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EFFECT OF MEND MAPPING TEACHING STRATEGY (MMTS) ON CHEMISTRY STUDENTS' ACHIEVEMENT, INTEREST, AND RETENTION IN ENUGU.

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Abstract
This study determined the effect of MMTS on chemistry students' interest retention and achievement in senior secondary school. The performance of students taught using MMTS (experimental) was compared with students taught without it as control. In order to give the study a sense of direction and carried it out effectively, three research questions were raised and answered while three null hypotheses were formulated and tested. A quasi experimental, non-equivalent, non-randomized pre-test post-test research design was adopted. The population of the study was 4,698 SS2 chemistry students in Enugu Educational Zone in 2008/2009 academic session. The sample was 194 SS2 chemistry students drawn through multistage sampling technique. Two instruments Chemistry Achievement Test (CAT) and Chemistry Interest Inventory (CII) were developed by the researcher and validated by two University experts in measurements and evaluation and two university experts of Chemistry Education. The internal consistency of the CAT and the CII were obtained using Kuder Richardson formula 20(KR-20) and Cronbach alpha procedure. Reliability coefficients of 0.8359 and 0.7214 were obtained for the CAT and the CII respectively. Results showed that MMTS was more effective in facilitating students' interest, retention and achievement in chemistry than the control group. The study concluded that MMTS has significant effect on students' cognitive achievement, interest and retention in Chemistry. Also, the study recommended that teachers should adopt MMTS as a teaching strategy in chemistry classrooms and laboratories. Also workshops and seminars should be organized for in-service chemistry teachers in order to train and develop teachers on the use of MMTS in administering education in every field of education.

Keywords: Mend Mapping Teaching Strategy (MMTS), Chemistry Students, Achievement, Interest, and Retention.

Introduction

Chemistry which is expected to be an interesting practical science subject is posing a great threat to many students nowadays, some have already developed phobia because of their consistent poor achievement on assessment or repeated failure in external examinations. Evidences have shown that most concepts in chemistry are indeed difficult to learn by most students. It was lamented that most chemistry educators have lost excitement in carrying out their pedagogical roles, and also considers almost the entire concepts in the senior secondary school Chemistry syllabus as areas commonly found difficult to teach by graduate teachers though there is no ideal situation that is devoid of one difficulty or the other and difficulty is an inherent variable in any purposeful activity.

The secondary school knowledge of chemistry is often characterized by lack of coherence, instead of having a well-structured and integrated domain-specific knowledge structures, students consider the different concepts as isolated elements of knowledge. Most students do not possess a well-founded basic framework in which newly acquired concepts can be integrated. This lack of integration is suspected to be the basis of students' difficulties concerning concept formation and application of acquired knowledge in exercises and practical work.

In assessing student's prior knowledge, diagnosing students' learning difficulties, relating new topics to common application and providing rationale for learning, matching instructional strategies to students learning style, with the use of problem-solving method and development of problem-solving skills, using mend mapping teaching methods are very essential.

Since everyone learns differently, understanding learning styles can help a teacher perform better by matching the teaching pattern with students learning styles for appropriate understanding of the lesson content and recent studies have reported on the efficacy of mend mapping teaching strategy in matching students learning styles and the lesson content. There are different learning styles exhibited by students though the same method or approach is employed during classroom instruction. There is no right or wrong learning style and it has nothing to do with intelligence but it has to do with the way a person's brain works to learn and store information efficiently.

Researches have shown that students' attitude towards learning affect their performance and educators are interested in the learners' attitude because they are affective variables that are durable. It was observed that affective variables are as important as cognitive variable in influencing learning outcomes. It is often believed that for any achievement in an endeavour, opportunity, ability and interest are the three essential ingredients of which interest is paramount. Interest (often measured by attitude and mostly reflected by individual' learning style) with its affective and cognitive dimension is a psychological construct that is considered to be a critical predictor of the behaviour of a student towards a subject or course, and it invariably determines the student's retention rate and achievement in a course or subject.

It is one thing to be taught chemistry via a preferred approach such as MMTS; it is another thing to remember it after some reasonable period of time must have elapsed, that is retention. Retention as defined by Hornby (2001) is the ability to remember things. For the purpose of this study, retention is defined as the ability to keep or retain the knowledge of chemistry learnt and to be able to recall it when required. Retention in chemistry is not acquired by mere rote-memorization but through appropriate teaching method. Retention in a course or subject also determines the level of achievement of the student in that course or subject. This study seeks to determine the effect of mend mapping teaching strategy on chemistry students' achievement, interest, and retention in senior secondary schools.

Statement of the Problem

Students, parents, educators, government and the populace are worried because of the persistent poor achievement of students in chemistry. Evidence shows that this condition is deplorably high, to the point that Nigerian students start competing for the last position instead of first in chemistry in School Certificate Examination among the eleven English-speaking West African Countries. Also, there is evidence to lend support to the fact that this poor achievement and retention is as a result of non-utilization of appropriate teaching approaches and strategies in the subject which has led to lack of interest in the course. One wonders why all the methods used so far are not capable of reversing this ugly trend. It is however noted that the use of mend mapping

teaching strategy has not been tried out in Nigeria, particularly in chemistry to see if it could reverse this poor achievement. Therefore, the problem of this study is how to provide evidence on the effectiveness or otherwise of the influence of mend mapping teaching strategy (MMTS) on students' interest, achievement and retention in chemistry in secondary schools.

Objectives of the Study

The study investigated the effect of MMTS on academic achievement, interest and retention using selected chemistry units of senior secondary school curriculum. Specifically, the study

i. Examined the difference in mean achievement score of students taught using MMTS and those taught without it.
ii. Examined the difference in mean interest score of students taught using MMTS and those taught without it.
iii. Examined the difference in mean retention score of students taught using MMTS and those taught without it.

Literature Review

Concept and Nature of Mend Mapping

A mend map is a diagram used to represent words, ideas, tasks or other items linked to and arranged radial around a central key word or idea (Buzan, 1991). (Buzan and Vanda, 2005) reported that mend map is needed to generate, visualized, structure and classify ideas, and as an aid in study, organization, problem solving, decision making and writing. It is an image-centered diagram of information. Mend map presents the connections in a radial, non- linear graphical manner. Hence it encourages brainstorming approach to any given intrinsically appropriate role for theoretical or conceptual framework to work with. To create your first mend map, you will need a large white plain sheet of paper and some colored pens. A mend map uses 4 key characteristics to form 1st, Central image of the subjects' topic is formed 2nd, main themes radiate from the central image. 3rd, Branches hold the key words on the central image. 4th, Smaller branches form a connected structure from main branches.

A mend map is based on radial or star structures. Hermann and Bovo (2005) stated that people have been using image- centered radial graphic organization techniques referred to as mental or generic mend maps for centuries in areas such as engineering, psychology and education although the claim to the origin of mend map has been made by a British popular psychologist and author (Buzan, 1991). The mend map continues to be used in various forms and for various applications including learning in education (whereas it is often taught as webbing). Planning and in engineering diagramming. Buzan (2001) suggested that mend maps have many applications in personal family, educational business situations, including note taking, brain storming where in ideas are inserted into the map radial around the central node, without the implication or sequential arrangement, and where in grouping and organizing is reversed for later stages, summarizing, revising and general clarifying of thought. Buzan and Vanda (2005) further suggested that one could listen to a lecture and take down notes using mend map for the most important points or key words. A mend map is similar to a road map to help you on your journey. It provides an overview or picture of a particular subject and helps you plan your route or choices. The mend map stores large amount of information efficiently, but the exciting part of form is discovering that the final mend map is not only easy to read and look at, but also uses the potential of the brain in a very exciting way. It helps develop new brain skills, which are overlooked by traditional teaching method (Buzan, 2001).

Similarly, Okwo (2002) stated that the activity mode of pictures, drawings and photographs facilitates instructions and mind map encompasses the above activities and similarly facilitates instructions. Buzan and Vanda (2005) state that one of the main reasons why mend mapping is so effective is how it enhances the acquisition of scientific skills, technological skills and even entrepreneurial skills within our brain. One can also use mind maps as a mnemonic technique or to sort out a complicated idea. Mend maps are promoted as a way to collaborate in colour or pen creativity sessions. The researcher therefore suggested that mend maps can be drawn by hand, either as “rough note” for example, during a lesson or taking minutes of meeting.

Williams (2000) declared in his encyclopedia that software and techniques research have concluded that managers and students find the techniques of mend mapping to be useful, being

better able to retain information and ideas than by using traditional "linear" note taking (lecture) method. Buzan and Buzan (2006) suggested using the following foundation structures for mend mapping guidelines. The guidelines are stated in steps as shown. First, start in the centre of a piece or plain paper or cardboard with an image of the topic using at least 3 colours. Second, use images, symbols, codes and dimensions throughout your mend mapping.

Third, select key word and print using upper- or lower-case letters. Fourth, each word or image must be alone and sitting on its own line. Fifth, the lines are connected starting from the central image. Sixth the central lines are thicker, organic and flowing becoming thinner as key radiate out from the centre. Seventh, make the lines same length as the word/image. Use colours your code throughout the mend map. Eight, develop your own style of mend mapping. Ninth, use emphasis and show association in your mend map. Tenth, keep the mend map clear by using radial hierarchy, numerical order or outlines to embrace your branches (Buzan, 2001). Buzan (2001) also hypothesized that the mind utilizes the full range of left and right cortical skills, balances the brain, taps into the alleged 99% of your used mental, as well intuition which he called "Supper logic". However, scholarly research suggested that such may actually be a marketing hype based on misconception about the brain and the cerebral hemispheres. Hemispheric specialization theory has been identified as pseudo-scientific when applied to mend mapping and concept mapping (Williams, 2000). He argued that there are benefits to be gained by applying a wide range of graphic organizers, and it follows that mend mapping specifically, is not equally suited to all learning tasks. Buzan and Buzan (2006) stated that the mend mapping laws are designed to help you more rapidly gain access to your intelligence by giving you specific techniques that are brain-compatible. By following the laws, your memory and creativity will be enormously enhanced.

Constructive teaching and mend mapping process

Any internally or externally mediated cognitive process that facilitates the transfer of information to be taught from short-term memory to long-term memory can be defined as a teaching strategy (Bruning, 1993). Learning/ teaching strategies are used to construct, rehearse, organize and

elaborate information to make it more meaningful. Some commonly used strategies include all forms of advance graphic organizers, underlining, analysing key points, repetition, outlining, categorization, concept mapping, mental imaging, queuing, forming analogues, inserting questions, paraphrasing, note taking method, providing instructional objectives prior to instruction (Novok 1998) and mend mapping (Buzan and Buzan, 2006).

All of these strategies are not equally effective in facilitating achievement of different learning objectives. In other words, which learning strategy is appropriate depends upon many other factors such as learning objectives to be achieved, individual differences of the learners, level or extent of prior knowledge of the learner, learning resources, process of the learning conditions and environment, teaching/learning methods etc. researchers in education have shown that a number of factors influence student's attainment of objectives of instruction.

Ausubel (1986) hypothesized that instruction can be organized in such a way that all students in a class can achieve at high level which is accomplished only by best students. Fafunwa (1997) emphasized those feasible and practical instructional methods that could improve cognitive and effective outcomes in sciences classrooms need to be sought for.

Similarly, some Nigerian educators & researchers such as Ali (1996) and Egbugara (1983) emphasized the need for examination of instructional practices in our educational institutions especially at secondary school level. To this end, researchers have been and are still being carried out by many others and educators with the aim of adopting or developing some of the existing instructional methods for the improvement of learning in our secondary schools.

Furthermore, elaboration of information is specifically useful in enhancing memory when similarities, differences, relationship and associations among items are being emphasized. In other words, elaboration of information helps the synthesizing of information (Maltin, 1998). Various learning methods can affect the learning result by constructing and elaborating on the information being processed. Mend mapping strategy (MMTS) with different degrees of construction and elaboration would instigate different levels of information process and therefore would bring about different enhanced learning results. Therefore, the researcher tenders that

mend mapping teaching strategy is one of the constructivist teaching method. If MMTS is adopted and applied strictly to learning situations in our secondary schools could enhance students mean achievement score, mean interest score, and mean retention score in secondary school chemistry. This is the focus of this study.

Summary of the Literature Review

Cognitive theory seeks to understand internal processes of human learning. How information as stimuli are received, processed, constructed, stored in and retrieved from memory. The memory is an active processor of information. Teaching is an active process of information processing. Teaching strategies such as MMTS could be used to facilitate information processing to achieve better results outcome as it is said to be memory enhancing. Constructivism theorized that the best way to teach students is to guide them construct their own knowledge instead of having someone construct it for them. Constructive teaching strategy is any internally or externally medicated cognitive process that facilitates the transfer of information to be taught from short memory to long term memory. Teaching strategies can be used to construct, organize, rehearse and elaborate information to be more meaningful. One of such teaching strategies is MMTS. A mend map is a diagram used to represent ideas, words, tasks and other items linked to and arranged in radials around a central keyword or topic. This is needed to generate, visualize, structure and classify ideas, and as an aid in teaching, organizing, studying, problem solving and decision making. Mend mapping has rules or laws designed to help all of us gain access to our intelligence by giving us specifics that are brain compatibles. Following these rules may make our memory and creativity more enormously enhanced. Furthermore, mend mapping teaching strategy is closely related to constructive teaching method. Constructive learning theory is also related to Ausubel's learning theory in recognition of prior knowledge and presence of motivational objects in classrooms. Several strategies of teaching chemistry were reviewed. The conclusion was that constructive (active) teaching strategies that encourage hands-on-mind-on activities are unique. MMTS and other similar teaching strategies could generate interest among chemistry students and as well may enhance academic achievement and retention. Some other

research studies with same dependent variables of academic achievement, interest and retention in chemistry were reviewed. It was found out that there was no consensus report on academic achievement, interest and retention in chemistry of the gender groups. Furthermore, students' disposition in chemistry depends on many other factors including teaching strategies adopted by chemistry teachers. Review showed that some students may have vocational interest in chemistry and chemistry related careers i.e. positive disposition. Therefore, the researcher considered it worthwhile to explore effect of teaching students using MMTS and the dependent variables of academic achievement, interest and retention in senior secondary school chemistry.

Research Methodology

Research Design

This study adopted quasi experimental non-equivalent pre-test-post-test non-randomized control group design. Intact classes were then used for the study. Subjects were not randomly assigned to groups rather intact classes were assigned to experimental and control groups. The choice of this design was because it offers maximum control over extraneous variables. The design way symbolically represented below

Table 1: Design.

Design	Achievement	Interest	Retention
Experimental group (MMTS)	O_1 x O_2	O_3 x O_4	O_5
Control group (CTM)	O_1 C O_2	O_3 C O_4	O_5

X = Treatment using MMTS (experimental)

C = CTM (control)

O1 = Pre-test of CAT

O2 = Post-test of CAT

O3 = Pre-test of CII

O4 = Post-test of CII

O5 = Post-test (retention)

Population of the Study

All the senior secondary two school's chemistry students in Enugu Education Zone made up the population. The figure was 4,698 as indicated in the Post Primary School Management Board (PPSMB) statistical unit of Enugu Education Zone, 1st term 2008/2009 academic session. They were 23 state secondary schools.

Sample and sampling technique

The sample of this study is 194 SS2 chemistry students (95 boys and 99 girls) in the four sampled schools. The students offered chemistry as one of their SS2 subjects. The sampling technique was multi-stage sampling. The distribution of the research subjects in their intact classes of this study is shown in Table 2 below.

Table 2: Distribution of Subjects in their Various Intact Classes in the School of Study by Gender

S/N	SCHOOLS	GENDER	MMTS (EXPERIMENTAL GROUP)	CTM (CONTROL GROUP)	TOTAL
1.	Girls Sec. Sch. Abakpa Nike Enugu	Girls	24	25	49
2.	Girls Sec. Sch. Emene Enugu	Girls	26	24	50
3.	Nike Grammar Sch. Enugu	Boys	25	23	48
4.	St. Patrick's Sec. Sch. Emene Enugu	Boys	23	24	47
	TOTAL		98	96	194

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Instrument for Data Collection

Two instruments were developed by the researcher for data collection. They are the chemistry achievement test (CAT) and the chemistry interest inventory (CII). The chemistry achievement test (CAT) was for collection of pre-test achievement score, post-test achievement score and retention test score. The chemistry interest inventory (CII) was for collection of pre-test interest score and post-test interest score.

Development of Instrument

Achievement test is the same as retention test except that retention test was administered two weeks after post-test to check for subjects' retention. The CAT is made up two sections, Section A and Section B. Section A contains personal data. Section B contains instructions for answering the questions and the items. The CAT is a 40 item, 4 options multiple choice objective test based on the content of the study in SS2 chemistry curriculum. The instrument contains four options 2 A-D for each of the 40 items selected out of the initial pool of 50 items. After validation, ten items were declared invalid by the experts. The table of specification below has 5 subunits of content of the study which was subdivided from 3 main units as specified earlier (FME, 1985).

Table 3: Table of Specification for Chemistry Achievement Test (CAT)

Content	Lower order	Higher order Objectives 40%	Total 100%
Rate of chemical reactions and factors affecting the 20%	5	3	8
Energy changes in chemical reactions 20%	5	3	8
Endothermic and exothermic reactions 20%	5	3	8
Equilibrium in chemical reactions 20%	5	3	8
Free energy changes, enthalpy and entropy changes in chemical reaction 20%	5	3	8
100%	25	15	40

The number of weeks each topic lasted in the Post Primary School Management Board (PPSMB) common scheme of work of secondary schools formed the basis of the weighting of the contents. The weighting for the objectives level was based on the proportion of lower and higher order performance objectives in the units of the study. Lower order objectives include levels of intellectual function objectives such as knowledge, Comprehension and application. Higher order objectives include analysis, synthesis and evaluation. Each unit has 5 questions of lower order or 60% of the total and 3 questions of higher order of 40% of the total. Therefore, the total of lower order questions is 25 while higher order questions are 15. The sum total = 25 + 15 = 40 questionsof equal item representation of the content in line with predefined objectives. The reliability of the test is 0.82. the psychometric indices were determined as follows (a) item discrimination (ID) (b) item facility (P) and (c) distracter index (DI). These helped the researcher to build the final CAT package that was used. The key for acceptance is given as item facility (P) 0.30 to 0.70 Discrimination index (D) 0.30 to 0.10

Distracter index (DI) options are with positive indices. The CII is made up of section A and Section B. Section A contains personal information. Section B contains the items and instructions for ticking the chosen responses of each item.

The CII is a 30-item interest inventory developed by the researcher. It has a 4-point scale response. The responses are strongly Agree, Agree, Disagree and Strongly Disagree. The respondents were expected to indicate their degree of agreement or disagreement on a number of statements (positive and negative) equal cues about the units of study in senior secondary chemistry. The instrument is non-dichotomously scored and there are 15 of positively and 15 negatively directed items. The scale and scoring pattern were shown below, the reliability coefficient of the test instrument was 0.7214.

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For Positive Items			for Negative Items		
Strongly Agree	=	4	Strongly Agree	=	1
Agree	=	3	Agree	=	2
Disagree	=	2	Disagree	=	3
Strongly Disagree	=	1	Strongly Disagree	=	4

Face Validation of Instruments

The CAT was face validated by two senior academic staff in Measurement and Evaluation and two in Chemistry Education from the University of Nigeria, Nsukka. The instruments were validated in terms of clarity of instructions; correct wording of items and appropriateness and adequacy of the items in addressing the purpose and problems of the study. The critical appraisal and comments of the experts were used for reformed in items. The CII was also face validated by two senior academic staff in Measurement and Evaluation and two in Chemistry Education in the University of Nigeria, Nsukka. The critical appraisal and comment of the experts were used for reforming the items.

Content Validation of Instruments

To ensure content validity of the CAT, a table of specification for chemistry achievement test (CAT) was developed by the researcher and validated by the experts with specification of curriculum developers. Two senior academic staff each in Measure and Evaluation and in Chemistry Education of the University of Nigeria, Nsukka validated the CAT items. They determined how effective in selecting questions considering the percentage allocation of the

various levels of the content units that were covered according to Blooms taxonomy. They also ensured equal number of items for each topic or unit was reflected according to the curriculum content of the units (FME, 1985). Also included are emphases on curriculum in generating questions of the items, content and number of questions generated from each topic or unit (see table 4). Similarly, the CII was content validated by two senior academic staff in Chemistry Education and two in Measurement and Evaluation. The experts ensured that the statement items are opinion response oriented. The 4-point scale was in order and well represented. The CII items have equal positive and equal negative cued items. The scales correspond to appropriate responses they are supposed to measure. Also, they ensured that the instrument is none dichotomously scored.

Trial testing of Instruments

The CAT instrument was trial tested using forty (40) SS2 chemistry students of the College of Immaculate Conception (CIC) and 40 students of the Holy Rosary College in Enugu. The CAT was administered to 40 students of the schools by their Chemistry teachers. The CII instrument was also trial-tested using twenty-six (26) SS2 chemistry students of the college of Immaculate Conception (CIC) and twenty-six (26) SS2 chemistry students of the Holy Rosary College (HRC) Enugu.

An hour was allowed for the test. The papers were marked, scores collated and collected. The choice of the above schools for the pilot testing was because these schools were considered equivalent to the schools of the study proper.

Reliability of the Instruments

The student's responses in the CAT were used to calculate the reliability coefficient of the CAT using Kudder Richardson's formula 20 (K-R20) procedures. Also, the students' responses in the CII were used to calculate the reliability coefficient of the CII using Cronbach alpha procedure. The reliability coefficients for the CAT and the CII obtained were 0.8359 and 0.7214 respectively.

Method of data collection

The pre-test score, post-test scores and the retention test scores were recorded after each marking exercise. The CAT items scored 2 marks each. The maximum mark is 80 marks for pre-test, post-test, and retention test respectively. A total of 194 copies of the CAT and the CII were issued and retrieved.

Methods of data analysis

The research questions were answered using mean and standard deviation scores while the null hypotheses were tested at 0.05 alpha level of significance using analysis of covariance (ANCOVA). The pre-test scores were used as covariates to the post-test scores. ANCOVA was appropriate here because it served as a procedure for controlling the initial groups' differences as well as increasing the precision due to the extraneous variables thus reducing error variance (Ferguson, 1981).

Decision rule

Reject the null hypotheses if the calculated value of test statistics F-Cal is equal to or greater than the critical or table value (F – Cal ≥ F critical) at 0.05 level of significance, and appropriate difference, otherwise accept.

Data Presentation, Analysis and Results

Research Question 1

What is the difference in mean achievement score of students taught using mend mapping teaching strategy (MMTS) and those taught without it?

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Table 4: Mean (X) and Standard deviation (SD) of achievement Scores of subjects by (MMTS and CTM).

Method	Gender				Overall	
	Male		Female			
MMTS	X	SD	X	SD	X	SD
(experimental)	18.17	8.93	25.74	7.33	21.95	8.13
N	48		50		98	
CTM (control) N	8.32	3.19	10.12	1.76	9.22	2.48
	47		49		96	
Overall	13.24	6.06	17.93	4.55	15.58	5.30
N	95		99		194	

As shown in Table 4 above, mean achievement score of students taught using MMTS is X = 21.95 while mean achievement score of students taught using CTM is X = 9.22. The difference in mean achievement score of students taught using MMTS and those taught using CTM is 12.23 in favour of MMTS groups. This suggests that students taught using MMTS obtained higher academic achievement score than students taught using CTM. Similarly, students taught using MMTS obtained standard deviation score of 8.13 while students taught using CTM obtained standard deviation score of 2.48. this is an indication that students taught using MMTS obtained higher spread out of scores about their mean than students taught using CTM that obtained lower spread out of scores about their mean. In order to make a valid decision on whether the students' difference in mean achievement score based on the use of MMTS and CTM in teaching senior secondary chemistry was due to error or variance, null hypothesis 1 was tested.

Hypothesis 1

There is no significant difference in mean achievement score of students taught using MMTS and those taught without it.

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Table 5: Summary of analysis of covariance (ANCOVA) on subjects' Pre-CAT and Post-CAT mean achievement scores by (MMTS and CTM)

Sources of variation	Sum of squares	Degree of freedom (DF)	Mean square	F-cal	F –Critical	Decision at P≤ 0.05 level
Covariates	201.36	1	201.36	5.60		
Pretest	201.36	1	201.36	5.60		
Main effect	6512.11	2	3256.06	90.55		
Treatment	6023.79	1	6023.79	167.51	3.84	S
Gender	811.63	1	811.53	22.57	3.84	S
2-way interactions	504.59	1	504.59	14.03		
Treatment X Gender	504.59	1	504.59	14.03	3.84	S
Explained	9618.25	4	2404.56	66.87		
Residual	6796.41	189	35.96			
Total	16414.669	193	85.050			

S = significant at 0.05 probability level; NS = Not Significant at 0.05 probability level.

As shown in Table 5 above, the calculated F-ratio for MMTS (treatment) is 167.51 against the F-critical value of 3.84 at 0.05 level of significance, 1df numerator and 193df denominator. Since F-calculated value of 167.51 is greater than the F-critical of 3.84. Therefore, null hypothesis 1 of no significant difference in the mean achievement score was rejected. This implies that the observed difference in the mean achievement score of students taught using MMTS and those taught using CTM was significant and was due to variance and not attributed to error.

Research Question 2

What is the difference in mean interest score of students taught using MMTS and those taught without it?

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Table 6: Mean (X) and Standard Deviation (S) of interest scores of subjects by (MMTS and CTM)

Method	Gender				Overall	
	Male		Female			
MMTS (experimental)	X	SD	X	SD	X	SD
	67.85	9.70	65.66	9.71	66.76	9.44
N	48		50		98	
CTM (control) N	56.13	17.24	63.90	11.05	60.01	14.14
	47		49		1. 96	
Overall	61.20	3.20	64.78	10.38	63.39	11.79
N	95		99		194	

As shown in table 6 above, mean interest score of students taught using MMTS is X = 66.76, and those taught using CTM is X = 60.01. the difference in mean interest score of students taught using MMTS and those taught using CTM is 6.75 in favour of MMTS groups. This is an indication that students taught using MMTS became more interested in chemistry than those taught using CTM. The standard deviation score obtained by the students taught using MMTS is 9.44 and those taught using CTM is 14.14. this is an indication that the MMTS group obtain lower spread out of score about their mean than the CTM group that obtained higher spread out of scores about their mean. In order to make a valid decision on whether the difference in mean interest score based on the use of MMTS and CTM in teaching senior secondary school chemistry is due to variance or error null hypothesis 2 was tested.

Hypothesis 2

There is no significant difference in the mean interest score of students taught using MMTS and those taught without it.

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Table 7: Summary of Analysis of covariance on subjects' pre-CII and Post-CII mean interest scores by (MMTS and CTM)

Sources of variation	Sum of squares	Degree of freedom (DF)	Mean square	F-Cal	F –Critical	Decision at P≤ 0.05 level
Covariates	1858.45	1	1858.45	13.39		
Pretest	1858.45	1	1858.45	13.39	3.00	S
Main effect	2294.39	2	1147.19	8.26		
Treatment	2254.98	1	2256.98	16.26		
Gender	35.48	1	35.48	0.26	3.00	NS
2-way interactions	741.05	1	741.05	5.34		
Treatment X Gender	741.05	1	741.05	5.34	3.00	S
Explained	5563.51	4	1390.88	10.02	3.00	S
Residual	26242.42	189	138.85			
Total	**31805.99**	193	**164.80**			

S = Significant at 0.05 probability level; NS = Not Significant at 0.05 probability level.

As shown in Table 7 above, the calculated F-ratio for interest is 13.39 against the F-critical value of 3.00 at 0.05 level of significance, 1df numerator and 193df denominator. Since the F-calculated value of 13.39 is greater than the F-critical of 3.00. null hypothesis 3 of no significant difference in the mean interest score was rejected. The implies that the observed difference in mean interest score of students taught using MMTS and those taught using CTM was significant. It was due to variance and not attributed to error.

Research Question 3

What is the difference in mean retention score of students taught using MMTS and those taught without it?

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Table 8: Mean (X) and Standard deviation (S) of subjects mean retention scores by (MMTS and CTM

Method	Gender				Overall	
	Male		Female			
MMTS (experimental)	X	SD	X	SD	X	SD
	29.06	3.99	32.14	3.51	30.60	3.75
N	48		50		98	
CTM (control)	10.09	1.56	18.02	20.72	14.05	11.14
N	47		49		96	
Overall	19.57	2.28	25.08	12.11	22.33	7.44
N	95		99		194	

As shown in Table 8 above, mean retention score of students taught using MMTS is X= 30.60 and those of the students taught using CTM is X = 14.05. The difference in mean retention score of students taught using MMTS and those taught using CTM is 16.55 in favour of MMTS group. This is an indication that students taught using MMTS retained chemistry concepts and principles more than students taught using CTM. The standard deviation score of students taught using MMTS is 3.75 and those of the students taught using CTM is 11.14. this is an indication that students taught using MMTS obtained lower spread out of scores about their mean than those of the students taught using CTM that obtained higher spread out of score about their mean. In order to make a valid decision on whether the students mean retention score based on the use of MMTS and CTM in teaching senior secondary school chemistry was due to variance or error. Hypothesis 3 was tested.

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Hypothesis 3

There is no significant difference in the mean retention score of students taught using MMTS and those taught using CTM.

Table 9: Summary of ANCOVA on subjects' mean retention score by (MMTS and CTM)

Sources of variation	Sum of squares	Degree of freedom (DF)	Mean square	F-Cal	F –Critical	Decision at P≤ 0.05 level
Covariates	84.49	1	84.49	.726		
Pretest	84.49	1	84.49	.726	3.84	NS
Main effect	5428.05	2	2714.03	23.34		
Treatment	5240.26	1	5240.26	45.06	3.84	S
Gender	1048.04	1	1048.04	9.01	3.84	S
2-way interactions	345.57	1	345.57	2.97		
Treatment X Gender	345.57	1	345.57	2.97	3.84	NS
Explained	15025.33	4	3756.33	32.29		
Residual	21.980.98	189	116.30			
Total	**37006.31**	**193**	**191.74**			

S = Significant at 0.05 probability level; NS = Not Significant at 0.05 probability level.

As shown in Table 9 above, the calculated F-ratio for mean retention score is 0.726 against the F-critical value of 3.84 at 0.05 level of significance 1df for numerator and 193df denominator. Since F-calculated value of 0.726 is less than the F-critical of 3.84. Null Hypothesis 3 of no significant difference in mean retention score of students taught using MMTS and those taught using CTM was not rejected. This implies that the observed difference in mean retention score of students taught using MMTS and those taught using CTM was not significant. It was attributed to error and not variance.

Summary of Result

This study discovered that;

1. Mean achievement score of students taught using MMTS was significantly higher than those taught without it.
2. Mean interest score of students taught using MMTS was significantly higher than those taught without it.
3. Mean retention score of students taught using MMTS was higher than those taught without it but not significantly different from those taught without it.

Conclusion

This study concludes that the MMTS has significant effect on students' cognitive achievement, interest and retention in Chemistry. The MMTS is more efficacious than the CTM.

Recommendations

MMTS has been discovered to be an effective teaching strategy for improving students mean achievement score, mean interest score and mean retention score in chemistry. Therefore, teachers should adopt it as a teaching strategy in chemistry classrooms and laboratories. Also workshops and seminars should be organized for in-service chemistry teachers in order to train and develop teachers on the use of MMTS in administering education in every field of education.

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