



Effects of 4MAT Teaching Model on Secondary School Students' Achievement, Retention and Attitude in Chemistry

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ABSTRACT

This study investigated the effect of Four Mode Application Technique (4MAT) on achievement, retention and attitude of students in Chemistry in Jalingo Education Zone of Taraba State. Quasi-experimental design was used for the study. Three research questions and hypotheses guided the study. A total of 203 students were sampled using multiple stage sampling technique. Two intact classes were randomly selected and assigned experimental and control groups. Two instruments used for the study were Chemistry Achievement Test (CAT) and Student Attitudes towards Chemistry Inventory (SATCI) with reliability indexes of 0.78 and 0.83 respectively. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.5 level of significance. Findings of the study revealed that students taught Chemistry using 4MAT achieved higher than their counterparts that used Demonstration Method. There is a significant difference between the mean attitude scores and mean retention scores of students with different learning styles taught chemistry using 4MAT and those taught using Demonstration Method. It is evident from the findings of this study to conclude that the use of 4MAT could provide a good way for students to learn chemistry since it enhanced students' achievement, retention, and attitude in Chemistry. The study recommended amongst others that both pre-service and in-service Chemistry teachers should be train on the use of 4MAT since it improved the academic achievement and retention of students; hence should be encouraged and integrated in chemistry lessons.

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INTRODUCTION

Chemistry is the systematic process of acquiring the fundamental knowledge about chemical concepts using different pedagogical approaches on students with diverse abilities, multiple intelligences and cognitive styles. There are also many physiological and psychological differences among students since each has his/her own uniqueness, genetic make-up and past experiences. These individual differences of students in cognitive, emotional and kinesthetic responses to the same teaching method has compelled science educators and researchers to study the structure of human brain to adequately address the learning occurrences and outcomes.

However, structurally the human brain is made up of right and left hemisphere. The human brain functions in many ways; it acts as two brains (right/left) hemisphere and it is the way individuals experience the world around them. Brain research (McCarthy, 1990, 1997 & 2005; McCarthy & McCarthy, 2006) has found out that the two hemispheres of the brain (left/right) process information differently, both hemispheres are equally important in terms of whole brain functioning and individuals rely more on one information-processing mode than the other, especially when they approach new learning. The left hemisphere is dominant with regard to language and logical processing, while

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the right hemisphere handles spatial perception. The left hemisphere is also serial, analytic, rational, systematic and verbal. Analysis and planning are key strategies in the left hemisphere. In this mode, problems are solved by looking at the parts and sequence is critical. The right hemisphere on the other hand is global, visual and holistic; it is able to see patterns and connections. The right mode processing seeks patterns and solves problems by looking at the whole picture (McCarthy 2005). Intuition, belief and opinion are key processing strategies of the right hemisphere.

The line of thought on brain hemisphericity and the knowledge of style the best way to teach learners in a classroom. This brought about the development of the Four Mode Application Techniques (4MAT). 4MAT is an instructional model that provides a systematic approach to organizing and delivering instructions in a manner that addresses the learning styles and hemispheric preferences of students. According to McCarthy (1990, p.31):

4MAT is an eight-step cycle of instruction that capitalizes on individual learning styles and brain dominance processing preferences. 4MAT Model has been developed in basis of two major premises: 1. people have major learning styles and hemispheric processing preferences and 2. designing and using multiple instructional strategies in a systematic framework to teach these preferences can improve teaching and learning.

Combining Kolb's theory with the theories about hemisphericity dominance, McCarthy created 4MAT learning cycle. In Figure 1 there is a learning cycle that combines the four learning styles with the right and left brain mode and the 8 steps of learning.

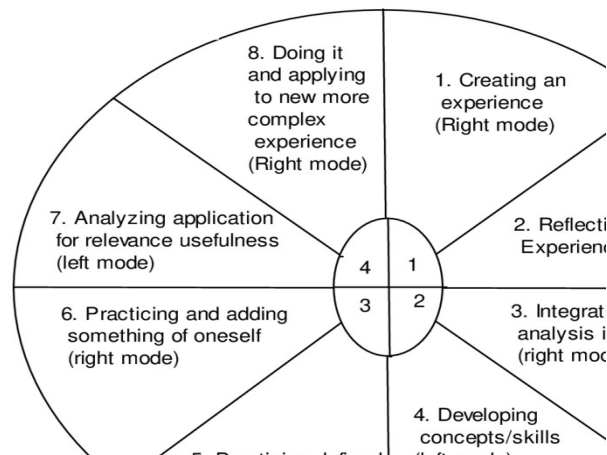


Figure 1: The 4MAT Teaching Method (McCarthy, 1990).

Key: The four major learners (1. Imaginative, 2. Analytic, 3. Common sense & 4. Dynamic)

According to McCarthy (1990, p. 33)

If all four learning styles are taught to all learners in a cycle that alternates from right to left mode information processing, and if in doing this, all styles are equally valued, this integration will allow

learners to be comfortable some of the time and stretched and challenged at other times. And because it is clear that all learners need all segments of the cycle, the entire cycle then becomes more valuable than any segment.



According to McCarthy (1990), all people feel, reflect, think and do, but they linger at different places along the way. These “lingerings” form people’s learning style preferences. Differences in people’s learning styles depend on many parameters such as, who we are, where we are from, how we see ourselves, what we pay attention to and what people ask and expect of us. The four major learners (imaginative, analytic, common sense, and dynamic) can use 4MAT to engage their whole brain. Learners use their most comfortable style while being challenged to function in less comfortable modes. 4MAT identifies four interrelated learning styles based on how individuals perceive and process new information. Its premise is that individuals learn primarily in one of the four different, but complementary ways based on how they perceive and process information (McCarthy & McCarthy, 2006). McCarthy, (1990) identified these four learning styles as Imaginative Learners (Type One Learners); Analytic Learners (Type Two Learners); Common Sense Learners (Type Three Learners); and Dynamic Learners (Type Four Learners), based on Kolb’s experiential learning theory thus, divergent, assimilative, convergent and accommodative learning style respectively. These four types of learner need to learn all the parts of the cycle at the same time in other to make learning successful i.e. the type one learner has to learn how to be type two, three, and four learners if he should learn anything well. The learner has to travel this cycle with a spin to fully engage in the activities of the four diverse learners.

The use of 4MAT teaching model has been supported by research in elementary and secondary and more recently in higher education classrooms. According to previous researches (Aktas & Bilgin, 2015; Al-Dasouqi, 2016; Al-Nu’aimi, 2014; Ayyash, 2013; Cengizhan & Özer, 2013; Ergin & Atasoy, 2013; Ghazal, 2016; Irfan & Almufadi, 2016; Okoyefi, 2014; Omar, Salah, Samer & Mohammad, 2020; Osama, Fahad & Ayman, 2016; Ovez, 2012a&b; Pratoomtong, 2011; Tezcan & Güvenç, 2017; Uyangör, 2012; Wilkerson & White, 1988) the 4-MAT teaching model showed positive results on students’ achievement, retention and attitudes; and its use in primary, secondary and tertiary education

levels, representing various disciplines including mathematics, biology and physics; but there exists a gap in chemistry.

The 4MAT model also integrates learning style with brain-based processing strategies and provides systematic model of planning instruction, which assumes that individuals learn in different but, identifiable ways and that engagement with a variety of diverse learning activities result in higher levels of motivation and performance. 4MAT model moves beyond enhancing students’ self-awareness of their learning strengths and weaknesses, to a framework student can use to adapt to the variety of teaching styles and disciplines required of today’s college students. Based on this idea McCarthy developed the 4MAT system and added two new views to Kolb’s model concerning the way the brain works (right/left mode) (McCarthy & McCarthy, 2006). The 4MAT system is a teaching model based on research on brain function to create a practical teaching method for maximizing human learning and potential. Learners will therefore work in small groups or at times work alone and use their intelligences; visual, interpersonal, musical, bodily kinesthetic, intrapersonal, linguistic, natural and logical to work at their own pace and create, build, evaluate and extend their learning (McCarthy, 2005).

Holistically 4MAT instructional model relies upon learning loop, which includes four types of students introduced by McCarthy and the right and left hemispheres of the brain, which makes learning a constant process. According to the model, the loops called 4MAT impeller or 4MAT quadrant is divided into eight steps and it is designed as a process that is made up of activities, which are appropriate for the four types of students (learning style) (McCarthy, 2005). In this loop, while the teacher is going around the impeller, the teacher teaches according to learner’s personal differences by utilizing the educational strategies that are appropriate for each student such as experimentation, group discussion, classroom interaction, lecture and other strategies that can stimulate the activities of the two hemisphere. Though they utilizes more than one strategies during the teaching and learning his major role is to guide the students



and so students remains active participant in the lesson unlike traditional mode demonstrations that are usually teacher-centred.

Demonstration method is a teaching technique that is designed to show or illustrate a procedure, process or phenomenon. Demonstrations in science are effective and provide excellent learning experiences. Successful demonstration activities carried out in teaching process provide concrete experiences and can be used for structuring future information for students. It allows the teacher to guide and channel learning in desired direction; since is teacher-activity centred making the students passive learners which may led to poor understanding of science concepts and gender-related issues.

Over the years, the achievement of students in Chemistry in Nigeria secondary schools has been low. Students' achievement in Chemistry in internal and external examination is on the decline. The WAEC Chief Examiner Report of 2015 - 2020 indicated poor achievement of students in Chemistry. The students' poor achievement in Chemistry according to research attributed to findings is so many factors amongst which are poor classroom management, use of gender biased instructional materials, lack of adequate instructional materials, lack of adequate laboratory activities, poor teaching methods employed in teaching Chemistry by the secondary school teachers and lack of competent Chemistry teachers. The problem of this study therefore, is to find out if the use of 4MAT strategy could enhance the achievement, retention and attitudes of students with different learning styles. The main purpose of this study is to investigate the effect of Four Mode Application Technique (4MAT) on achievement, retention and attitude of students with different learning styles in Chemistry.

Research Questions

The following research questions were posed to guide the study:

- i. What is the mean achievement score of students with different learning styles taught Chemistry using Four Mode Application Techniques (4MAT) and

those taught using demonstration method?

- ii. What is the mean attitude score of students with different learning styles taught Chemistry using Four Mode Application Techniques (4MAT) and those taught using demonstration method?
- iii. What is the mean retention score of students with different learning style taught Chemistry using 4MAT and those taught using demonstration method?

Hypotheses

To also guide the study, the following null hypotheses were formulated and tested at alpha level of 0.05:

H0₁: There is no significant difference in the mean achievement scores of students with different learning styles taught Chemistry using 4MAT and those taught with demonstration method.

H0₂: There is no significant effect of 4MAT on attitude of students with different learning styles taught and those taught with demonstration method.

H0₃: There is no significant difference in the mean scores on retention of students with different learning styles taught Chemistry using 4MAT and those taught with demonstration method.

METHODOLOGY

Quasi-experimental design, specifically the non-equivalent control group design was used in this study because intact classes was used to avoid disruption of normal class lessons. The treatment variable is Four Mode Application Techniques (4MAT) used by the experimental group and Demonstration method used by the control group.

The population of the study consisted of all Secondary School Two (SS II) students offering Chemistry in the government owned secondary schools in Jalingo Education Zone during the 2020//2021 academic session. The



sample for the study comprised of 201 chemistry students were randomly drawn from two intact classes from GSSS Jalingo and GDSS Kona all from Jalingo education zone. The selected schools were randomly assign to two groups (A and B) using hat and draw method. Group A was randomly assigned as experimental group taught with 4MAT strategy and group B was assigned as the control group that was taught using demonstration method.

The instruments used for data collection was Chemistry Achievement Test (CAT) made up of Pretest, Post-test and Post-Post-test or retention test; and Student Attitudes towards Chemistry Inventory (SATCI). The first type was the Chemistry achievement test (CAT), was made up of 40 multiple-choice questions. Based on the National Policy on Education (FRN, 2014), the researcher modified 2015 to 2018 SSCE past questions. A table of specification is drawn to cover the topics during the period of investigation which was designed to test the cognitive ability of the students of SS II after being taught chemistry concepts by their teacher. Each item in the test has options lettered A to E. Each correct answer carries one (1) mark and zero (0) for the wrong answer. The CAT was scored over a total of 40 marks. The CAT was administered to students as pre-test and later on reshuffled as post-test and post-post-test or retention test. And CAT is designed to assess students' achievement and retention in the Chemistry topics used for the study. The SATCI was a 20 items questionnaire of a modified four Likert scale adapted from a study on student's attitude. This was done after the two methods of teaching must have been employed in order to determine the student's attitudes in Chemistry.

The instruments CAT and SATCI were validated by three Science education specialists. The experts assessed the instruments in terms of face and sampling validity (content validity). Face validity is to ensure the extent to which the instruments appears to deal with relevant content in the considered subject area of the study, and sampling validity assess how well the instruments samples the total content area. Each expert was provided with a copy of CAT and SATCI in which their judgement involved a systematic evaluation of the instruments. The

observations and comments of the specialists was used for the final modification, and selection of the items for the study.

The reliability of the instruments (CAT & SATCI) was determined by trial testing the instrument using 50 SS II students from Government Secondary School, Bali and the data will be gotten from the trial testing was used to determine the reliability of the instruments. The reason for selecting a pilot school different from the sampled schools is to avoid experimental bias or contamination. The aim is to ascertain the reliability index of the research instruments. The internal consistency of the CAT was determined using Kuder-Richardson-20 ($K-R_{20}$) formula. The choice of $K-R_{20}$ is because it is appropriate for determining the degree of reliability of a standard test with binary variables (i.e. answers that are right or wrong). For the Chemistry Achievement Test (CAT), an internal consistency reliability coefficient index of 0.78 was obtained, while that of SATCI using Cronbach alpha was 0.83 which were considered reliable and good for the study.

The administration of the instruments was done in two phases: the first phase was a pre-test, which was administered to the students a week before the treatment. After the administration of the pre-test, the students were taught the selected topics: Acids, Bases & Salts for four weeks in the same intact classes by the regular teachers (research assistants). The second phase was post-test was done after the experiment to determine which of the teaching strategy is more effective. Both groups were taught for four weeks. At the end of the teaching, post-test, was administered to the students in both the treatment and control groups. Retention test was also administered to the students in the two groups two weeks after the post test. Data collected to determine students' achievement both in the pre-test, post-test and retention test (post-post-test) was analyzed.

For the demonstration method (control group), following the steps on the lesson plan, the teacher was encouraged to follow the normal demonstration method where the teacher does the talking and demonstrates on



concepts taught as few things are written on the chalk board and the students only listens. The control group is more of teacher centred method of teaching (teachers active) while the students are passive recipients.

For the experimental group which is more student centred, the researcher explains to the teachers using the lesson plan (instructional guide) prepared for 4MAT teaching strategy that, provides an avenue for the teacher to teach the students the skills and thinking habits necessary to interact with others and control their own behaviour (students) where the teacher only act as a facilitator. In using 4MAT, the teacher is expected to use/have four types of learning/Learners: Imaginative Learning/Learners, Analytic Learning/Learners, Common Sense Learning/Learners and Dynamic Learning/Learners. The students are actively engaged in different learning styles class.

In the 4MAT teaching method used for the study, for Type 1 (Imaginative learners), co-operative learning, watching relevant slides/short video clips on different concepts maps and short lectures/discussions on Acids, bases and salts. For Type 2 (Analytic learners), reading of acid-base related concepts, giving lectures/discussions and independent research on Acids, bases and salt related concepts were used. For Type 3 (Common sense learners),

experiential learning activities involving practice (e.g. acid-base reaction, test for acids) and usage of real life experiences (using improvised materials such as unripe fruits, ash, and flower extracts litmus papers). While for Type 4 (Dynamic learner), Games (Neutralization), Simulations (using computer simulations to show Acid-base reactions), Role play (Acid-base reactions), and Problem solving (Acid-base calculations) via hands-on experiences and learning by trial and error.

Mean and standard deviation was used to respond to the research questions; while the Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance with the pre-test, which acts as covariate. The ANCOVA statistic was used to investigate whether the difference between the two mean values was statistically significant.

RESULTS

The data collected using the instruments developed for the study were analyzed, interpreted and are presented as follows:

Research Question One: What is the mean achievement score of students with different learning styles taught Chemistry using 4MAT and those taught using demonstration method?

Table 1: Mean Achievement Scores and Standard Deviations of Pretest and Posttest of Experimental and Control Groups

Group	N	Pretest		Posttest		
		Mean	Std. Dev.	Mean	Std. Dev.	Mean Gain
4MAT	145	21.72	6.08	30.19	11.34	8.47
DM	60	21.00	7.16	22.53	6.50	1.53
Mean Difference		0.72		7.66		6.94

Results of Table 1 show that the posttest mean achievement scores of students with different learning styles taught Chemistry using 4MAT is 30.19, while that of those taught using Demonstration Method is 22.53 with standard deviation of 6.50. The difference between the pretest and posttest achievement mean scores of 4MAT group is 8.47 and that of the Demonstration Method group is 1.53. These

differences show what were achieved by the two groups. There is also a difference of 7.66 between the posttest mean scores of the two groups; which is in favour of the 4MAT group; with mean gain of 6.94. The implication is that the students with different learning styles taught Chemistry using 4MAT gained in achievement more than their Demonstration Method



counterparts. But, was tested with H_{01} as shown in Table 2.

Hypothesis One: There is no significant difference between the mean achievement

scores of student with different learning styles taught Chemistry using 4MAT and those taught using demonstration method.

Table 2: One-way Analysis of Covariance of the Mean Achievement Scores of the Experimental and Control Groups

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8527.821 ^a	2	4263.911	57.499	.000	.363
Intercept	1105.518	1	1105.518	14.908	.000	.065
Pretest	6037.835	1	6037.835	81.420	.080	.287
Group	2099.889	1	2099.889	28.317	.000	.123
Error	14979.581	202	74.157			
Total	183668.000	205				
Corrected Total	23507.512	204				

Table 2 is one-way ANCOVA between groups analysis of covariance to assess the effect of 4MAT and demonstration method on students' achievement in Chemistry. The result $F(1, 202) = 28.317$, $P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is not retained. Therefore, there is a significant difference between the mean achievement scores of students taught chemistry using 4MAT and those taught using

demonstration method. The effect size (eta square = .123) is low and it indicates that 12.3% of the difference in the mean score is based on the technique used.

Research Question Two: What is the attitude score of students with different learning styles taught Chemistry using 4MAT and those taught using demonstration method?

Table 3: Mean Attitude Scores and Standard Deviations of Pre-attitude and Post-attitude of Experimental and Control Groups

Group	N	Pre-attitude		Post-attitude		
		Mean	Std. Dev.	Mean	Std. Dev.	Mean Gain
4MAT	145	46.74	7.26	64.50	5.99	17.76
DM	60	45.97	6.85	52.93	7.23	6.96
Mean Difference		0.77		11.57		10.80

Results of Table 3 show that the post-attitude mean scores of students with different learning styles taught Chemistry using 4MAT is 64.50 with standard deviation of 5.99, while that of those taught using Demonstration Method is 52.93 with standard deviation of 7.23. The difference between the pre-attitude and post-attitude mean scores of 4MAT group is 17.76 and that of the Demonstration Method group is 6.96. The implication is that the students with different learning styles taught Chemistry using 4MAT acquired positive attitude more than their

Demonstration Method counterparts. There is also a difference of 11.57 between the post-attitude mean scores of the two groups; which is in favour of the 4MAT group. But, was tested with H_{02} as shown in Table 4.

Hypothesis Two: There is no significant difference between the mean attitude scores of student with different learning styles taught Chemistry using 4MAT and those taught using demonstration method.

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Table 4: One-way Analysis of Covariance of the Mean Attitude Scores of the Experimental and Control Groups

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5771.227 ^a	2	2885.613	71.563	.000	.415
Intercept	18702.094	1	18702.094	463.810	.000	.065
Pre-attitude Group	96.789	1	96.789	2.400	.123	.012
Group	5734.302	1	5734.302	142.210	.000	.413
Error	8145.193	202	40.323			
Total	779530.000	205				
Corrected Total	13916.420	204				

Table 4 is one-way ANCOVA between groups analysis of covariance to assess the effect of 4MAT and demonstration method on students' attitude in Chemistry. The result $F(1, 202) = 142.210, P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is not retained. Therefore, there is a significant difference between the mean attitude scores of students taught chemistry using 4MAT and those taught using demonstration method.

The effect size (eta square = .413) is moderate and it indicates that 41.3% of the difference in the mean score is based on the technique used.

Research Question Three: What is the mean retention score of students with different learning styles taught Chemistry using 4MAT and those taught using demonstration method?

Table 5: Mean Retention Scores and Standard Deviations of Pretest and Retention of Experimental and Control Groups

Group	N	Pretest		Retention		Mean Gain
		Mean	Std. Dev.	Mean	Std. Dev.	
4MAT	145	21.72	6.08	33.10	11.67	11.38
DM	60	21.00	7.16	22.22	6.43	1.22
Mean Difference		0.72		10.88		10.16

Results of Table 5 show that the mean retention scores of students with different learning styles taught Chemistry using 4MAT is 33.10 with standard deviation of 11.67, while that of those taught using Demonstration Method is 22.22 with standard deviation of 6.43. The difference between the pretest and retention mean scores of 4MAT group is 11.38 and that of the Demonstration Method group is 1.22. These differences show what were retained by the two groups. There is also a difference of 10.88 between the retention mean scores of the two groups and the mean gained by the experimental

group is 10.16. The implication is that the students with different learning styles taught Chemistry using 4MAT gained in retention more than their Demonstration Method counterparts. But, was tested with H_0 as shown in Table 6.

Hypothesis Three: There is no significant difference between the mean retention scores of students with different learning styles taught Chemistry using 4MAT and those taught using demonstration method.

Table 6: One-way Analysis of Covariance of the Mean Retention Scores of the Experimental and Control Groups

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9242.827 ^a	2	4621.414	52.378	.000	.341

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Intercept	2568.050	1	2568.050	29.106	.000	.126
Pretest	4212.868	1	4212.868	47.748	.085	.191
Group	4553.442	1	4553.442	51.609	.000	.203
Error	17822.763	202	88.232			
Total	210547.000	205				
Corrected Total	27065.590	204				

Table 6 is one-way ANCOVA between groups analysis of covariance to assess the effect of 4MAT and demonstration method on students' retention in Chemistry. The result $F(1, 202) = 51.609$, $P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is not retained. Therefore, there is a significant difference between the mean retention scores of students taught chemistry using 4MAT and those taught using demonstration method. The effect size ($\eta^2 = .203$) is low and it indicates that 20.3% of the difference in the mean score is based on the technique used.

DISCUSSION OF FINDINGS

The result in Tables 1 and 2 revealed that a significant difference exists among the mean achievement scores of student taught chemistry using 4MAT and Demonstration Method. The students who were taught using 4MAT had higher mean achievement scores in Chemistry than those who were taught using Demonstration Method. This means that the 4MAT adopted in teaching chemistry is significant in enhancing students' achievement in chemistry. This implies that the two strategies are not of equal efficacy. The findings also supports previous researches (Aktas & Bilgin, 2015; Al-Dasouqi, 2016; Al-Nu'aimi, 2014; Ayyash, 2013; Cengizhan & Özer, 2013; Ergin & Atasoy, 2013; Ghazal, 2016; Irfan & Almufadi, 2016; Okoyefi, 2014; Omar et al. 2020; Osama et al. 2016; Ovez, 2012a&b; Pratoomtong, 2011; Tezcan & Güvenç, 2017; Uyangör, 2012; Wilkerson & White, 1988) which revealed that the 4-MAT strategy showed positive results on students' achievement. The implication is that the students with different learning styles taught Chemistry using 4MAT gained in achievement more than their Demonstration Method counterparts.

Result of Tables 3 and 4 revealed that there is a significant difference between the mean attitude scores of student taught chemistry

using 4MAT and those taught using demonstration method. The post attitude mean scores of student with different learning styles taught Chemistry using 4MAT is higher compared to those taught using Demonstration method. The difference between the pre-attitude and post-attitude mean scores of 4MAT group is in favour of students taught using Demonstration Method. The implication is that the students with different learning styles taught Chemistry using 4MAT acquired positive attitude more than their Demonstration Method counterparts. This study agrees with the findings of previous researcher (Al-Nu'aimi, 2014; Ayyash, 2013; Irfan et al. 2016; Osama et al. 2016; Uyangör, 2012; Wilkerson & White, 1988) who found that students who were taught using the application of 4MAT in classroom develop higher attitude in terms of learning in educational processes and a greater commitment to teaching and learning. The implication is that the students with different learning styles taught Chemistry using 4MAT gained in achievement more than their counterparts because of their interest.

Results of the findings in Tables 5 and 6 confirmed that there is significant difference between the mean retention scores of student with different learning styles taught Chemistry using 4MAT than those taught using Demonstration Method. The implication is that the students with different learning styles taught Chemistry using 4MAT gained in retention more than their Demonstration Method counterparts. This study agrees with the findings of these previous researchers (Adebola, 2012; Cengizhan & Özer, 2013; Okoyefi, 2014; Omar et al. 2020; Wilkerson & White, 1988) who found that 4MAT instructional strategy aids student's retention, students' gain scores would differentiate according to the school and their learning styles.

The findings have shown that 4MAT strategy contributes in developing the learner's intellectual abilities to the highest possible limit



and enables him/her to access knowledge through additional ways using more than one sense in learning. This is because the model offers a complete chance to process the information in the right way, which helps in understanding and analyzing the thoughts, and making attempts to link and use them in more than one situation. The model also helped learners to experience hands-on-learning which was meaningful, resulting to keeping learnt concepts in the long-term memory, and facilitates its retrieval. However, this is contrary to the traditional method of teacher demonstrations/lectures that includes superficial processing of the information as they are based on instant recitation and recollection, which renders the information subject to forgetting' hence poor retention of concepts.

CONCLUSION

It is evident from the findings of this study to conclude that the use of 4MAT could provide a good way for students to learn chemistry since they achieved higher than their counterparts taught Chemistry using Demonstration Method. Also, there is significant difference between the mean retention and mean attitude scores of students with different learning styles taught Chemistry using 4MAT than those taught using Demonstration Method. Therefore, the 4MAT model is more effective than Demonstration (traditional) method in terms of increasing students' achievement, attitude and retention of Chemistry concepts; since the model takes all learners into account. The application of the 4MAT Model in Chemistry instructional materials/lessons suggests a balanced method of delivering new information in a total of learners having different characteristics and learning styles.

RECOMMENDATIONS

The implication of this study and the associated recommendations as it borders on chemistry education are as follows:

1. Chemistry pre-service and in-service teachers should be encouraged to use 4MAT model in lessons since it improved the students' academic

achievement, retention and attitude in chemistry.

2. The 4MAT learning model should be encouraged and integrated in chemistry lessons as it exposes students to dynamics and richness of the subject chemistry using different learning styles.
3. Curriculum planners, and science teachers should incorporate innovative, problem and activity based pedagogical strategies like 4MAT learning model in all teacher education institutions.

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