

Innovative Pedagogy and Improvement of Students' Knowledge Retention in Science Education: Learning Activity Package Instructional Approach

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ABSTRACT

Knowledge retention can be described as the ability of the students to assimilate available information during the learning process and recall/apply such knowledge obtained over time. Previously, students' active involvement in the teaching and learning processes through innovative pedagogies has enhanced their capacity for knowledge retention. This study, therefore, evaluated the potency of innovative pedagogy, the learning activity package (LAP), in fostering students' knowledge retention in science subjects in secondary schools, using gender as a moderating variable. The design was quasi-experimental. The sample was 208 class two students grouped into experimental and control groups exposed to LAP

and lecture methods, respectively. Data were obtained using the Chemistry Achievement and Retention Test and analyzed with mean, standard deviation, standard error, and the analysis of covariance, computed with SPSS. The findings revealed that the innovative pedagogy improved the students' knowledge retention in science more than the lecture method at $F_{(1,202)} = 45.72, p = .00, p < .05$. Besides, there was no interaction effect of method and gender on the students' retention of knowledge in science at $F_{(1,203)} = 2.47, p = .12, p > .05$. The implication is the avalanche of innovative science teachers

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who blend their instructional strategies to provide for the student's active participation in the teaching-learning processes for enhanced students' knowledge retention in science subjects. This research is novel because science teachers can easily adopt the LAP approach for effective lesson delivery, culminating in enhanced students' knowledge retention in secondary schools in developing nations.

Keywords: Active learning, developing nations, gender influence, innovative pedagogy, interactive learning, knowledge retention, learning activity package, science education students

INTRODUCTION

Science education entails teaching science concepts, teaching methods, and the various ways of addressing scientific misconceptions held by learners (Lee-Roy, 2012). Continuing, Lee-Roy emphasized the importance of science education in any nation's social and economic development. Chemistry education is a branch of science education concerned with the systematic processes of acquiring the fundamental knowledge of the universe to shape and reshape the world for the benefit of man (Emendu, 2014). Contributing to the definition of chemistry education, Stephen and Berhanu (2011) viewed education chemistry as a systematic inculcation of important cognition, skills, and disposition in the students that are required for the efficient and purposeful interplay in the surroundings for fixing existential issues within the society. Stephen and Berhanu reiterated further that the usefulness of education

chemistry in the socio-economic growth of nations cannot be over-emphasized.

Accordingly, chemistry education as part of science education is vital for national development. However, researchers have observed that students' knowledge retention in the subject is unimpressive in Nigeria (Ajayi & Ogbeba, 2017). The evidence is the poor academic performance in external examinations. Buttressing this, the West African Examination Council (WAEC, 2018) revealed that the standardized tests and evaluations conducted by the Council in the past decade have shown that students' performance in chemistry in the West African countries, including Nigeria, has been below the expected level. Therefore, several studies have been conducted to unravel the mysteries of the persistent students' poor academic performance in chemistry, specifically in Nigeria.

In one of the studies, Ajayi (2017) revealed that the students' low knowledge retention contributes to the persistently low levels of student academic performance in chemistry in senior secondary schools at the various public examinations in Nigeria. Ajayi based his conclusion on the fact that despite all the considerable efforts made by stakeholders at various levels in terms of engagement and motivating the teachers and provision of other facilities for learning, there was no appreciable improvement in the student's academic performance in chemistry over the years. Data in the West African Examination Council (WAEC) appraisal reports that the average percentage performance of the students in chemistry

was 44.44% between 2011 to 2017 (WAEC, 2018). These students' results were below the government's expected average performance of above 60% in science-related subjects (Federal Government of Nigeria [FGN], 2004). This current research focuses on fostering students' academic retention of knowledge in science subjects by utilizing innovative pedagogies which are student-centered. From the above submissions of previous research studies, it can be deduced that some of the efforts geared towards the improvement of student's academic performance in science subjects have been on the welfare of the teachers without incorporating the corresponding well-being of the students in the areas of the teachers utilizing innovative teaching strategies that can help to boost the students' retentive abilities and address their scientific misconceptions.

This current research expects that when the teachers and students are actively involved in proffering solutions to the problems of poor academic achievement, they might remarkably improve students' academic performance in science subjects in secondary schools in developing nations.

This study was structured according to the PJSSH format with the running title, title, abstract, and keywords. It was followed by the introduction in which previous research studies on the impact of active learning and innovative pedagogies on students' academic achievement and knowledge retention in science subjects were examined. The major variable in the study was knowledge retention, which is

the ability of students to retain learned concepts over time. Students' gender was a moderating variable. The interaction effect of method and gender on students' knowledge retention in chemistry was also examined. These were modeled into the research questions and corresponding null hypotheses that guided the study. The method and materials for the study were determined, and the results were collated. The study was concluded by discussing the findings and implications of the study. Finally, acknowledgments and references were listed.

Students' Academic Performance and Teaching of Science Subjects

A plethora of research studies showed persistent students' poor performance in external examinations in science subjects, specifically chemistry. For instance, Kurumeh et al. (2012) noted that the lingering poor performance of students in chemistry is attributable to the students' poor retention of knowledge of the learned concepts. Similarly, Ajayi and Ogbaba (2017) attributed the poor performance partly to the teachers' choice of instructional strategies that do not keep the students actively involved through hands-on and minds-on activities during lesson deliveries. Specifically, Udoh (2008) concluded that most teachers in developing nations use the conventional lecture method as their preferred instructional strategy. However, Wilson and Varma-Nelson (2016) disapproved of the utilization of the lecture method in science instructions and

opined that the lecture method, which is characterized by “talk-chalk mannerism,” is denoted as a teacher-centered approach, which might not be effective in the teaching of science subjects. Therefore, it is expected that any instructional strategy that provides for students’ activities in the learning processes will help the students to retain more knowledge of the concepts learned (Ajayi & Ogbeba, 2017; Udu, 2018a; Wilson & Varma-Nelson, 2016). These previous studies concluded that science subjects should be taught to students using active learning instructional strategies, which may help enhance their knowledge retention.

Meanwhile, Adegoke (2010) has identified the lecture method as economical in time and syllabus coverage. Furthermore, Adegoke deduced that the lecture method allows teaching large classes in African countries, including Nigeria, where large classes are a regular occurrence. However, Henderson et al. (2000) countered the claims of Adegoke. They emphasized that among the effective strategies for achieving better retention of knowledge by the students was the provision of student-centered and activity-oriented learning environments. These learning environments encourage students to participate actively in the class during the teaching-learning processes. In addition, research studies have shown that three levels of chemical representation—the macro, sub-micro and symbolic, are needed for students to understand chemical concepts (Gilbert & Treagust, 2009; Tan et al., 2009). These studies referred to the three levels of chemical representations as a triplet relationship, a key model for

chemical education. Illustrating further, Tan et al. (2019) noted that the macro-level seeks to represent phenomena/concepts as experienced with the senses, the sub-micro level seeks to support a qualitative explanation of those phenomena/concepts, and the symbolic level seeks to support a quantitative explanation of those phenomena/concepts. Therefore, it is expected that any innovative instructional strategy that exposes the students to link these three levels of chemical representation will enhance students’ understanding of chemical concepts that may help improve their academic performance in science subjects.

Previous research studies isolated and utilized several innovative instructional strategies centered on the students and were activity-oriented. They include cooperative learning, concept mapping, learning activity package, and many others (Udu, 2018a; Wilson & Varma-Nelson, 2016). These innovative pedagogies were found to promote active engagement of learners in hands-on and minds-on activities in the learning processes, which may culminate in improved students’ retention of knowledge in the subjects. Furthermore, some of these innovative strategies have the potential to aid the students in linking the three levels of chemical representation. This study, therefore, evaluated the effectiveness of the LAP instructional approach in assisting the students to link the three levels of chemical representation to improve their understanding of chemical concepts, thereby improving their knowledge retention in science subjects.

Concept of Learning Activity Package

Learning Activity Package (LAP), according to Duke (1975), is an innovative pedagogy that centers on the student's active engagement in learning activities in the classroom. In the LAP, the teacher serves as a facilitator of learning by guiding the students through a series of problem-solving activities. Duke maintained that in the LAP pedagogy, the students are expected to adhere to a logically sequenced pattern of problem-solving activities, which may assist them in accomplishing the goals of the learning experiences. Udu (2018a) emphasized that the learning activity package (LAP) pedagogy helps to foster the students' retention of knowledge in science subjects through active participation in the learning process.

Meanwhile, Arseneau et al. (1994) viewed the objectives of the learning activity package as achievable when the active learning materials are sequentially arranged, from the known to the unknown and in ascending levels of difficulty. Arseneau et al. note further that the LAP pedagogy is structured to enhance students' individualization of learning and help them master specific objectives from the general ones. Duke (1975) identified the characteristics of the Learning Activity Package as follows: LAP is a program of study in printed package form that covers a particular aspect of a subject; it follows a logical sequence of instructional objectives and activities for implementing the objectives; it gives the students freedom to proceed through the objectives and activities

at their own pace; learning materials are broken into small steps that are arranged sequentially from known to unknown and in increasing order of difficulty; it is structured for individualizing instruction that leads the students from the general idea to mastery of designated goals; it is designed to be used by a class as a whole, yet still provide for individual differences.

In addition, Ward and Williams (1976) highlighted the features of the Learning Activity Package to include: LAP has a general idea stating what is to be studied; specific skills to be achieved; a multimedia approach to practice and learn the skills; enrichment activities; series of three tests - test of prior knowledge, self-test, and a mastery test to determine the student's level of competence after completion of the package. Relating these features of LAP to the three levels of chemical representation in chemical education follows that the general idea, specific skills, and multimedia approach to practice and learn the skills help the students to understand the macroscopic level, while the enrichment activities and series of three tests help them to understand the submicroscopic and symbolic levels. The sub-micro and symbolic levels give a detailed premise to understanding the macroscopic level.

From the above submissions, the researchers assert that the learning activity package (LAP or package) is a good illustration of an active learning strategy rooted in the constructivists' learning approach. Zubeyde and Muhammed (2014) recognized LAP as a constructivists

instructional approach because of the active learning environment it provides, which may encourage students' active participation in learning activities. It helps enhance the student's knowledge retention abilities in the teaching-learning process. Zubeyde and Muhammed observed that a significant positive relationship exists between constructivist approaches to learning and students' academic retention. In constructivists' instruction, learners are trained to build mental images of what they learn rather than mere recipients of facts from their teachers.

Besides, Kirbulut and Gokalp (2014) opined that the learning principles of the learning activity package are deductions of the constructivists' instructional approaches, which are dependent on the assumption that the more opportunities for active learning for the students, the more the retention of knowledge. Ugur et al. (2017) underscore the constructivists' learning approaches to encourage students' active engagement in exploring knowledge by thinking, explaining the observed concepts, and extending their findings to real-world applications. These processes culminate in the acquisition of knowledge retention abilities by the students when motivated, guided, and evaluated by their teachers. In conclusion, Zubeyde and Muhammed (2014) accentuated that the learning activity package pedagogy, like other constructivists' instructional approaches, is self-instructional, student-paced, and student-directed, providing accountable learning and may ultimately improve the

students' retention of knowledge in the subject areas. It is on this backdrop that this present study is necessitated to apply the learning activity package pedagogy to a case study evaluation in a developing nation. Hopefully, the use of the learning activity package pedagogy, if effectively and consequentially applied in the learners' education, may assist in the educational development of the region.

Theoretical Foundation of LAP

The learning activity package innovative pedagogy is underpinned theoretically by the constructivist learning theory, specifically Dewey's theory of progressive learning and Kolb's experiential learning theory.

John Dewey propounded the theory of progressive learning in 1977. In theory, Dewey suggested the problem-solving approach to learning. He believed that for a child to learn, he should be subjected to a problem-situation, provided with necessary materials, and left alone to find the solution. In this type of learning, all the sense organs of the learner are involved in active interaction with the concept under study. The involvement of several sense organs in learning ensures meaningful and more permanent learning. Teaching science and chemistry, in particular using LAP, allows learners to interact with objects and phenomena for a better understanding, using the sense organs during the teaching-learning processes. Thus, the use of LAP in teaching science in secondary schools draws inspiration from Dewey's theory of progressive learning.

According to Dario et al. (2006), the experiential learning theory was propounded by Psychologist David Kolb. The theory emphasizes that students can create knowledge through the processes of an experience transformation. The learning theory describes the effects of experience, cognitive abilities, and learning environment on students' emotions in the learning processes. Accordingly, Kolb's model of experiential learning highlights that learners gain experience by forming concrete and conceptual ideas from reflective observations and active experimentation (Dario et al., 2006). The experiential learning model fits into the learning activity package pedagogical approach to science instructions. The LAP pedagogy helps students to build the capacity to acquire concrete experiences through active interaction with materials. Besides, these concrete experiences gained by the students are transformable through observation and active experimentation. Therefore, the learning activity package is modeled according to the experiential learning theory. In the process, the teachers are to facilitate the students' learning by steering them through actions that will enhance their abilities to gain concrete learning experiences.

Empirical Studies of LAP

Previous research studies have found the learning activity package effective in improving students' knowledge retention in science subjects. Specifically, Neboh (2012) conducted a study on the effect of

learning activity package (LAP) on male and female students' achievement in secondary school biology and found, among other things, that students exposed to the learning activity package pedagogy recorded higher retention of knowledge in biology than their counterparts taught with the lecture method.

Similarly, Abu (2001) conducted a study on the effectiveness of individualized and lecture instructional methods of teaching biology at the senior secondary level of education in Nigeria and concluded that the student's knowledge retention in biology was enhanced more with the learning activity package pedagogy than with the conventional (lecture) method. Furthermore, a study conducted by Udu (2018b) on the efficacies of cooperative learning instructional approach, learning activity package, and lecture method in enhancing students' academic retention in chemistry, found that students who were taught chemistry concepts with the learning activity package pedagogy had better retention of knowledge of the concepts learned more than their counterparts who were taught the same concepts in chemistry with the conventional (lecture) method.

Besides, the LAP pedagogy gives students freedom of choice and motivates them to operate within an organized framework (Arseneau et al., 1994). Arseneau et al. added that the learning activity package furnishes structures for the student's learning while providing for the differences in their learning rates. This case study research assessed the potency of the innovative learning activity package

pedagogy in fostering students' knowledge retention in science subjects in a developing nation, Nigeria.

Concept of Knowledge Retention

Ajit (2019) describes students' knowledge retention as assimilating available information during the learning processes and the ability to recall and apply the knowledge obtained from the learning process over time. Emphasizing further, Ajit noted the ease at which individuals tend to forget what they had learned and narrated that "after an hour, people hold only half of the information presented to them; after one day, people forget more than 70% of everything they have learned; and after a week, people forget 90% of the information on their learning session". Ajit, therefore, advises teachers to utilize innovative instructional strategies to stimulate multiple senses in the students, which may help them improve their knowledge retention abilities.

Besides, Kundu and Tutoo (2002) defined knowledge retention as a preservative factor of the mind that acquires materials of knowledge through sensation and perception. Kundu and Tutoo emphasized that the acquired materials in mind must be preserved in images to develop and retain knowledge. Paden and Dereskiwsky (2007) revealed that the low retention abilities of students could be a result of instructional strategies adopted by teachers. They maintained that the use of less effective instructional approaches in teaching science subjects could invariably translate to students' inability to retain the

knowledge acquired, which they could not put into practical reality. The inability to retain the concepts learned could prevent the students from solving real-life problems.

Therefore, to curb the low retention abilities of the students, there is a need to explore innovative approaches to instruction for effective teaching and easy assimilation of facts by students in the science subjects. These innovative pedagogies have been found to encourage the students to be fully involved in the teaching-learning processes through active participation in the learning activities and enhance the students' linking of the three levels of chemical representation for easy assimilation of chemical concepts. Moreover, active engagement in teaching/learning activities triggers students' abilities to remember learned concepts. It may enhance their capacity for knowledge retention and improve their academic performance in external examinations in the long run. Besides, the learning activity package pedagogy is an innovative instructional strategy that stimulates multiple senses in the students by helping them to link the triplet relationship of chemical representations.

Gender Influence and Students' Academic Retention in Science Subjects

Gender influence on students' knowledge retention has been a topical issue in education. However, there are conflicting research findings on this issue. For example, Bosede (2010) and Ezeudu (2013) found that gender significantly influences students' knowledge retention in science subjects.

Specifically, Ezeudu (2013) and Lawal (2009) found that female students performed better than their male counterparts when taught some concepts in physics and chemistry, respectively. Also, Agomuoh (2010) reported male students' higher knowledge retention in science subjects than their female counterparts. In contrast, Nzewi (2010) reported a non-significant influence of gender on students' knowledge retention in science subjects. These contradictory findings on gender influence on students' knowledge retention in science subjects also necessitated this study.

This study, therefore, evaluated the potency of LAP pedagogy in fostering students' retention of knowledge in science subjects using the lecture method as control and gender as a moderating variable.

RESEARCH QUESTIONS AND CORRESPONDING HYPOTHESES

Based on the outcomes of previous studies. The following research questions with corresponding hypotheses were formulated to guide the study:

R1. What is the effect of learning activity package pedagogy on students' knowledge retention in science subjects?

H₀1. There is no statistically significant effect of learning activity package pedagogy on students' knowledge retention in science subjects.

R2. Is there any difference in the male and female students' mean retention scores in science subjects taught with learning activity package pedagogy and the lecture method?

H₀2. There is no statistically significant difference in the male and female students' mean retention scores in science subjects taught with learning activity package pedagogy and the lecture method.

R3. Did the interaction of teaching method and students' gender affect the students' knowledge retention in science subjects?

H₀3. The interaction of teaching method and students' gender does not have any statistically significant effect on the student's knowledge retention in science subjects.

METHOD AND MATERIALS

Research Design and Population of the Study

This study adopted a pretest-posttest, non-randomized, control group, quasi-experimental design. The population for the study comprised 3,965 senior secondary school class two (SSS2) chemistry students in coeducational schools in the 2019/2020 academic session in a developing nation, Nigeria.

Sample and Sampling Techniques

A sample of 208 chemistry students, made up of 99 males (47%) and 109 females (53%), were selected from intact classes of six (6) secondary schools through convenience sampling and purposive sampling techniques (Creswell, 2009). The parameters adopted in selecting the sample schools used for the study were the availability of experienced chemistry

teachers who have taught chemistry for up to a decade and the schools that have participated in external examinations conducted by the West African Examination Council for at least a decade. Also, each class size was not more than 40 students, and allocation into class streams was gender-sensitive, representing a fair, reasonable, and equitable mixture of both gender in each class. The average age of the participants was 15 years. The schools were randomly assigned to experimental and control groups with three schools each. The experimental group consisted of 120 students (53 males and 67 females), and the control group contained 88 students (46 males and 42 females). The two groups were taught topics in chemistry using the learning activity package pedagogy and lecture method. The teaching was done by the regular chemistry teachers at the schools.

Instruments for Data Collection

The study used three instruments: the learning activity package manual (LAPM),

the chemistry achievement and retention test (CART), and the lecture lesson manual (LLM) for the control group. The LAPM instrument was an adaptation from the works of Ward and Williams (1976). It had the following seven components: the pre-testing, specific performance objectives, conception stage, performance activities, personal evaluation/testing self, mastering stage/post-testing stage, and opportunity for enrichment (Figure 1). The contents of the LAPM were from the senior secondary school chemistry curriculum for Nigerian students (FGN, 2004). The experimental and control groups were taught “carbon and its compounds” in organic chemistry. The essence of the learning activity package is to help students learn organic chemistry concepts by facilitating their understanding of the sub-microscopic and symbolic level explanations of the macroscopic level experiences of the procedures for determining the organic compounds. Students experience a certain chemical phenomenon at the macroscopic level and

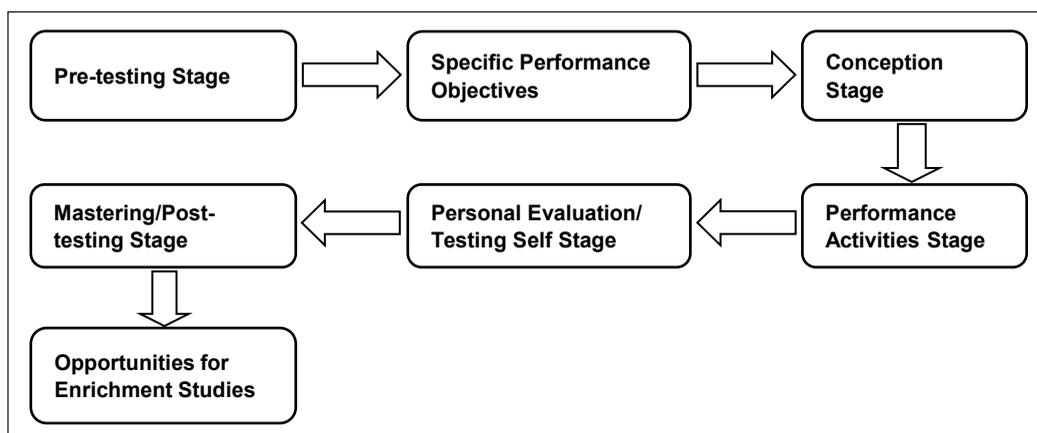


Figure 1. Flowchart of the learning activity package components pathway
Source: Udu (2018a)

learn the theory and reactions at the sub-microscopic and symbolic levels.

For example, in the teaching of the “structure and valency of carbon” using the LAP approach, the “pre-test,” “performance objectives,” “conception,” and the “enrichment opportunities” are the theoretical components that will expose the students to the macroscopic understanding of the “structure and valency of carbon.” In contrast, the “performance activities,” “self-test,” and “mastery test” are the components that will expose the students to the sub-microscopic and symbolic understanding of the “structure and valency of carbon.” The learning activities will help the students to gain a detailed understanding of the bonds, electron transfer, the distance and orientation between the carbon atoms, thereby enhancing their understanding of the structure and valency of carbon at the sub-micro and symbolic levels, which will subsequently enhance their understanding at the macroscopic level.

These may generally enhance the students' knowledge retention in organic chemistry. Meanwhile, the learning activity package was chosen for this study among other innovative pedagogies because of its proven potency and ease of application by not necessarily requiring electronic media. The implication is that the LAP utilization by teachers in rural areas with no or irregular supply of electricity is possible. Therefore, the teachers can utilize the LAP in the classrooms with ease. Also, with moderate training, the teachers can conveniently prepare and use the LAP.

The researchers developed the CART. It contained 20 multiple-choice questions. The content validity determination was through a table of specifications. The test construction was under three cognitive objectives of knowledge, recall, and application levels. (Knowledge 9 questions; Recall 6 questions; Application 5 questions). Each question had options A to D. One option was the correct answer, while the other three served as distracters. Item analysis was conducted on the CART's initial draft containing 25 questions. However, after the item analysis, 20 questions were valid and were used for the study. The test-item selection was on the recommendations of Bruce and Edward (2003) that “for any question to be selected, it should have a difficulty index of between .40 and .60, possess a positive item discrimination index of +.30 and above, and have a positive distracter index”. All the questions selected and used in this study met these criteria. Meanwhile, any correct answer was awarded two marks; hence, the minimum score was 0 while the maximum score was 40.

Validation and Reliability of the Instruments

Three test development experts from the department of science education of the researchers' institution validated the instruments. The experts validated the CART in language, wordings of the items, and others. Moreover, the experts vetted the specifications table to ensure the CART's content validation. Establishing the reliability of the CART was through

a pilot study conducted on 30 equivalent students in a different location twice. The initial test result was analyzed using Kuder-Richardson's formula-20 (KR_{20}), and an internal consistency reliability index of .90 was obtained. The test-retest method was adopted to determine the stability of the CART. The results were analyzed using Pearson's product-moment correlation, and a stability reliability index of .91 was obtained. These results indicated that the CART was internally consistent and stable for the study.

Experimental Procedure

The regular chemistry teachers of the sampled schools participated in the study. To maintain uniformity of teaching and minimize teacher differences, the researchers organized a training session for the teachers five days before the commencement of the experiment. The training was on the teachers' proper usage of the learning activity package in lesson delivery. The teachers were drilled by using the LAPM to teach students. These helped to identify lapses that might have arisen through improper use of the materials and were addressed immediately. However, the teachers of the control groups used the lecture method in their lesson deliveries.

The experiment commenced with a pre-testing of the two groups using the "pre-CART" for 50 minutes. Moreover, the results were collated. Then, the two groups taught "carbon and its compounds" with LAP and the lecture method. The entire experiments were completed in four (4) weeks. At the end of the four (4) weeks, the

students were subjected to another round of tests using the "post-CART." The students were given the post-post-CART (retention test) two weeks after the post-CART. The pre-CART and post-post-CART were the same sets of questions. However, the post-CART questions were different at face value because they were obtained by reshuffling/re-numbering the pre-CART. The results of the three (3) tests were collated and used for the data analyses.

Method of Data Analyses

Data collected were analyzed with the mean, standard deviation, standard error, and analysis of covariance (ANCOVA). The mean and standard deviation established the initial differences in the students' knowledge retention in the experimental and control groups. The one-way ANCOVA was used to establish the effect of the innovative pedagogy in improving the students' knowledge retention in the topics taught. The effect size of the treatment on knowledge retention was reported with the partial Eta squared. The calculations were done with the statistical package for social sciences (SPSS) software version 23. The alpha level for testing the hypotheses was .05.

Control of Extraneous Variables

The researchers tried to minimize the effects of extraneous variables, which would have affected the study's findings. For instance, the experimental and control groups were in different schools. These helped to eliminate subject interaction. Also, the initial training of the regular teachers may have assisted in

reducing the effect of teacher differences. Furthermore, the use of regular chemistry teachers minimized the Hawthorne effect. Finally, intact classes were used for the study to reduce the effect due to bias in the sample selection. The summary of the research method employed in this study is in Figure 2.

RESULTS AND DISCUSSIONS

The results were organized, presented, and discussed under the following sub-headings.

Effect of Learning Activity Package Pedagogy on Students' Retention of Knowledge

Tables 1 and 2 show the results of the descriptive statistics and analysis of

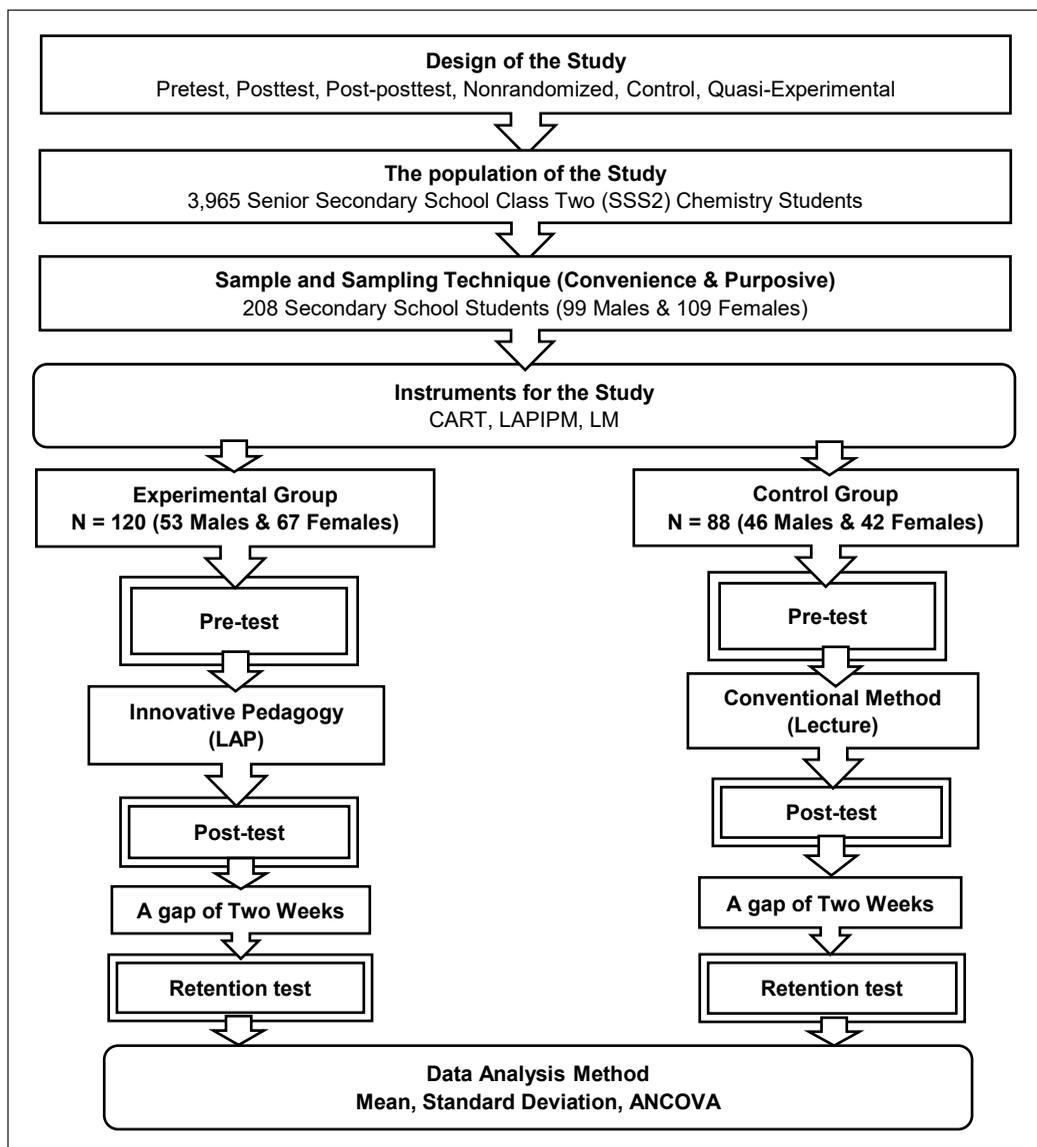


Figure 2. Flowchart presentation of the research method

Table 1
Unadjusted and covariate-adjusted descriptive statistics for students' knowledge retention

Teaching methods (Treatment)	Pre-test			Post-test				Retention test			
	N	Mean	SD	Unadjusted		Adjusted		Unadjusted		Adjusted	
				Mean	SD	Mean	SE	Mean	SD	Mean	SE
Experimental (LAP)	120	8.49	2.35	30.77	5.15	30.49	.34	29.82	5.03	25.66	.18
Control (Lecture)	88	7.86	2.22	20.05	2.97	20.42	.39	17.61	2.97	23.28	.22

Table 2
Summary of one-way analysis of covariance of the groups to determine the effect of the methods effects of tests of between-subjects

Dependent Variable: Retention-test							
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	
Corrected Model	10865.39 ^a	5	2173.08	918.94	.00	.96	
Intercept	.23	1	.23	.10	.76	.00	
Posttest	2212.59	1	2212.59	935.65	.00	.82	
Group	108.11	1	108.11	45.72	.00	.19	
Error	477.68	202	2.37				
Total	137768.00	208					
Corrected Total	11343.08	207					

Note: a. R Squared = .958 (Adjusted R Squared = .957)

covariance (ANCOVA) conducted on the chemistry achievement and retention test scores of the experimental and control groups. The results show that there was a significant difference ($F(1,202) = 45.72$, $p = .00 < .05$) between the unadjusted retention mean scores of the experimental group ($M = 29.82$, $SD = 5.03$) and the control group ($M = 17.61$, $SD 2.97$) with a mean difference of 12.21. The partial Eta Squared value of .19 indicates that the magnitude of the difference in the means (effect size) was small when compared with Cohen's guidelines (.2 – small effect, .5 – moderate effect, .8 – large effect). The results show that the experimental group taught with the Learning Activity Package had higher chemistry retention mean score

than the control group taught with the lecture method. Therefore, null hypothesis 1, which states that there is no statistically significant effect of learning activity package pedagogy on students' knowledge retention in science subjects, was rejected at a .05 alpha level. That means the main effect of the teaching method was statistically significant. The implication is that the innovative pedagogy (LAP) may have effectively improved the students' knowledge retention in science subjects (chemistry) more than the lecture method. This study has, therefore, found the learning activity package pedagogy to have effectively enhanced the students' retention of knowledge in science subjects (chemistry) within the given experimental conditions of this study. This finding gives

credence to previous research studies such as Abu (2001) and Neboh (2012). They found that the learning activity package enhances students' knowledge retention in biology more than the conventional (lecture) method. Supporting the finding further, Anderson et al. (2005) stated that innovative pedagogies involving active learning strategies foster the students' positive attitude toward learning by increasing their knowledge-based and exposing them to critical thinking and problem-solving abilities. Similarly, Paden and Dereskiwsky (2007) found that students' active involvement in the teaching and learning processes enhances their capacity for knowledge retention and improves their academic performance generally in science subjects.

Meanwhile, previous research studies have shown that teachers' engagement in constructivists' instructional approaches in their classrooms creates conducive learning environments for students' active participation in the teaching-learning processes. Hake (2002) observed that conducive learning environments encourage students to voluntarily engage in hands-on and mind-on activities that help to improve their academic achievement and retention of knowledge. In this study, the learning activity package pedagogy provided opportunities for the students to participate actively in the learning processes and link the triple relationship of macro, sub-micro, and symbolic levels of chemical representation, unlike the lecture approach. These might have contributed to the success of the LAP recorded over the conventional

(lecture) approach. Butressing the points further, Ugur et al. (2017) emphasized that constructivists' learning approaches encourage students' active engagement by exploring knowledge through thinking, explaining the observed concepts, and extending their findings to the real world under the guidance and evaluation of their teachers. These innovative instructional approaches enhance the overall students' academic achievement and retention of knowledge.

Students' Retention of Knowledge in Science Subjects by Group and Gender

Tables 3 and 4 show the descriptive statistics and analysis of covariance (ANCOVA) conducted on the chemistry achievement and retention test scores of the male and female students in the experimental and control groups. The results show that there is no statistically significant difference ($F(1,203) = .49, p = .49 > .05$) between the unadjusted retention mean scores of the experimental group, male ($M = 29.77, SD = 4.99$), and female ($M = 29.85, SD = 5.11$) and the control group, male ($M = 18.22, SD = 2.87$), and female ($M = 16.95, SD = 2.97$) with mean difference of $-.08$, and 1.27 respectively. Since the innovative pedagogy was more effective in enhancing students' knowledge retention, it can be deduced from the result that the student's knowledge retention in chemistry could be enhanced regardless of gender difference when taught with innovative pedagogy. The implication is that the effectiveness of the instructional strategy in improving

Table 3
Unadjusted and covariate-adjusted descriptive statistics for students' knowledge retention by group and gender

Teaching methods (Treatment)	Gender	Pre-test			Post-test				Retention test			
		N	Mean	SD	Unadjusted		Adjusted		Unadjusted		Adjusted	
					Mean	SD	Mean	SE	Mean	SD	Mean	SE
Exptal (LAP)	Male	53	8.91	2.53	30.60	5.34	29.88	.51	29.77	4.99	25.74	.24
	Female	67	8.16	2.16	30.90	5.03	30.96	.45	29.85	5.11	25.55	.22
Control (Lecture)	Male	46	8.78	1.81	20.96	2.66	20.37	.54	18.22	2.87	23.08	.26
	Female	42	6.86	2.22	19.05	3.00	20.50	.59	16.95	2.97	23.58	.30

Table 4
Summary of one-way analysis of covariance on the influence of gender and interaction effect of method and gender on students' retention of knowledge in science subjects

Tests of Between-Subjects Effects							
Dependent Variable: Retention-test							
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	
Corrected Model	10861.39 ^a	4	2715.35	1144.34	.00	.96	
Intercept	.50	1	.50	.21	.65	.00	
Post-test	3265.83	1	3265.83	1376.34	.00	.87	
Group	107.26	1	107.26	45.20	.00	.18	
Gender	1.15	1	1.15	.49	.49	.00	
Group * Gender	5.87	1	5.87	2.47	.12	.01	
Error	481.69	203	2.37				
Total	137768.00	208					
Corrected Total	11343.08	207					

Note: a. R Squared = 0.958 (Adjusted R Squared = 0.957)

the students' knowledge retention in the subject matter was not affected by gender. The finding of this study is in harmony with Neboh (2012), Nzewi (2010), and Oludipe (2012), who found separately that the male and female students' mean academic retention scores do not significantly differ when taught with innovative pedagogies.

On the contrary, Agomuoh (2010), Ajayi and Ogbeba (2017), Bosede (2010), Gipps (2004), and Lawal (2009), in their separate studies, established that a significant difference exists between the male and

female students' mean academic retention scores in science subjects. However, these contradictory findings for and against the influence of gender on students' retention of knowledge in science subjects have shown no consensus yet on the influence of gender on students' retention of knowledge in science subjects. Nevertheless, this present study has found no statistically significant gender influence on the students' knowledge retention in chemistry. Buttressing the finding further, Adegoke (2012) emphasized that active learning strategies such as the

learning activity package reduce gender disparity to the barest minimum in the students' knowledge retention. Adegoke added further that male and female students retain learned concepts more when exposed to the same learning environments that promote their active participation in learning.

Furthermore, Alam et al. (2021) reiterated that the teacher plays a significant role in encouraging female students to pursue STEM education using innovative instructional strategies that provide equal opportunities for male and female students to participate in the learning processes actively. Moreover, Swarat et al. (2012) maintained that knowledge retention is a function of students' interest in a subject matter, mostly derived from the effectiveness of the instructional strategies utilized in the lesson delivery. Therefore, this study has provided the basis for science teachers to embrace innovative pedagogies and be discouraged from using conventional teaching methods. It will help address any gender disparity that may arise in the student's academic achievement and knowledge retention in science subjects.

Effect of Method and Gender Interaction on the Students' Retention of Knowledge in Science Subjects

The results in Table 4 show that the effect of the teaching method and gender interaction was not statistically significant. It means that the interaction effect of method and gender on the students' knowledge retention was not statistically significant. This finding agrees with Adekoya and Olatoye (2011),

Ajayi and Ogbeba (2017), and Udu (2018b) that interaction of method and gender has no significant effect on the student's retention of knowledge in science subjects. It implies that there was no observed interaction effect of gender and treatment on students' mean retention scores taught using LAP and Lecture methods. Any interaction effect was not significant and may be due to error. It implies that the instructional strategies enhanced male and female students' knowledge retention in the subject matter. Furthermore, the study has shown that the instructional strategies utilized could enhance male and female students' knowledge retention abilities without recourse to their gender. Teachers should, therefore, be encouraged to utilize innovative instructional pedagogies such as the learning activity package in teaching-learning processes, as this study has established its effectiveness in enhancing students' knowledge retention abilities in science subjects in secondary schools.

CONCLUSION

Research studies have widely reported that students' poor knowledge retention could result in poor academic performance. Teachers' instructional strategies during lesson deliveries are partly responsible for the poor performance. This study has established that the student's knowledge retention in science subjects can be improved significantly when the teachers embrace innovative pedagogies such as the learning activity package in their lesson deliveries. This current research has provided evidence

to support that these innovative pedagogies can enhance students' learning abilities which could help to improve the retention of knowledge in the subjects. Therefore, the researchers implore the teachers to adjust their instructional strategies to accommodate regular use of innovative pedagogies that encourage active participation of the students in learning activities and help them link the triple relationship of macro, sub-micro, and symbolic representations of chemical concepts during the teaching-learning processes. It is because innovative pedagogies are student-centered and enable the teachers to create educational environments that encourage active learning and reduce gender disparity in the students' knowledge retention.

The implication is the avalanche of innovative science teachers who blend their instructional strategies to provide for the student's active participation in the teaching-learning processes and de-emphasize the use of conventional teaching approaches. Furthermore, the teachers need to restructure the lecture method to accommodate the learners' active engagement by providing learning activities that motivate them in the lessons. With this approach, the learning environment would shift from the current teacher-centered approach to the recommended student-centered approach. These will result in the improvement in the students' retentive abilities in the science subjects.

This research work is novel because science teachers have been exposed to a flexible, innovative approach to instructions (LAP) that can easily be adapted for effective

lesson delivery, culminating in enhanced students' knowledge retention in secondary schools in developing nations.

RECOMMENDATIONS

The researchers, therefore, recommend that the in-service science teachers should be encouraged by the school authorities and other stakeholders in education to regularly attend conferences, seminars, and workshops to enable them to learn different innovative instructional strategies and how to apply them in their lesson deliveries which will help to improve their effectiveness and culminate in improved students' knowledge retention in science subjects. Furthermore, the students should be encouraged to participate actively and engage in hands-on, active learning activities as part of the innovative instructional strategies that will help enhance their knowledge retention abilities in science subjects. Science teachers should also embrace student-centered and active learning pedagogies in their classroom teaching-learning processes since they effectively enhance students' knowledge retention abilities in science subjects. The science teachers should also restructure the popular lecture approach by making it activity-oriented to engage the students actively in the teaching-learning processes to enhance their academic achievement and knowledge retention in science subjects.

Further studies on this innovative pedagogy, with students' attitudes and interest in any other science subject, could be compared with the conventional lecture method.

LIMITATIONS OF THE STUDY

The instructional manuals and the achievement tests used in data collection in this study were not standardized, although they were valid and reliable. It could have affected the results of the study. Secondly, the students were not fully committed to the experiment because it was their first time engaging in such activities. Many distractions might have affected the outcome of the study. Furthermore, the use of regular chemistry teachers in the schools might have introduced teacher differences, and some of the teachers could have deviated from the stipulated guidelines, which might have affected the results of this study. Finally, the findings of this study could not be generalized because the number of sample schools used was limited.

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