INFLUENCE OF GENDER ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT, RETENTION AND ATTITUDE IN CHEMISTRY USING 4 MAT TEACHING MODEL

By

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Abstract

This study investigated the influence of gender on secondary school students achievement, retention and attitude in Chemistry using 4MAT teaching model in Jalingo Education Zone of Taraba State. Quasi-experimental design was used for the study. Four research questions and hypotheses guided the study. A total of 205 students (115 males & 90 females) were sampled using multiple stage sampling technique. Two intact classes were randomly selected and assigned experimental and control groups. Two instruments used for data collection were Chemistry Achievement Test (CAT) and Student Attitudes towards Chemistry Inventory (SATCI) with reliability indexes of 0.78 and 0.83 respectively. The data collected were analyzed using mean and standard deviation to answer the research questions; while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.5 level of significance. Findings of the study revealed that there is no statistically significant difference between the mean achievement scores of male and female students taught chemistry using 4MAT and Demonstration Method. The study also revealed an insignificant effect of gender, insignificant effect of attitude, and insignificant interaction effect of gender and treatments on students' achievement in Chemistry using 4MAT. 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 enhance students achievement, retention, and is attitude and gender friendly. Therefore, it is recommended amongst others that both pre-service and in-service chemistry teachers should be train on the use of 4MAT since it incorporate all types of intelligences in teaching and learning and helps in improving both male and female students' achievement, retention and attitudes in Chemistry.

Keywords: *Four Mode Application Technique (4MAT), Demonstration method, Gender, Achievement, Retention, Attitude of students.*

Introduction

Science Education is the type of training given to a learner so as to facilitate them to value their environment and to become useful to themselves and the society at large. It is a norm to introduce science to the Nigerian child right from the primary school because this will enable the child (learner) to develop interest in science, learn science, practice science and

contribute effectively to the scientific and technological development of the nation. The foundation of science is presented to the learner earlier in school so that science subjects will not sound strange to the learner at secondary school level.

Science can be thought of as both a body of knowledge (the things we have already discovered), and the process of acquiring new knowledge (through observation and experimentation—testing and hypothesising). Both knowledge and process are interdependent, since the knowledge acquired depends on the questions asked and the methods used to find the answers. Science embodies all educational processes aimed at providing unlimited opportunities for learners to understand and utilize necessary knowledge, skills and attitudes required to operate effectively in a scientific society. It is in attainment of this goal of science education that we hope to produce the required large pool of experts in science, which will help to bring about the much needed socio-economic development of a nation. These experts can only be produced through a well-organized and efficient science education which Chemistry is an aspect.

Chemistry is a subject of universal interest in human development with regards to the utility of its knowledge in real-life situations likely to be faced by many of the students someday. Chemistry embraces a variety of fields of study and is combined with other subjects to satisfy the Secondary School Examination (SSCE) requirements. And, Chemistry education is the vehicle through which chemical knowledge and skills reach the people who are in need of capacities and potentials for development, These people or individuals have their physiological and psychological differences in the way they learn and understand chemical concepts due to their own uniqueness, genetic make-up and past experiences. Hence, there are differences among people in the way they learn. These differences are recognized and classified as individual's learning style.

Some educators have tried to study about learning styles, for instance, Kolb (1983), and McCarthy, (1990 & 2005) stated that for learners to be effective, they need four different kinds of abilities; concrete experience, reflective observation, abstract conceptualization, and active experimentation. The iindividual differences that affect learning as coined from Tezcan and Güvenç, (2017) include intelligence, ability, learning strategies, learning styles, prior knowledge, personality, interest, type and level of motivation, gender, age, etc. Among these, learning style which defines the best way of learning for each individual takes an important place. Learning style can be viewed in two aspects: i) as the way of concentrating on new and hard information and processing and making it permanent; and ii) as preferences about the way of perceiving and processing the new information.

Differences in individual's learning styles results from the differences in the brain parts that they frequently prefer to use. The line of thought on brain hemisphericity and the knowledge of style led to a research by Bernice McCarthy in

1990, about the best way to teach learners in a classroom with a goal of creating a simple and effective model for teachers that would help them reach out to more students more often. This brought about the development of the Four Mode Application Techniques (4MAT) which can help transform the quality of learning of an organization. The studies (McCarthy, 1990; 1997; McCarthy, 2005; McCarthy & McCarthy, 2006) indicated that each brain was unique and different patterns and changes emerge in each student's brain while learning and for this reason the best learning ways are differentiating. In 4MAT learning, environment is arranged according to individual differences. One reason for this difficulty is not considering individual differences for teaching science. The 4MAT is a model for creating more dynamic and engaging learning. It is a framework for learning that helps educators deliver information in more dynamic and engaging ways. The four learning-style types from the 4MAT model are Innovative, Analytic, Common Sense, and Dynamic. 4MAT. McCarthy, (1990), developed her system to format a lesson according to how the needs of learners changes as they go around the learning cycle, called the 4MAT System. Right-brain learners are intuitive, emotional, holistic, parallel, and tactile learners. The 4MAT system is designed to provide every student with a preferred task during every lesson. In 4MAT model, learners takes over in the last two quadrants, where they must apply learning in real life situations or contexts.

4MAT is an instructional model which provides a systematic approach to organising and delivering instructions in a manner that addresses the learning styles and hemispheric preferences of students. 4MAT is an eight steps instructional model that capitalizes on individual learning styles and brain dominance processing preferences. Inherent in the 4MAT are two major premises: one is that people have major learning style and hemispheric (right mode and left mode) processing preferences; and secondly, teachers should design and use multiple instructional strategies in a systematic framework to teach to these preferences putting cognisant individual differences in other to improve teaching and learning.

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, 1990; McCarthy & McCarthy, 2006). McCarthy 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 as shown in Figure 1.
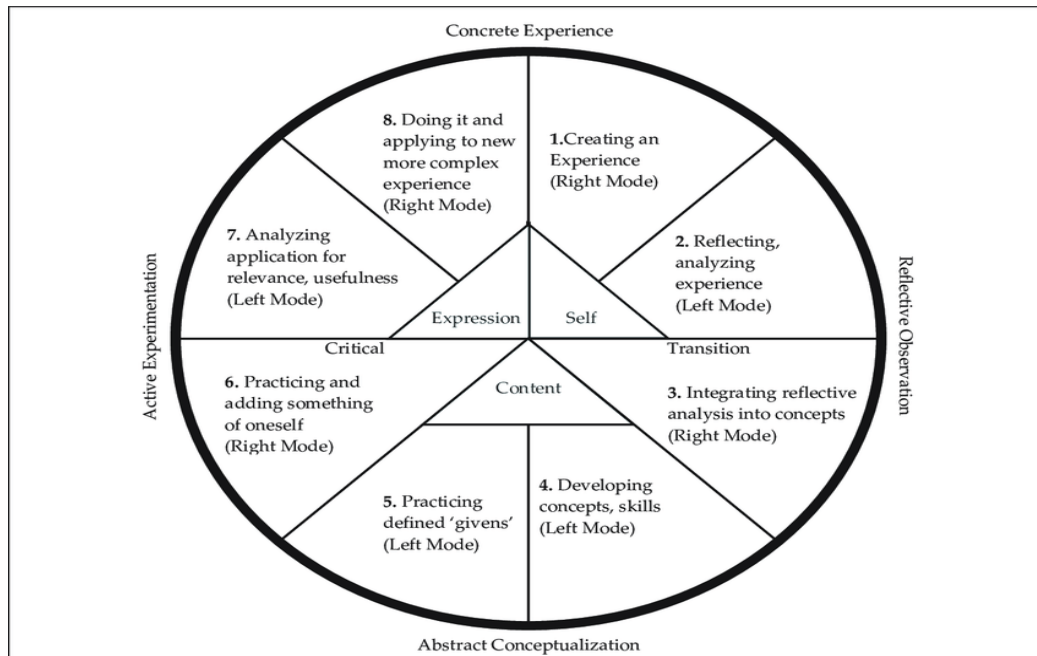
Figure 1. The 4MAT System (McCarthy, 1990, p. 33)

Imaginative Learners (Type 1) learn best through personal experience. They benefit from opportunities to find meaning in what they are learning and they enjoy discussing their beliefs, feelings, and opinions with others. The Type I learners are reflective in nature, learn primarily through dialogue and are skilled at perspective taking and are sensitive to the needs of others. The second one is analytic Learners (Type 2) approach learning in a logical, organized manner by examining details and specifics. As students, they often excel in a traditional classroom setting. Analytic Learners enjoy reflecting on new ideas and connecting new learning to other information they known to be true. The type 2 learners are logical in nature, enjoy formulating theories and models, strive for precision and prefer teachers that do so as well. The third type is common Sense Learners (Type 3) learn by doing. When presented with new information they immediately focus on practical

applications. These learners are active, preferring to get right to work in the classroom and dislike assignments that do not have an obvious purpose or application. These learners learn best when provided with hands-on, experiential learning opportunities. The fourth type is dynamic Learners (Type 4) are active learners, enjoy taking risks and learn primarily through self-discovery. These learners like to connect their learning to things that matter in their lives (McCarthy 2006). They enjoy synthesizing information and applying their learning in new ways. When properly sequenced, the dynamic learning styles provide a natural framework for teaching and learning.

These four types of learners would learn best if they are taught how to learn like each other at the same time in other to make learning successful, i.e. the type one learner has to learn how type two, three, and four learners learn. The teachers have to travel the 4MAT cycle with a spin to

fully engage all the learners in the activities of the four diverse learners. The four types of learners are; imaginative learners, analytic learners, common sense learners and dynamic learners (McCarthy, 1990; 2005). Each of these learners has to learn different but complimentary ways.

i. Type one learners are imaginative learners, they seek to personal associations, seek meaning and involvement. In making connection, their key question is WHY?

ii. The type two learners are analytic learners. They enjoy listening to and thinking about information, they seek facts, think through ideas and listens to what the experts think. In formulating ideas, their key question is WHAT?

iii. The type three learners are the common sense learners. They learn by experimenting, building ideas, creating usability, tinkering in applying ideas. Their key question is HOW?

iv. The type four learners are dynamic learners. They prefer doing and feeling things, they seek hidden possibilities, they explore learning by trial and error and they engage in self-discovery. In creating original adaptations, their key question is IF? That is, IF this is true what can I do with it?

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 by previous researchers (Aktas & Bilgin, 2015; Al-Dasouqi, 2016; Al-Nu'aimi, 2014; Ayyash, 2013; Cengizhan & Özer, 2013; Dounghathai, 2001; Ergin & Atasoy, 2013; Ghazal, 2016; Gurcay & Ferah, 2017; Irfan & Almufadi, 2016; Nikolaou & Koutsouba, 2012; Okoyefi, 2014; Omar, Salah, Samer & Mohammad, 2020; Osama, Fahad & Ayman, 2016; Ovez, 2012a & 2012b; Pratoomtong, 2011; Tezcan & Güvenç, 2017; Uyangör, 2012; Wilkerson & White, 1988). And, the 4-MAT strategy 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.

4MAT requires teachers to present teaching appropriately for each of the four learning styles so that they can develop other learning styles, use their own learning styles well and become successful. If the use of 4MAT strategy helps develop knowledge retention in Learners, academic achievement has taking place. 4MAT strategy which consists of successive, organized steps, beginning with the reflective observation, and then concept formulation, active experimentation, and finally ending with

the concrete experiences; in addition to the continuous feedback.

Okoye (2012) further stated that active participation during instruction increases learning and retention. This study aims to find out if 4MAT could enhance Chemistry student retention of knowledge. In addition, this study will determine if the effect of 4MAT on various variables that are gender related or if there is a gender dimension in the use of 4MAT and its various effects and influences; though it is student-activity centred 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.

Gender is a major factor that influence career choice and subject interest of students which may also have adverse effect on their academic performance. Gender role differentiation are also encouraged in pictorial illustration in textbooks which usually portray males as doctors, lawyers, engineers, professors while the females are seen as nurses, cooks, mothers etc. this creates mental picture in the mind of the reader of the role expectation from the society (Ezeudu & Obi, 2013). With the world declaration on Education for All (EFA), it is expected that the learning experience offered to the children in schools should not discriminate against males and females (Ezeudu & Obi, 2013). There is the need to see that both boys and girls are given equal access to education especially in science (chemistry).

One of the Sustainable Development Goals (SDGs) is gender equality. Suleiman (2011) investigated whether gender difference has any effect on science achievement, and the result from the findings revealed that; males are more interested in studying sciences than females. The research by Adesulu, (2014) also has shown that in Nigeria females'

achievement is low as compared to their male counterparts in Basic Sciences, particularly in chemistry. These stereotypical beliefs regarding gender differences in the area of perceptions and cognitive ability has become a serious concern to studies carried out in Nigeria with reference to gender and chemistry achievement and related task abound. Gender has been acknowledged as one of the attribute that affects students' achievement in chemistry subjects at secondary school level. Adesulu (2014) also reported that significant difference in chemistry achievement to the advantage of the males scored significantly higher than the females in deductive items, immediate recall of quantitative information in the area of computation and comprehension. However, some studies (Amoken, 2020; Jack, 2013; Jack & Japhet, 2020) show that gender does not affect students' academic achievement when the male and female are taught under the same condition. This shows that the issue of gender in chemistry achievement is not yet been resolved. It is believed that the gap between male and female students' academic achievement could be filled through the use of appropriate instructional strategies in the teaching of chemistry. Hence, the need for further study is required. This shows that the issue of gender in chemistry achievement is not yet been resolved. It is believed that the gap between male and female students' academic achievement could be filled through the use of appropriate instructional strategies in the teaching of chemistry such as 4MAT.

The 4MAT strategy seems to be an effective teaching method for all educational levels and academic disciplines in many parts of the world. However, a shortage of research still exists in Secondary education related to Chemistry discipline. This study was carried out to fill this gap and provide further research evidence to the suitability of the 4MAT strategy. Hence, the need for further study is required. Based on the fore evidence from research on the influence of gender on students' achievement in secondary school chemistry, 4MAT teaching method on secondary school chemistry students was used to ascertain its effectiveness in bridging the gap between male and female students' achievement, retention, and attitude in the subject. The statement of the problem therefore is: 'will the use of 4MAT teaching model in Science classrooms help in bridging the gap between male and female students' achievement, retention and attitude in chemistry'?

The purpose of this study therefore, is to find out if the use of 4MAT teaching model would minimize is gender influence on secondary school students model achievement, retention and attitudes using 4MAT teaching model. The study also intend to ascertain if the use of 4MAT could help to streamline the gender differences in students' performance in Chemistry. The purpose was achieved, by answering these under-listed research questions, and testing the hypotheses that guided the study.

Research Questions

The following research questions were posed to guide this study

i. What is the difference in the mean achievement score of male and female students taught Chemistry using 4MAT and those taught using demonstration method?

ii. What is the difference in the mean attitude score of male and female students taught Chemistry using 4MAT and those taught using demonstration method?

iii. What is the influence of gender on retention of students with different learning styles in Chemistry and those taught using demonstration method?

iv. What is interaction effect of 4MAT and gender of students' achievement with different learning styles in Chemistry?

Hypotheses

The following null hypotheses were formulated and was tested at alpha level of 0.05.

H0₁: Gender does not significantly influence the mean achievement scores of student in Chemistry using 4MAT and those taught with Demonstration Method.

H0₂: There is no significant influence of gender and attitude of students with different learning styles in Chemistry using 4MAT and Demonstration Method.

H0₃: Gender does not significantly influence the mean scores on retention of students taught Chemistry using 4MAT and Demonstration Method.

H0₄: There is no significant interaction effect of treatments on students achievement with different learning styles in Chemistry.

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 (DM) 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 205 (115 males & 90 females) 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 from 2015 to 2018 SSCE past questions. A table of specification was 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, the CAT was 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 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.

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 using mean and standard deviation to answer the research questions while Analysis of covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significance as presented as follows:

Research Question One

What is the difference in mean achievement score of male and female students taught Chemistry using 4MAT and those taught using Demonstration Method?

Table 1

Mean Achievement Scores and Standard Deviations of Pretest and Posttest Based on Gender of the Two Groups

Group	Gender	N	Pretest		Posttest		Mean
			Mean	Std. Dev.	Mean	Std. Dev.	Gain
4MAT	Female	55	22.29	6.43	30.80	12.69	8.51
	Male	90	21.38	5.86	29.82	10.49	8.44
	Mean Difference		0.91		0.98		0.07
DM	Female	35	22.23	7.70	23.71	6.46	1.48
	Male	25	19.28	6.05	20.88	6.33	1.60
	Mean Difference		2.95		2.83		0.12

Results of Table 1 show that the posttest mean achievement scores of female students taught Chemistry using 4MAT is 30.80 with standard deviation of 12.69, while that of the male students is 29.82 with standard deviation of 10.49. The difference between the pretest and posttest mean scores of the female students is 8.51 and that of the male students is 8.44. These differences show what were achieved by the male and female students. The difference between the posttest mean scores of the two sexes is 0.98 and the mean gained in favour of the female students is 0.07. The implication is that the female students taught Chemistry using 4MAT gained in achievement more than their male counterparts.

On the other hand, it can be seen that the posttest mean achievement scores of female students taught Chemistry using Demonstration Method is 23.71 with standard deviation of 6.46, while that of the male students is 20.88 with standard deviation of 6.33. The difference between the pretest and posttest mean scores of the female students is 1.48 and that of the male students is 1.60. These differences show what were achieved by the male and female students. The difference between the posttest mean scores of the two sexes is 2.83 and the mean gained in favour of the male students is 0.12. The implication is that the male students taught Chemistry using Demonstration Method gained in achievement more than their male counterparts. But, was tested with $H0_1$ as shown in Table 2.

Testing Hypothesis One

H0₁: Gender does not significantly influence the mean achievement scores of student in Chemistry using 4MAT and Demonstration Method.

Table 2: Two-way ANCOVA of the Mean Achievement Scores of Students taught Chemistry using 4MAT and Demonstration Method based on Gender

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8530.791[a]	4	2132.698	28.480	.000	.363
Intercept	1102.833	1	1102.833	14.727	.000	.069
Pretest	5891.017	1	5891.017	78.669	.080	.282
Gender	2 .078	1	2 .078	.038	.856	.000
Group	2047.087	1	2047.087	27.337	.000	.120
Gender * Group	**.171**	**1**	**.171**	**.002**	**.962**	**.000**
Error	14976.721	200	74.884			
Total	183668.000	205				
Corrected Total	23507.512	204				

Table 2 is two-way ANCOVA between gender analysis of covariance to assess the effect of 4MAT and Demonstration Method on male and female students' achievement in chemistry. The result F $(1, 200)$ = .002, P = .962 > 0.05 shows that the variation of scores for male and female students of the two groups is the same. Thus, the null hypothesis is retained. Therefore, there is no statistically significant difference between the mean achievement scores of male and female students taught chemistry using 4MAT and Demonstration Method. The effect size (eta square = .000) is zero and it indicates that 0.00% of the difference in the mean score is based on gender.

Research Question Two: What is the difference in mean retention score of male and female students taught Chemistry using 4MAT and those taught using Demonstration Method?

Table 3: Mean Retention Scores and Standard Deviations of Pretest and Retention Based on Gender of the Two Groups

Group	Gender	N	Pretest		Retention		Mean Gain
			Mean	Std. Dev.	Mean	Std. Dev	
4MAT	Female	55	22.29	6.43	35.27	13.42	12.98
	Male	90	21.38	5.86	31.78	10.31	10.40
	Mean Difference		0.91		3.49		2.58
DM	Female	35	22.23	7.70	23.86	6.17	1.63
	Male	25	19.28	6.05	19.92	6.18	0.64
	Mean Difference		2.95		3.94		0.99

Results of Table 3 show that the retention mean scores of female students taught Chemistry using 4MAT is 35.27 with standard deviation of 13.42, while that of the male students is 31.78 with standard deviation of 10.31. The difference between the pretest and retention mean scores of the female students is 12.98 and that of the male students is 10.40. These differences show what were retained by the male and female students. The difference between the retention mean scores of the two sexes is 3.49 and the mean gained in favour of the female students is 2.58. The implication is that the female students taught Chemistry using 4MAT gained in achievement more than their male counterparts.

On the other hand, it can be seen that the mean retention scores of female students taught Chemistry using Demonstration Method is 23.86 with standard deviation of 6.17, while that of the male students is 19.92 with standard deviation of 6.18. The difference between the pretest and retention mean scores of the female students is 1.63 and that of the male students is 0.64. These differences show what were retained by the male and female students. The difference between the retention mean scores of the two sexes is 3.94 and the mean gained in favour of the female students is 0.99. The implication is that the female students taught Chemistry using Demonstration Method gained in retention more than their male counterparts. But, was tested with $H0_2$ as shown in Table 4.

Testing Hypothesis Two:

H0₂: Gender does not significantly influence the mean retention scores of student in Chemistry using 4MAT and Demonstration Method.

Table 4: Two-way ANCOVA of Mean Retention Scores of Students taught Chemistry using 4MAT and Demonstration Method based on Gender

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9572.210[a]	4	2383.052	27.360	.000	.354
Intercept	2750.349	1	2750.349	31.444	.000	.136
Pretest	3899.210	1	3899.210	44.579	.085	.182
Gender	227.911	1	227 .911	2.606	.108	.013
Group	4820.153	1	4820.153	55.108	.000	.216
Gender * Group	**9.423**	**1**	**9.423**	**.108**	**.743**	**.001**
Error	17493.381	200	87.467			
Total	210547.000	205				
Corrected Total	27065.590	204				

Table 4 is two-way ANCOVA between gender analysis of covariance to assess the effect of 4MAT and Demonstration Method on male and female students' retention in chemistry. The result $F_{(1, 200)}$ = .108, P = .743 > 0.05 shows that the variation of scores for male and female students of the two groups is the same. Thus, the null hypothesis is retained. Therefore, there is no statistically significant difference between the mean attitude scores of male and female students taught chemistry using 4MAT and Demonstration Method. The effect size (eta square = .001) is very low and it indicates that 0.01% of the difference in the mean score is based on gender.

Research Question Three: What is the difference in mean attitude scores of male and female students taught Chemistry using 4MAT and those taught using Demonstration Method?

Table 5: Mean Attitude Scores and Standard Deviations of Pre-attitude and Post-attitude Based on Gender of the Two Groups

Group	Gender	N	Pre-attitude		Post-attitude		
			Mean	Std. Dev.	Mean	Std. Dev	Mean Gain
4MAT	Female	55	47.69	6.56	65.33	5.63	17.64
	Male	90	46.17	7.63	63.99	6.17	17.82
	Mean Difference		1.52		1.34		0.18
DM	Female	35	46.20	9.19	53.57	6.41	7.37
	Male	25	45.64	6.47	52.57	8.29	6.93
	Mean Difference		0.56		1.00		0.44

Results of Table 5 show that the post-attitude mean scores of female students taught Chemistry using 4MAT is 65.33 with standard deviation of 5.63, while that of the male students is 63.99 with standard deviation of 6.17. The difference between the pre-attitude and post-attitude mean scores of the female students is 17.64 and that of the male students is 17.82. Therefore, the difference between the post-attitude mean scores of the two sexes is 1.34 and the mean gained in favour of the male students is 0.18. The implication is that the male students taught Chemistry using 4MAT acquired positive attitude more than their female counterparts.

On the other hand, it can be seen that the post-attitude mean scores of female students taught Chemistry using Demonstration Method is 53.57 with standard deviation of 6.41, while that of the male students is 52.57 with standard deviation of 8.29. The difference between the pre-attitude and post-attitude mean scores of the female students is 7.37 and that of the male students is 6.93. Therefore, the difference between the post-attitude mean scores of the two sexes is 1.00 and the mean gained in favour of the female students is 0.44. The implication is that the female students taught Chemistry using Demonstration Method acquired positive attitude more than their male counterparts. But, was tested with $H0_3$ as shown in Table 6.

Testing Hypothesis Three

H0₃: Gender does not significantly influence the mean attitude scores of student in Chemistry using 4MAT and Demonstration Method.

Table 6: Two-way ANCOVA of Mean Attitude Scores of Students taught Chemistry using 4MAT and Demonstration Method based on Gender

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5884.048[a]	4	1471.012	36.627	.000	.423
Intercept	18735.424	1	18735.424	466.498	.000	.700
Pre-attitude	114.017	1	114.017	2.845	.093	.014
Gender	97 .127	1	97.127	2.418	.121	.012
Group	5821.762	1	5821.762	144.957	.000	.420
Gender * Group	**.085**	**1**	**.085**	**.002**	**.963**	**.000**
Error	8032.372	200	40.162			
Total	779530.000	205				
Corrected Total	13916.420	204				

Table 6 is two-way ANCOVA between gender analysis of covariance to assess the effect of 4MAT and Demonstration Method on male and female students' attitude in chemistry. The result $F_{(1, 200)} = .002$, $P = .963 > 0.05$ shows that the variation of scores for male and female students of the two groups is the same. Thus, the null hypothesis is retained. Therefore, there is no statistically significant difference between the mean attitude scores of male and female students taught chemistry using 4MAT and Demonstration Method. The effect size (eta square = .000) is zero (0.00%) and it indicates no difference in the mean score is based on gender.

Research Question Four: What is the interaction effect of treatments and gender on students' achievement with different learning styles in Chemistry?
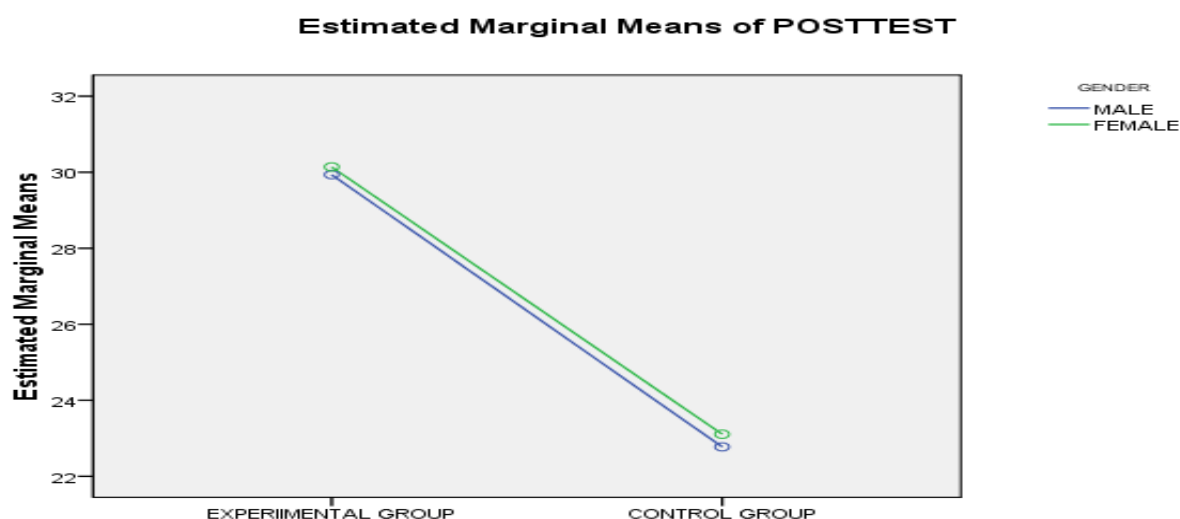

Figure 1: Interaction Effect of Treatments and Gender on Students' Achievement in Chemistry

In Figure 1, the profile plot/graph shows the interaction effect of treatments and gender on students' Achievement in Chemistry. The interaction pattern shows that the plots for males and females do not intersect. However it shows that the lines are very close to each other and are not parallel lines. This indicates that there is a high tendency of an interaction effect between treatments and gender on students' achievement in chemistry, for Four Mode Application Techniques (4MAT). But when the plot is extrapolated, the intersection could only be at infinity, which means that the interaction effect between treatments and gender may be tenable in this case. But, was tested with $H0_7$ as shown in Table 7.

Testing Hypothesis Four: There is no significant interaction effect of gender and treatments on students' achievement in Chemistry.

Table 7: ANCOVA of Interaction Effect of Treatments and Gender on Students' Achievement in Chemistry.

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8530.791[a]	4	2132.698	28.480	.000	.363
Intercept	1102.833	1	1102.833	14.727	.000	.069
Pretest	5891.017	1	5891.017	78.669	.080	.282
Treatment	**2 .078**	**1**	**2 .078**	**.038**	**.856**	**.000**
Gender	**2047.087**	**1**	**2047.087**	**27.337**	**.000**	**.120**
Treatment * Gender	**.171**	**1**	**.171**	**.002**	**.962**	**.000**
Error	14976.721	200	74.884			
Total	183668.000	205				
Corrected Total	23507.512	204				

Table 7 is two-way ANCOVA between gender analysis of covariance to assess the effect of 4MAT and Demonstration Method on male and female students in chemistry. After adjusting the mean for the pretest scores, the result F (1, 200) = .002, P = .962 > 0.05 shows that there was no significant interaction effect of treatment and gender on post-test scores of student in chemistry achievement test. This implies that the null hypothesis is not rejected. Also, the effect size (eta square = .000) is zero; and it indicates no difference in the mean score is based on the gender. Also, the main effect for treatment: F (1, 200) = 0.038, p = 0.856 is insignificant. But for gender effect: F (1, 200) = 27.337, p = 0.000, is significant.

Based on the data collected and analyzed, the findings are summarized as follows:

i. There is no statistically significant difference between the mean achievement scores of male and female students taught chemistry using 4MAT;

ii. There is no statistically significant difference between the mean retention scores of male and female students taught chemistry using 4MAT;

iii. There is no statistically significant difference between the mean attitude scores of male and female students taught chemistry using 4MAT; and

iv. There is no significant interaction effect of treatment and gender on post-test scores of students taught chemistry using 4MAT.

Discussion of Findings
The findings of this study are discussed under seven major sub-headings thus:
From Tables 1 and 2 the findings revealed that the female students taught Chemistry using 4MAT achieve higher than their

male counterpart; though statistically insignificant. The implication is that the female students taught Chemistry using 4MAT gained in achievement more than their male counterparts; though the difference is not significant. The finding supports Okoyefi, (2014) whose revealed that there was no significant main influence of gender on students achievement in biology. The finding of this study is also in line with the findings of Pratoomtong (2011) carried out a study on development of science learning activities based on 4MAT model to promote multiple intelligences of sixth grade students and found out that female students had higher multiple intelligences score than their male counterparts. The implication is that 4MAT strategy is gender-friendly and enhances students achievement in chemistry due to the application of different learning styles and consideration of multiple intelligences.

Results of the findings from Tables 3 and 4 revealed that the retention mean scores of female students taught Chemistry using 4MAT is higher than that of the male students; though not statistically significant. The finding supports Okoyefi, (2014) whose revealed that there was no significant main influence of gender on students retention in biology using 4MAT. The implication is that 4MAT strategy is gender-friendly and helps students in retention of concepts due to the application of different learning styles and consideration of multiple intelligences. This study contradicts the finding of Kelimeler and Ogrenme (2009) who found that male students had higher achievement

and retention score than their female counterparts.

Results of Tables 5 and 6 revealed that the post-attitude mean scores of female students taught Chemistry using 4MAT is higher than that of the male students; though statistically insignificant. The finding supports Okoyefi, (2014) whose revealed that there was no significant main influence of gender on students attitudes in biology using 4MAT. The implication is that 4MAT strategy is gender-friendly and helps in promoting higher or positive attitudes in students due to the application of different learning styles and consideration of multiple intelligences.

The interaction pattern from Figure 1 showed that the plots for males and females do not intersect. However it shows that the lines are very close to each other and are not parallel lines. This indicates that there is a high tendency of an interaction effect between treatments and gender on students' achievement in chemistry, for 4MAT. But, when the plot is extrapolated, the intersection could only be at infinity, which means that the interaction effect between treatments and gender may be tenable in this case. But, when tested with $H0_4$ on Table 7 the result ascertained that there is no significant interaction effect of gender and treatments on students' achievement in Chemistry. This finding supports Okoyefi, (2014) whose result revealed that there was no statistical significant main interaction effect of methods and gender on students achievement and retention of biology concepts using 4MAT.

Generally, there was a slight difference in students achivement, retention and attitude scores (which was not statistically significant) as a result of the nature of instructions (4MAT) delivered to the students, which enabled both the male and female students to be actively involved during the teaching and learning process. The findings from this study therefore supports Gurcay and Ferah, (2017) who found that multiple intelligences based instruction had a significant effect on students' achievements in the Force and Motion topics. However, multiple intelligences based instruction from their study also had no significant effect on students' attitudes towards force and motion topics. In addition, their study revealed that a large majority of the students in the experimental group found the courses based on multiple intelligences more enjoyable and found more instructive. Aktaş and Bılgınb (2015) also attested that the application of the 4MAT model increases student motivation and participation in the lesson, lessons are more amusing and enjoyable, and the self-confidence of the students increases; while Ergin and Atasoy, (2013) affirmed that 4MAT teaching method was more effective than the traditional method in reducing misconceptions in electricity.

The results showed a gender-friendly aspect of the treatment used in the experimental group that are imputed to the nature of the 4MAT strategy, which consists of successive, organized steps, beginning with the reflective observation, and then concept formulation, active experimentation, and finally ending with the concrete experiences; in addition to the

continuous feedback. Each stage according to McCarthy, (1990) consists of two types of the various activities that fit the pattern of the brain control (left and right hemisphere). Such successive and organized steps enable the learner to learn the concepts and the related terms of the educational materials accurately; and further helps the learner build new knowledge by himself during concept formulation stage. The feedback according McCarthy, (2005) enables the learner to make many inquiries and extend the concept, which helps in mastering the educational subject, and ability to retain it for the longest possible period. In addition, this strategy contributes in developing the learner's intellectual abilities to the highest possible limit and enables him to access knowledge through additional ways using more than one sense in learning. Furthermore, it 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. In general, learning as opined by McCarthy, (1990, 2005) becomes meaningful leading to the stability of the new knowledge and settling down into the learner, which enables him to keep in the long-term memory, and facilitates its retrieval. This is contrary to the traditional method such as teacher demonstrations that includes superficial processing of the information as they are based on instant recitation (memorization) and recollection, which renders the information subject to forgetting. The implication of the findings is that if chemistry teachers uses effective pedagogical approaches such as 4MAT

that takes care of the differences in students' hemispheric preferences and learning styles in teaching the subject; the constant gender differences and poor performance, retention and attitude of the students in the subject will be eradicated.

Conclusion and Recommendation

The conclusions reached from the findings of the study are: there was no significant influence of gender on students' mean achievement scores, mean retention scores and mean attitude scores taught chemistry using 4MAT. Also, there is no significant interaction effect of treatment and gender on post-test scores of students taught chemistry using 4MAT. Therefore, 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 and is gender-friendly. Hence, gender was not a significant factor in mean achievement, retention and attitude scores of students in Chemistry.

Based on the conclusions drawn, it is recommended that 4MAT should be encouraged and integrated in chemistry lessons as it exposes students to dynamics and richness of the subject chemistry; since learning is through learner's suitable style and is gender friendly. Teachers should also use instructional approaches such as 4MAT that can streamline gender differences in science classrooms. Also, the content and method of instruction can be adjusted to fit the learning styles of students, which requires students to participate in the learning process as active learners using 4MAT strategy.

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