' knowledge inferred through adaptive tests. Beside the self-assessment tests, adaptive learning can offer hints with the question or provide feedback with the answer, focusing on cognitive diagnosis for students irrespective of gender.

Gender according to Nwona (2015) is the cultural difference among women and men based on the biological division between male and female. It refers to the social or cultural construct, characteristics, behaviours and role which society ascribes to males and females (Lazarides & Laumann, 2019). One common phenomenon in the educational sector is gender stereotyping. According to Matthew, Jonathan, Lewis, William and Tatiana (2021) educational practitioners give science subjects such as physics and chemistry masculine outlook.

Long-standing biases and gender stereotypes are discouraging girls and women away from science related fields, and STEM research in particular. Science and gender equality are, however, essential to ensure sustainable development as highlighted by UNESCO. In order to change traditional mindsets, gender equality must be promoted, stereotypes defeated, and girls and women should be encouraged to pursue STEM careers. Women worldwide Luttenberger, Paechter and Ertl (2019) ascerted tend to be at a greater disadvantage in crises compared to men. The pandemic according to Palmer, Burke and Aubusson (2017) has further worsened longstanding gender and other inequalities in science. Depending on various factors, such as family responsibilities, available support or career stage, women in science had to cope with additional issues complicating their career progress. Female scientists worldwide must have to find ways of how to make the best use of their time to minimize setbacks in their research careers.

In Nigeria, and perhaps the whole of Africa, gender bias is still very prevalent (Perez-Felkner, Nix & Thomas, 2017). This is a view which Schipolowski, Wittig, Mahler and Stanat (2019) pointed out and noted that gender roles are somewhat rigid in Africa including Nigeria in particular where gender differences are emphasized. It is common place to see gender stereotypes manifested in the day-to-day life of an average Nigerian. The issue of low female participation and attainment in Science, Technology and Mathematics (STM) is not peculiar to Nigeria alone, but a global problem which needs urgent reaction and sustained attention.

PURPOSE OF THE STUDY

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

1. difference between the mean retention scores of students taught chemistry using adaptive learning approach (ALA) and those taught using conventional instructional method (CIM)
2. difference between the mean retention scores of male and female students taught chemistry using ALA.
3. interaction effect of instructional approaches and gender on students' retention in chemistry.

RESEARCH QUESTIONS

The following research questions guided the study.

1. What is the difference between the mean retention 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 retention scores of male and female students taught chemistry using ALA?

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the mean retention 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 retention scores of male and female students taught chemistry using ALA.
3. There is no interaction effect of instructional approaches and gender on students' retention in chemistry.

IV. Method

Research Design

The study adopted the quasi-experimental design. Specifically, a pretest posttest non-equivalent control group design was used. Quasi-experimental design according to Nworgu (2015) is a study where random assignment of subjects to experimental and control groups is not possible and as such intact or pre-existing groups are used. The choice of quasi-experiment design therefore was because the administrative set up in the secondary school does not allow for randomization of students for experiment as it may disrupt school activities. The design of the experiment is shown in Figure 2.

$$\begin{array}{cccc} E & O_1 & X & O_2 \\ C & O_1 & \sim X & O_2 \end{array}$$

Figure 1: Diagrammatical Representation of the Research Design

Where;

E = Experimental group

C = Control group

O_1 = pretest

O_2 = post-test

X = experimental treatment using Adaptive Learning (AL)

$\sim$X = non-experimental using conventional method

--- = non-equivalent group

Area of the Study

The area of study is Awka Education Zone of Anambra State. The zone is situated in the capital city of Anambra state, in Awka. The area is inhabited by civil servants and traders. A few high institutions of learning are situated in Awka Education Zone of Anambra State namely, the prestigious Nnamdi Azikiwe University as well as many high class secondary schools. Awka South has 18 secondary schools comprising nine (9) single sex schools and Nine (9) co-educational secondary schools.

Population of the Study

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 offing chemistry in Awka Education Zone.

Sample and Sampling Techniques

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).

Instruments for Data Collection

Two instruments were used for data collection namely: Chemistry Achievement Test (CAT) and Learning Progress Test (LPT).

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. CAT will be used as pretest, test of achievement after instruction (posttest) and retention test (delayed posttest) after three weeks of administering the posttest.

LPT is an 8-13 item essay test questions designed to identify students' learning weaknesses on the unit concepts taught and knowledge deficiency about requisite/entry knowledge required for the understanding of the concept taught.

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.

Validation of the Instruments

The validation of the contents of the CAT was established using a table of specification to ensure that enough questions are drawn from the contents taught. CAT, the objectives of the study and the lesson plans were given to experts for validation. The experts are two lecturers from the Department of Science Education and Educational Foundations, Nnamdi Azikiwe University, Awka and one other lecturer from the Department of Measurement and Evaluation, Federal College of Education Umunze. The validators were requested to vet the instruments in terms of clarity and appropriateness for the level of students under study. The corrections from the validators were effected in the final copy of the instruments.

Reliability of the Instrument

The reliability of CAT was established using Kudder-Richardson 20 (KR-20). KR-20 was used because it is the most appropriate reliability estimate for establishing the internal consistency of multiple choice test items. CAT was administered once to 40 chemistry students offering in Community Secondary School Ezenifite in Aguata Education Zone of Anambra State and the generated scores were used to compute the reliability of the instrument 0.77.

Experimental Procedure

The treatments was done in two stages. In the first stage, regular chemistry teachers in the intact classes involved in the study will be 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 requite 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 were 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 requite 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.

Control of Extraneous Variables

1. Hawthorne effect: Hawthorne effect occurs when students put up imposturous behaviour having become sensitive to being used in a study. The study therefore used the regular chemistry teachers who were monitored closely throughout the study.

2. Class Interaction: Students involved in a study within close vicinities may interact over the experiment (class interaction) resulting in an invalid outcome. The study made use of schools that are further apart to avoid class interaction.
3. Non-equivalence: The study employed the use of robust analytical tool namely Analysis of Covariance (ANCOVA) which uses a covariate to correct for any initial group differences. In the present study, the pretest was used as covariate.
4. Test Knowledge**:** Test knowledge may result from the use of the same instrument in the pretest, posttest and retention test. To reduce test knowledge, the research print the posttest on a different colour of paper with the serial numbering of the questions changed. In the retention test, another colour of paper different from both the pretest and posttest as used and the serial numbering also altered. There was also a change in the numbering of answer options. More so, the experimental duration is long enough to reduce test knowledge.
5. Experimenter Bias: Experimental conditions may be conducted in a manner as to favour one group over the other, resulting in biased outcomes. The researcher used regular chemistry teachers who adhered to the lesson plans and closely monitored by the researcher.

Method of Data Collection

CAT was administered to the students in their groups as pretest before treatment and as posttest after treatment. No feedbacks were given after the pretest. After three weeks of the posttest, the same instrument was administered again as retention test on a different colour of paper. LPT was given to the students after every lesson and analysed to diagnose students' weaknesses. Information from the LPT was used to select what remedial lessons the students received from the deficient knowledge inventory. The administration of the instrument was done through the help of the regular chemistry teachers who were used as research assistants in the study.

Method of Data Analysis

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 ($P > 0.05$).

V. Results

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

Table 1: Mean Retention Scores of students taught Chemistry using ALA and CIM

Group	N	Posttest Mean	Posttest SD	Retention Mean	Retention SD	Loss in Mean
ALA	59	73.75	8.41	67.42	5.90	6.33
CIM	50	69.72	6.63	53.32	8.50	16.40
Mean Difference		4.03		14.01		10.07

Table 1 reveals that the students taught chemistry using ALA has retention mean score of 67.42 with loss in mean score of 6.33, while those in the control group taught with conventional instructional method has retention mean score of 53.32 with loss in mean score of 16.40. Students taught chemistry using ALA had a more homogeneous retention score (5.90) than those taught using CIM (8.50). The difference between the loss in mean scores of both groups is 10.07 with those in the control group having a higher loss in mean.

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

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

Gender	N	Posttest Mean	Posttest SD	Retention Mean	Retention SD	Loss in Mean
Male	32	79.41	5.44	69.38	5.39	10.03
Female	27	67.04	6.02	65.11	5.73	1.93
Mean Difference		12.37		4.27		8.1

Table 2 reveals that the male students taught chemistry using ALA has retention mean score of 69.38 with loss in mean score of 10.03, while the females has retention mean score of 65.11 with loss in mean score of 1.93. Female students taught chemistry using ALA had a more homogeneous retention score (5.73) than those taught using CIM (5.39). The difference between the loss in mean scores of both groups is 8.10 with those in the male students having a higher loss in mean.

Hypothesis 1: There is no significant difference between the mean retention 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 Retention Scores of Students taught Chemistry using ALA and CIM

Source	Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	6262.665[a]	4	1565.666	34.762	.000	
Intercept	2409.086	1	2409.086	53.488	.000	
Posttest	13.174	1	13.174	.293	.590	
Method	4323.488	1	4323.488	95.993	.000	Sig.
Gender	61.909	1	61.909	1.375	.244	Not Sig.
Method * Gender	667.032	1	667.032	14.810	.000	Sig.
Error	4684.106	104	45.039			
Total	415926.000	109				
Corrected Total	10946.771	108				

Table 3 shows that there is a significant main effect of the treatment on students' retention in chemistry F (4, 104) = 95.993, P = 0.000 < 0.05. Therefore, the null hypothesis is rejected meaning that there is a significant difference between the retention scores of students taught chemistry using ALA and those taught using CIM in favour of ALA.

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

Table 3 shows that there is no significant main influence of gender on students' retention in chemistry F (4, 104) = 1.375, P = 0.244 > 0.05. Therefore, the null hypothesis is accepted meaning that there is no significant difference between the mean retention scores of male and female students in chemistry.

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

Table 3 shows that there is a significant interaction of instructional approaches and gender on students' retention in chemistry F (4, 104) = 667.032, 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' retention in chemistry.

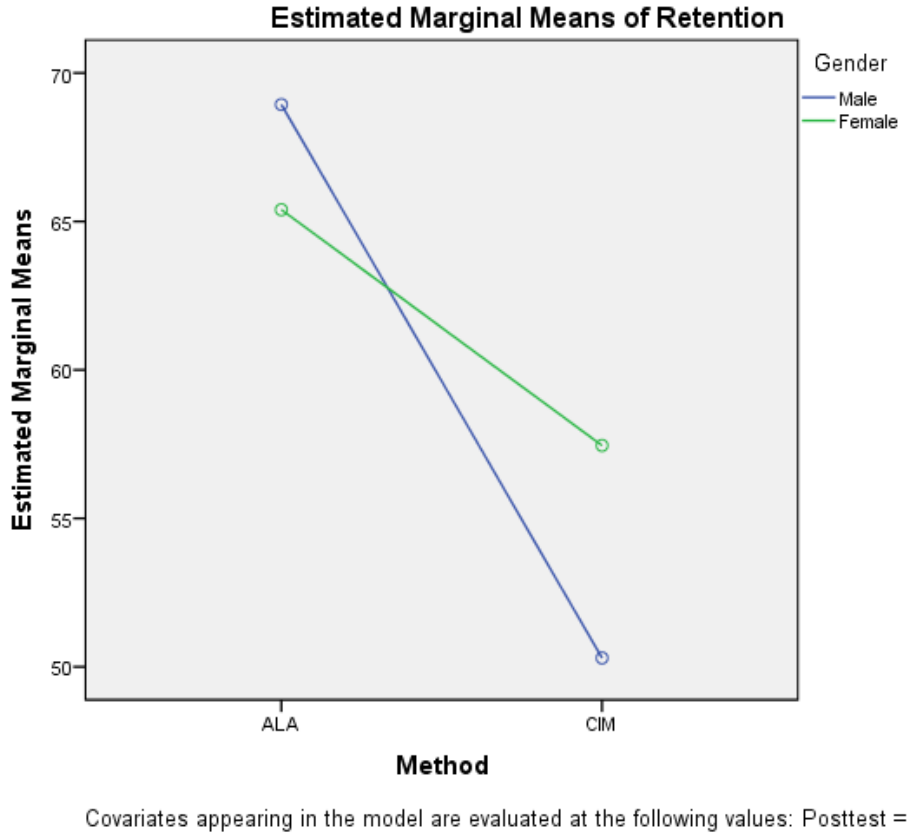

Figure 2: Plot of interaction effect of instructional approaches and gender on students' retention in chemistry

The plot of interaction effect of instructional approaches and gender on students' retention in chemistry is significant and disordinal. This shows that the instructional approaches have different effects on retention of students on different conditions, for example, the effect of the teaching approaches on students' retention changed when gender was consideration.

VI. Discussion

The finding of the study showed that there was a significant difference between the mean retention of students taught chemistry using ALA and those taught using CIM in favour of ALA. The observed result is because students in the adaptive learning classroom went over the materials a lot of time in an attempt to learn it. The remedial instructions also enabled them to properly understand the materials making the remembering of the materials very easy. The students in the adaptive learning group also had materials broken down to smaller units that made need procedural and sequential enhancing easy recall.

One way to improve a students' retention is by testing the progress in learning. This was common in adaptive learning as students were given learning progress test to determine the areas they needed further instruction. With the test and the feedback, the progress of students was ensured as the learning materials are visited again with different instructional styles that facilitate understanding and retention.

The finding of the study is in line with the finding of Adeyemi (2017) that there was a significant effect of the adaptive learning strategy on students' performance in civic education and retention. The finding of the study also contradicts that the finding of Anunobi, Gambari, Abdullahi and Alabi (2016) that there was no significant difference between the mean retention scores of male and female student exposed to web-based instructions.

VII. Conclusion

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

VIII. Recommendations

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. When adopting adaptive learning approach for chemistry students, chemistry teachers should create groups constituting male and female students to ensure that there is uniformity in the engagement of students, irrespective gender.

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