



Effect of Four Modes Application Technique on Academic Performance and Retention Among Senior Secondary Chemistry Students, Katsina State, Nigeria

Mustapha Sani & Aminu Salisu

Department of Science and Vocational Education, Umaru Musa Yar'adua University Katsina, Katsina State, Nigeria

Corresponding Author: icepadon@gmail.com

Abstract

The study examined the effect of four modes application technique on academic performance and retention among senior secondary chemistry students, Katsina State, Nigeria. The study developed four objectives, answered four research questions and tested four research hypotheses. The study adopted Quasi-experimental research design. The population of the study comprised 13,222 Chemistry students from twenty co-educational public secondary schools in Katsina Zonal Education Quality Assurance. Two schools were selected based on cluster sampling and intact classes were used in each school with a sample size of 104 students. A validated Chemistry Performance Test (CPT) was used for data collection. The reliability coefficient of the CPT was obtained using Pearson Product Moment Correlation Coefficient which was 0.89. The Research questions were answered using mean and standard deviation, while null hypotheses were tested at $p < 0.05$ level of 'significance using Analysis of Covariance (ANCOVA). The major findings revealed there was a significant difference in the mean academic performance and retention level between experimental and control group in favor of experimental group, it was concluded that the students taught Chemistry using 4MAT performed significantly better than those taught using lecture method and that 4MAT is gender friendly. The study recommended among others that Chemistry concepts should be taught using methods, strategies and or techniques such like 4MAT which allows active participation and creative manipulation of the learnt materials.

Keywords: 4MAT, Students, Performance, Retention.

Introduction

Chemistry is the branch of science that deals with study of chemical composition of matter and their transformation from one form to another. According to Omiko (2015), Chemistry is a branch of science which tries to make people understand the nature, composition and usefulness of natural things and those materials made by human beings. Chemistry is viewed as essential aspect of science because it is considered as a requirement to further study in all science and its related disciplines such as Engineering, Medicine and others (Aderonke, 2016). The life process of all organisms involves chemical changes and many activities centers on the study of Chemistry, as a result chemistry plays vital role in the development of drugs, which helps to prevent, cure and alleviate diseases and prolong lifetime and Chemists are involved in the fields like biotechnology, pharmacy, genetic engineering and they are the forefront of many developing fields (Emendu, 2014; Ababio, 2017). Heneke and Robertson (2016) identify four branches of chemistry which are; Organic, Inorganic, Physical and Analytical Chemistry.

Ezeudu (2019) reported that the students' academic performance in Chemistry at internal and

external examination has persisted to be considerably poor despite the applications of Chemistry in industries and day to-day activities. Teachers are under pressure to cover the contents of the curriculum and prepare the students for external examinations. This has made the teaching of Chemistry insufficient as some difficult Chemistry concepts that need special teaching approach are over looked. Some find the subject so abstract and irrelevant to experiences and survival needs of cultural and economic environment. Some studies attributed poor students' academic achievements in Chemistry to poor methods of teaching involving excessive teacher-talk, rote learning and copying of notes (Omiko, 2015).

The inappropriate teaching methods used by the teachers could be the main problem that causes poor academic performance of chemistry students in secondary schools (Science Teachers Association of Nigeria, 2013; Arokoyu & Obunwo, 2014). According to Ogunleye and Babajide (2019), science teachers have been using conventional teaching methods whereby no chance was given to students in teaching and learning activities. This is a method of teaching, whereby the teacher presents spoken contents on a particular topic in



a subject and shy away from activity-oriented teaching strategies which are child-centered such as four modes application technique 4MAT, concept mapping, and guided inquiry and so on are known as teacher-centered or rather conventional teaching approaches. However, a shift beyond conventional teaching approaches in the teaching of science, technology and mathematics for better academic performance and retention in secondary schools means adopting the innovative approach to teaching and learning of science, technology and mathematics (Fatokun & Eniayeju, 2014; Muhammed, 2015). Therefore, it is important to ensure that the students learn chemistry meaningfully so that competence of knowledge transfer to other domains and how to apply the knowledge and experience in answering questions and revolving problems.

Four Modes Application Technique (4MAT) is a technique that operates based on experiential learning theory by David Kolb 1984 (Joan & Susan, 2017). Guzman and Guzman (2016) defined 4MAT as a process for delivering instruction in a way that appeals to all types of learners. 4MAT engages, informs and allows for practice and creative use of material learned within each lesson. It is based on the principle that different individuals perceive and process experience in different preferred ways. Umate (2018) reported that 4MAT teaching technique helps in improving academic achievement of chemistry students and that students taught chemistry concepts with 4MAT retained the concepts better than those taught using conventional teaching method, as such 4MAT improves student retention ability. Nikolaou and Koutsouba (2019) stated that 4MAT operates with a cyclic environment using 8-steps lesson plan that is followed in logical order. The model considered learning process as a journey by asking four simple questions. Why? What? How? And If? Why question seeks a reason or motivation for learning, what question seeks for information and knowledge, how question seeks to find a way of applying the knowledge or information gained and if question develops extensions for the students to bring out new experiences from the learned materials (Osama, Fahad & Ayman, 2016).

Academic performance as a variable in students' learning has been a matter of concerned in the present-day research. Busari (2015) defines academic performance as the level of achievement in the subject as exhibited by an individual. According to Ogundukun, and Adeyemo, (2016), Academic performance is the exhibition of knowledge attained or skills developed by students in the school subject usually designed by test

scores or by marks assigned by teachers which can be low or high. Umate (2018), ascertained that, academic performance is a function of a various factors such as method of teaching, teachers' qualifications, child's home background, school environment, attitude, interest among others.

Olurundare (2015), revealed that the academic performance of students in chemistry is generally poor at senior secondary school level. Chief Examiners' Reports of both the West African Examination Council (WAEC, 2020) and National Examination Council (NECO, 2020) revealed that the poor academic performance of students in chemistry still persist in Katsina State.

Retention is an individual's capacity to remember and recall academic information, materials and skills over a time. Okoye (2019) describes retention as the process of maintaining new meanings or part of them. Human memory is imperfect and fragile as a result periodic review is required for the long-term retention of knowledge, information and skills. The learned materials in mind need to be preserved in form of image. However, for retention to be maintained a stimulating situation must occur, so that the retained image can be easily revived or reproduced to make memorization and understanding possible. Teachers could improve retention of concepts and information after teaching by explicitly creating memorable events involving auditory or visual images and actively engaging the students during teaching and learning (Okurumeh, 2016). Against this background, this study therefore is set to investigate the effect of 4MAT teaching technique on students' performance and retention in chemistry among senior secondary schools of Katsina state.

Statement of the Problem

Chemistry is one of the core sciences subjects which is designed to prepare students with the knowledge and skills of relevant scientific concepts and processes. Some research findings revealed that the poor students' achievement and retention was as a result of using lecture method used in chemistry lesson delivery, ill equipped laboratory, lack of practical and the abstract nature of chemistry. Among these factors poor teaching method was a major contributory factor for students failure in chemistry. Therefore, this study intends to investigate how effective four (4) modes application technique (4MAT) can be in improving students' academic performance and retention in senior secondary schools of Katsina state, Nigeria.

Objectives of the study

The study;

1. Investigated the effect of 4MAT on students' academic performance when taught chemistry among senior secondary schools in Katsina State, Nigeria.
2. Determined the effect of 4MAT on students' retention when taught chemistry among senior secondary schools in Katsina State, Nigeria.
3. Investigated the difference between the academic performance of male and female students taught chemistry using 4MAT among senior secondary schools in Katsina State, Nigeria.
4. Find out the difference between the retention of male and female students taught chemistry using 4MAT among senior secondary schools in Katsina State, Nigeria.

Research Hypotheses

The following null hypotheses guide the study:

1. There is no significant difference between the mean academic performance score of students taught Chemistry using 4MAT and those taught with conventional lecture method.
2. There is no significant difference between the retention of students taught Chemistry using 4MAT and those taught with conventional lecture method.
3. There is no significant difference between the mean academic performance score of male and female students taught Chemistry using 4MAT.
4. There is no significant difference between the retention of male and female students taught chemical bonding and hybridization concepts using 4MAT.

Methods

The study employed quasi-experimental research design. Specifically, pretest, posttest and post-posttest design. According to Creswell (2012), a quasi-experimental design is a type of experimental design that does not provides for full control of extraneous variables, primarily because of the lack of random

assignment of subjects to groups. In the design, the researcher utilized two groups, experimental group (EG) and the control group (CG). The two groups were pre-tested to ensure group equivalence before treatment. The treatment is teaching using 4MAT and lecture method for a period of six weeks. At the end of treatment, post-test was administered to determine students' academic performance. Post post-test was administered to the groups after 2 weeks of post test to determine their retention level due to exposure to treatment.

The population for this study comprise the entire public senior secondary school year II (SS II) students in Katsina Zonal Education Quality Assurance students offering Chemistry from co-educational schools. According to Katsina State Ministry of Education (KTMOE, 2022) there are thirteen thousand two hundred and twenty-two (13,222) SS II students offering chemistry in the study area of which eight thousand two hundred and sixty-six (8,266) are male while four thousand nine hundred and fifty-six (4,956) are female

This study has a total of 104 students as samples (57 male and 47 female) drawn from two schools in the study area. Cluster sampling technique was used to select 2 schools from the population based on their comparative abilities from the pre-test result, while intact classes were used as samples (one from each school sampled), for both the experimental and control groups.

Chemistry Performance Test (CPT) was used for data collection. The Chemistry Performance Test (CPT) is a 40 items multiple choice questions developed by the researcher to determine the performance and retention in chemical bonding and hybridization. The CPT was developed from chemical bonding concept of secondary school chemistry curriculum taking into consideration all the six educational taxonomy of bloom to ensure distribution of the items over the units.

The data collected was analyzed using SPSS software (V23.0). The Null Hypotheses were tested at $p \leq 0.05$ levels using inferential statistics (ANCOVA).

Result

Table 1: Analysis of Covariance of the effect of treatments on the students' performance in Chemistry

Source	Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	2000.950	2	1000.475	127.429	0.00	
Intercept	585.681	1	585.681	74.598	0.00	
Pretest	34.133	1	34.133	4.347	0.39	
Groups	1960.135	1	1960.135	249.660	0.00	Significant
Error	902.889	111	7.851			
Total	106421.000	114				
Corrected Total	2903.839	113				

Significant at $P \leq 0.05$

Table 1 shows that the calculated value for the effect of treatment on students' performance in Chemistry has probability value of 0.00 which is less than 0.05 level of significance ($P < 0.05$). Thus, there is a significant difference between the mean academic performance score of students taught Chemistry using 4MAT and those taught with conventional lecture method.

Table 2: Analysis of Covariance of the effect of treatments on the students' Retention in Chemistry

Source	Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	1753.604	2	876.802	150.741	0.00	
Intercept	618.232	1	618.232	106.287	0.00	
Posttest	33.846	1	33.846	5.819	0.017	
Groups	352.283	1	352.283	60.565	0.00	Significant
Error	668.912	111	5.817			
Total	107247.000	114				
Corrected Total	2422.517	113				

Significant at $P \leq 0.05$

Table 2 shows that the probability associated with the tabulated value for the effect of treatment on students' retention in Chemistry is 0.00. Since the probability value of 0.00 is less than 0.05 level of significance ($P < 0.05$). The null hypothesis was rejected. Hence there is a significant difference in the mean retention of students taught Chemistry using 4MAT and those taught with conventional lecture method.

Table 3: Analysis of Covariance of the effect of treatments on male and female students' performance in Chemistry

Source	Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	24.288	2	12.144	1.528	0.226	
Intercept	462.571	1	462.571	58.186	0.00	
Pretest	22.897	1	22.897	2.880	0.095	
Groups	6.709	1	6.709	0.844	0.362	Not Sig.
Error	429.291	54	7.950			
Total	65735.000	57				
Corrected Total	453.579	56				

Significant at $P \leq 0.05$

Table 3 shows that the probability associated with the tabulated value for the effect of treatment on male and female students' Performance in Chemistry is 0.362. Since the probability value of 0.00 is greater than

0.05 level of significance ($P > 0.05$). The null hypothesis was retained. Hence there is no significant difference between the mean academic performance score of male and female students taught Chemistry using 4MAT.

Table 4: Analysis of Covariance of the effect of treatments on male and female students Retention in Chemistry

Source	Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	70.291	2	35.146	5.889	0.005	
Intercept	164.891	1	164.891	27.629	0.00	
Posttest	69.780	1	69.780	11.692	0.001	
Groups	1.385	1	1.385	0.232	0.632	Not Sig.
Error	322.270	54	5.968			
Total	65336.000	57				
Corrected Total	392.561	56				

Significant at $P \leq 0.05$

With reference to table 4, it is observed that the calculated value of P for influence of gender on students' retention in chemistry is 0.632. Thus gender has no significant influence on students' retention in chemistry when exposed to 4MAT since the probability value of 0.847 is greater than the probability at 0.05 level of significance ($P > 0.05$) the hypothesis is therefore retained. Hence, there is no significant difference between the retention of male and female students taught chemical bonding and hybridization concepts using 4MAT.

Discussion

From the results, it was clear that there was a significant difference in the mean academic performance and retention between those taught Chemistry 4MAT and those taught using lecture method, among senior secondary schools in Katsina state Nigeria, in favor of students taught Chemistry 4MAT. This finding is line with that of other researchers that reported 4MAT to have significantly enhances students' academic performance in Chemistry.

The findings to Research Hypothesis 1 indicated that 4MAT enhanced the students' performance and provides them with adaptive environment which enable them to learn what they need. This is so because, 4MAT engages, informs and allows for practice and creative use of material learned within each lesson. It is based on the principle that different individuals perceive and process experience in different preferred ways. This finding is line with that of Umate (2018) which reported that 4MAT teaching technique helps in improving academic achievement of chemistry students better than those taught using conventional teaching method, as such 4MAT improves students' academic performance.

In addition, the finding to Research Hypothesis 2 indicated that 4MAT appears to be activity-oriented method that tries to simulate students to action and significantly improve their retentions as reported, this finding is in line with that of Umate (2018), Abdelsalam (2017), Nurma (2015) and Okoyefi (2014) which reported significant retention after treatment with 4MAT which advocate learners' active participation, uniting the students' experiences and body through a method of thinking and doing as opined by Dewey (Guzman & Guzman, 2016) and designing learning activities that can be connected to learners' previous experiences or knowledge.

Similarly, from the findings of Research Hypotheses 3 and 4 revealed that there was no significant difference in the mean academic performance and retention between male and female students taught Chemistry using 4MAT, among senior secondary schools in Katsina state Nigeria. This implies that both male and female students taught using 4MAT performed at almost the same pace. This finding agrees with that of Umate (2018), who discovered that 4MAT is gender friendly and is contrary to that of Okoyefi (2014) which reported that female students had higher achievement scores than male counterpart when taught using 4MAT instructional method and male students had higher retention female counterparts when exposed to 4MAT teaching method.

Conclusion

Based on the findings of this study, the researcher concluded that 4MAT teaching technique improves students' academic performance and retention in Chemistry if used in the right way and that 4MAT teaching technique helps in improving academic performance and retention of both male and female students in chemistry, therefore 4MAT is a gender friendly technique.

Recommendations

Based on the findings of this study, the following recommendations were made;

- i. Chemistry concepts should be taught using strategies, methods and or techniques like 4MAT that allows active participation and creative manipulation of the learnt materials.
- ii. Since Lecture method was found less effective in this study with respect to students' academic performance and retention, teachers should be discouraged from using it in teaching chemistry in secondary schools.
- iii. Chemistry teachers should be encouraged to use 4MAT in teaching chemistry in order to improve students' academic performance and retention.
- iv. Chemistry teachers should also be encouraged to use 4MAT in teaching chemistry in order to improve students' performance and retention irrespective of gender because 4MAT is a gender friendly teaching technique.

Reference

- Ababio, O.Y. (2017). *New school chemistry for senior secondary schools*. Onitsha, Nigeeria. Africana first Publishers plc.
- Abdelsalam, M., A., (2017). The effect of teaching science using McCarthy model on the 8th grade students' retention of learning in Jordan. *Jornal of Education and Psychological Studies*, 11(1), 191-206
- Achimugu, L. (2016). Factors affecting the effective implementation of senior secondary education chemistry curriculum in Kogi state, Nigeria. *International Journal of Scientific and Research Publications*, 6(5), 561-566.
- Aderonke, M., O., & Victoria, Y., A.,(2016).School Factors as Correlates of Students' Achievement in Chemistry. *International Journal for Cross-Disciplinary Subjects in Education*, 3(3), 1516-1523.
- Alhassan, D.S., Victor, I.E, & Danteni, I.W. (2018).Effects of computer assisted instructional package on junior secondary school students achivement and retention in geometry in Minna Niger state, Nigeria. *International Journal of Humanities and Social Science Invention*, 2(5), 69-74.
- Arokoyu, A.A., & Obunwo, J.C. (2014). Concept- mapping: An instructional strategy for retention of organic chemistry concepts. *International Journal of Scientific Research and Innovative Technology*, 1(3), 50-57.
- Busari, A. (2015). The effect of simulation method on students' achievement and retention in biology.



- International Journal of Science Education*, 26 (2), 151–169.
- Emendu, N.B. (2014). The role of chemistry education in national development. *International Journal of Engineering and Science*, 3(3), 2319 – 1805.
- Ezeh, D.N. (2016). *Science without women: a paradox*. 75th Inaugural Lecture of the University of Nigeria, Nsukka delivered on 30th May, 2013. Nsukka: University of Nigeria Senate Ceremonials Committee.
- Ezeudu, F.O. (2019). Influence of concept maps on achievement and retention of senior secondary school students in organic chemistry. *Journal of Education and Practice*, 4(19), 35-44.
- Fatokun, K.V.A., & Eniayeju, P.A. (2014). Effect of concept mapping-guided discovery integrated teaching approach on the chemistry students' achievement and retention. *Academic Journal of Educational research and Review*, 9(22), 1218-1223.
- Guzmán, C. R., & Guzmán D. S. (2016). The 4MAT system applied to a blended-learning scenario. *Lateral American Journal of Education*, 6(1), 275-279.
- Heneke S. B. & Robertson S. (2016). *Excellence in chemistry*. Cambridge University Press. 3-4
- Jacob f., & Linus k. s., (2017). Effect of gender on senior secondary school students' academic achievement in geography in Ganye Educational zone, Nigeria. *European Journal of Education Studies*, 3(4), 394-410.
- Joan, M.N., & Susan, N.S. (2017). Assessing the impact of the 4mat teaching model across multiple disciplines in higher education. *College Teaching*, 58, 19-27.
- Muhammad, B.A. (2015). An evaluation of the efficacy of conceptual instructional method of teaching practical chemistry: the case of secondary schools in Zaria educational zone Kaduna state, Nigeria. *African Journal of Education and Technology*, 4(1), 112-118.
- Nikolaou, A., & Koutsouba, M. (2019). Incorporating 4MAT model in distance instructional material an innovative design. *The European Journal of Open, Distance and E-Learning*. 1(2), 1-10.
- Njoku Z.C and Ezeodurukwe, P.I. (2015). Resolving Nigerian secondary school students' learning difficulties in Nuclear chemistry using computer animation solutions. *Procedia of Social and Behavioral Sciences*, 176, 1034 – 1040.
- Nurma, A., (2015). Effect of 4MAT Instruction on Learning Achievement, Retention and Instructional Satisfaction of Grade 12 Students. Masters Degree Thesis, Prince of Songkla University, Thailand.
- Ogundukun, B. & Adeyemo, A. (2016). The effects of a constructive teaching approach on student academic achievements, self-concept and learning strategies. *Asia Pacific Education Review*, 6(1) p7 – 19.
- Ogunleye, B.O., & Babajide, V.F.T (2019). Generative Instructional Strategy Enhances Senior Secondary Schools Students Achievement in Physics. *European Journal of Educational Studies*, 3(3), 453-463.
- Okoye, A. C. (2019). *Effects of Computer Assisted Instruction on Students' Acquisition of Science Process skills, retention and Interest in Biology*. Ph.D thesis, University of Nigeria, Nsukka, Nigeria
- Okurumeh, E. A. (2016). Effect of Discussion and Invention Teaching Strategies on Secondary School Students on Retention of Chemistry Concepts in Delta State, Nigeria. *International Journal of Science and Research*, 5(3), 1739-1744.
- Okwara, O. L., Anyagh, P. I., & Ikyaan, G. S. (2017). Effect of Projected Instructional Media on Senior Secondary School Students Achievement in Biology. *International Journal of Scientific Research in Education*, 10(2), 137-147.
- Omiko, A. (2015). Impact of instructional scaffolding on students' achievement in chemistry in secondary schools in Ebonyi state of Nigeria. *International Journal of Education, Learning and Development*, 3(7), 74-83.
- Omwirhiren, E.M. (2019). Enhancing academic achievement and retention in senior secondary school chemistry through discussion and lecture methods: a case study of some selected secondary schools in Gboko, Benue State, Nigeria. *Journal of Education and Practice* 6(21), 151-161.
- Osama, M. I., Fahad A. A., & Ayman, M.B. (2016). Effect of using 4MAT method on academic achievement and attitudes toward engineering economy for undergraduate students. *International Journal of Vocational and Technical Education*, 8(1), 1-11.
- Umate, B. A (2018). *Effects of four modes application technique on the academic achievement and retention of secondary school chemistry students of Maiduguri metropolitan council Borno-Nigeria*. M. Sc. Ed Dissertation (Unpublished) Bayero University, Kano, Nigeria.