



INTERACTION EFFECT OF GENDER AND TREATMENT ON MEAN RETENTION SCORE OF CHEMISTRY STUDENTS TAUGHT USING MEND MAPPING TEACHING STRATEGY (MMTS) IN ENUGU.

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Abstract

This study examines the interaction effect of gender and treatment on mean retention score of chemistry students taught using mend mapping teaching strategies (MMTS) in Enugu. The study sought to specifically study the following objectives; to determine the difference in mean retention score of students taught using MMTS and those taught without it; to ascertain the difference that exists in mean retention score of male and female students taught using MMTS; to determine the interaction effect of gender and treatment on mean retention score of the students taught using MMTS and those taught without it. 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. The instrument Chemistry Achievement Test (CAT) was developed by the study and validated by two University experts in measurements and evaluation and two university experts of Chemistry Education. The instrument was trails tested at secondary schools in Enugu Education Zone in Enugu State. The internal consistency of the CAT was obtained using Kuder Richardson formula 20(KR-20) and Cronbach alpha procedure. Reliability coefficient of 0.8359 was obtained for the CAT. Mean and standard deviation scores were used to answer the two research questions while the three null hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). Results showed that MMTS was more effective in facilitating students' retention in chemistry than the control group. Gender was not a significant factor on students' academic achievement in chemistry when taught using MMTS. Furthermore, the results revealed that there was no significant interaction effect of gender and treatment on student's retention. This study recommends that Chemistry teachers should adopt MMTS as a teaching strategy in chemistry classrooms and laboratories, and the teacher training institutions should include the use of MMTS in their chemistry method course content to ensure the training of the pre-service chemistry teachers. Also that author of chemistry text-books should include MMTS in their texts for easy access for students and teachers.

Keywords: Gender, Mean Retention Score, Chemistry Students, Mend Mapping Teaching Strategies.

Introduction

The development of any nation depends largely on the level of education attained by her citizens especially in the area of science and technology. Education is an instrument “par excellence” for effective national development. It is highly rated as the most important instrument of change since any definite change in the intellectual and social outlook of the people must be preceded by an educational revolution. In cognizance with the importance of science and technology in Nigeria, science subjects such as chemistry are taught in secondary schools to prepare a base for any science and technological development.

Chemistry is an experimental science that systematically studies the composition, properties, and activities of organic and inorganic substances and various elementary forms of matter. However, the West African Examination Council (WAEC) Chief Examiners report on Chemistry results indicates that students are weak in chemistry concepts in the Senior Secondary School Certificate (SSCE) Chemistry syllabus. The WAEC Chief Examiner’s attributed the poor achievement of students due to their unfamiliarity with the use of simple laboratory equipment, inadequate exposure to laboratory techniques, lack of observational skills, omission of units in calculated values, inability to write chemical equation correctly, assign correct charges to ions as well as inability to carry out simple calculations among others.

The problem of chemistry students’ under-performance in secondary schools in Nigeria has been a much discussed educational issue. In solving any problem however, it is pertinent to understand the causes of such problems. Many causes or agents have been studied as the etiological starting point for investigating the phenomena of school failure or success. These causes are looked into from several perspectives including the role of the students, teachers, parents or family, school environment, society, government and also the teaching methods and practices, etc.

Gender is one of such factors also mentioned in literature to have considerable effects on students’ academic performances especially in science subjects. Gender is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the feminine and masculine (female and male) population. The importance of examining performance in relation to gender is based primarily on the socio-cultural differences between girls and boys. Some vocations and professions have been regarded as men’s (engineering, arts and crafts, agriculture etc.) while others as women’s (catering, typing, nursing etc.). In fact, parents assign task like car washing, grass cutting, bulbs fixing,

climbing ladders to fix or remove things etc. to the boys. On the other hand, chores like dishes washing, cooking, cleaning and so on is assigned to the girls. In a nutshell, what are regarded as complex and difficult tasks are allocated to boys whereas girls are expected to handle the relatively easy and less demanding tasks. As a result of this way of thinking the larger society has tended to see girls as a weaker sex". Consequently, an average Nigerian girl goes to school with these fixed stereotypes, and also this stereotype have also been attributed to the retention and assimilation rate of chemistry students in Secondary schools.

In Nigeria, there has been recurring arguments on the interacting effect of gender and treatment on mean retention score of chemistry students taught using different teaching strategies, researches have been carried out on treatment interaction in order to ascertain the best teaching strategy most especially in the field of pure sciences, but most results have been inconclusive, or proven wrong due to the recent performances of the students. Therefore, there has been a difficulty in ascertaining the existing treatment interactions, and also determining a suitable teaching strategy in the field. Treatment interaction generally implies that different learners with different characteristics may profit more from one type of instructional method than from another and that therefore it may be possible to find the best match of learners' characteristic and instructional method in other to maximize learning outcomes.

Linda and Collins (1991) investigated the effect of concept mapping on the critical thinking in nursing students. They found out that there was significant difference in mean pre-test scores and mean post-test scores in achievement of subjects. The mean post-test scores were higher than the mean pre-test scores. Mend mapping teaching strategy (MMTS) may affect a difference also in pre-test and post-test scores of this study.

Buzan (1991) stated that mend mapping teaching strategy (MMTS) is a constructive and classification graphic organizer of ideas which uses the cortical skills to unlock the brain potentials. Buzan and Buzan (2006) stated that a mend map is a powerful graphic organizer of ideas, which provides a universal key to unlock the potential of the individual brain. It harnesses the full range of cortical skills, words, image, number, logic, rhythm, colour and spatial awareness in a single uniquely powerful manner. In doing so it gives the learner the freedom to roam the infinite expanses of his or her brain. Thus, this study seeks to examine the interaction effect of gender and treatment on mean retention score of chemistry students taught using mend mapping teaching strategies (MMTS) in Enugu.

Purpose of the Study

The study investigated the interaction effect of gender and treatment on mean retention score of chemistry students taught using mind mapping teaching strategies (MMTS) in Enugu.

Specifically, the study

- i.** Determined the difference in mean retention score of students taught using MMTS and those taught without it.
- ii.** Ascertained the difference that exists in mean retention score of male and female students taught using MMTS.
- iii.** Determined the interaction effect of gender and treatment on mean retention score of the students taught using MMTS and those taught without it.

Literature Review

Conceptual Framework

Similarity of Human Brain Information Processing and Mind Mapping

Cognitive theory seeks to understand internal processes of human learning; how information as stimuli is received, processed, stored in and retrieved from memory. Most models of information processing can be traced to Atkinson and Schiffrrin (1998) who offered a multi-store, multistage concept of memory. According to them when information is received by human information processing system, it must undergo a series of transformations until it can be permanently stored in the memory. This process according to Driscoll (2000) is called information processing. It is also known as multi-store and multistage model of information processing. The multi-store and multistage information processing explains how information is processed by the three basic stage of memory: (a) Sensory Memory (b) Short-term Memory and (c) Long-term Memory (Driscoll, 2000). The entire process shows that this information processing system is linear, organize, dynamic and active. According to this model of human memory, information processing consists of three stages: sensory memory, Short-term (Working) memory and Long-term memory (Gredler, 2001).

If information is not meaningful retained or rehearsed in the working memory, it will disappear from working memory in about 30 seconds (Gagne, 2007 and Sweller, 2003). In other words unattended information drops out of the system while the information meaningfully retained or rehearsed is encoded into some meaningful form and transferred to the long-term memory, the information processed and encoded is permanently store. Driscoll (2000) described it is a permanent store house of information in an inactive state of previously learned concepts. Unlike the short-term memory, the long-term memory has unlimited

capacity and information in it is not subject to decay (Smith and Ragan, 1999). The information stored in long-term memory is not randomly scattered in the storehouse but is organized so that information stored can be retrieved. The recall of information is related to the ways in which specific knowledge items are presented, and the organization of bodies of knowledge in the long-term memory which is related to the ways the information is processed or constructed (i.e. the level or quality of information processing) and the number of items the information is processed or reconstructed in the long-term memory (Gredler, 2001).

The implications of human information processing for this study are that the memory in an active organized processor of information and teaching also is an active process of information processing. Information processing can be manipulated and its result can be enhanced by the way the information in form of stimulus is presented to the sensory registers, working memory and activating prior knowledge in the long-term memory. Teaching strategy such as mend mapping teaching strategy (MMTS) could be used to facilitate information processing to achieve better outcomes.

(Smith and Ragan, 1999) defined learning as the set of cognitive processes that transforms the stimulation from the environment into the several phases of information processing necessary for acquiring a new capacity. Learning occurs when the stimulus is selected, processed, encoded and retrieved. Various teaching methods can facilitate this process so that better results of learning outcomes can be achieved. Ausubel (2002) mentioned two kinds of learning in his assimilation theory of learning, meaningful and rote learning. In meaningful learning, learning consciously and explicitly tie new knowledge to relevant concept or proposition already possessed Fisher (2001) and Okebukola (1990).

Meaningful learning occurs when a learner connects and constructs new knowledge to a pre-existing cognitive framework (Snead, 2000). Rote learning is verbatim involving externally dictated stimulus response association as stated by (Clibum, 1986) and Ausubel (2002) believe that three conditions must exist for meaningful learning to occur. (a), the learner must sense a relationship among the concepts to be learned. (b) the learner must possess specific relevant ideas (mend) to which this new material can be related and (c) the learner must actually intend to relate these constructed new ideas (mend map) to idea already possessed (prior-knowledge) which he has. One of the main reasons why mend mapping is so effective is how it enhances the skills within our brain. The brain has been the subject of research for many years, however, it is only in the last 15 or so years that most of the exciting developments in brain research have described it as being more powerful than the most

powerful computer, however, it is now estimated that we only use about 1% of the potential of the brain in our everyday activities. Within the millions of nerve cells in our brain, we have infinite potential waiting to be used contrary to popular belief. We can increase our skills with age as we create thousands of new nerve cells in our brain every day (Buzan & Buzan, 2006). Mend map uses the right and left hemispheres of the brain to help generate ideas.

The central cortex (cerebrum) of our brain (thinking cap) consists of left and right side of the brain. The left side of the brain mainly focuses on the cortical words, logic, lists, analysis and numbers (WLLAN), whereas the right side of our brain focuses on such cortical words like rhythm, imagination, colour, images, dimension and day dreaming (RICIDDD) (Buzan and Barry, 2005). This is where mend map linking and associating occurs. We are in effect using both sides of the brain to enhance our learning creativity and clarity of our thinking, to acquire scientific skills, technological skills and even entrepreneurial skills.

Constructivism

In the past two centuries, constructivists' ideas were not widely valued due to the perception that children's plays were seen as aim less and of little importance. Jean Piaget did not agree with these traditional views, however, he saw play as an important and necessary part of the student's cognitive development, and has provided scientific evidence for his views. Today, constructivist theories are influenced throughout much of the formal and the informal learning sector. Some historical figures that influenced constructivism are listed below. They were Giambaltista Vico, Immanuela Kant, John Dewey, Jean Piaget, Lev Vygostsk, Jerome Brunner, Herbert Simon, Paul Watzlawick, Ernest Voncilouferfiel, Edgan Moerin, and Porphyry and now Buzan T. Formalization of the theory of constructivism is generally attributed to Jean Piaget, who articulated mechanism by which knowledge is internalized by learners. He suggested that through process of accommodation and assimilation, individuals construct new experience into an already existing framework without changing that framework. Therefore, constructivism is applied to both learning theory and epistemology – both to how people learn and to the nature of knowledge.

Many educators such as (Dogru and Kalender, 2007) believed that the best way to learn is by having students construct their own knowledge instead of having someone construct it for them. Constructivism learning theory explains this belief. This theory states that learning is an active process of constructing meaning from different experiences. In other words students will learn best by trying to make sense of something on their own with the teacher as a guide to help them along the way. Since all sensory input is organized by the person receiving the

stimuli, it cannot always be directly transferred from the teacher to the student. This means that a teacher cannot “pour” information into students’ brain and always expect to process it and apply it correctly later. For example, the researcher tenders that you may think of a time when you have to prepare to teach someone else something. You will probably to teach the material. This is because you constructed the knowledge for yourself.

Glasson and Laik (2003) suggested a list of different methods of teaching. The percentages listed below represent the average amount of information that is retained through that particular teaching method.

Note the method that produces the highest retention rate

1. Lecture Method	=	50%
2. Reading Method	=	10%
3. Audio Method	=	20%
4. Demonstration Method	=	30%
5. Discussion Group Method	=	60%
6. Practice by Doing Method	=	75%
7. Teach others/ Immediate use of Learning Method	=	90%

(Glasson and Laik, 2003)

The researcher therefore, remarked that a person’s prior knowledge may help or hurt the construction of meaning. People’s prior knowledge comes from their past experiences, culture and their environment. Generally, prior knowledge is good, but sometimes misconceptions and wrong information may be a hindrance. Sometimes, time must be spent correcting prior knowledge before learning can occur. Constructivism refers to idea that learners construct knowledge for themselves – each learner individually and socially constructs meaning as he or she learns. Constructing meaning is learning, there is no other kind. Therefore, Vygotsky (2008) reported that learning is an active process in which the learner uses sensory input and constructs meaning out of it i.e. learning is not the passive acceptance of knowledge which exists “out there” but that learning involves the learner’s engaging the world. People learn to learn as they construct meaning. Learning consists both of constructing meaning and reconstructing system of meaning. The construction of constructing meaning is mental. It happens in the mind.

Constructive teaching strategy is based on the constructivist learning theory. Which holds that learning should build upon knowledge that a student already has, and that learning is more effective when a student is actively involved in the construction of knowledge, rather than

when they are passively listening to a lecture from a teacher. John Dewey and Piaget researched on children development in education. Their theories are now encompassed in those dealing with progressive education. The constructivism learning theory states that children learn best when they construct a personal understanding based on experiencing things and reflecting on those experiences (Vygotsky, 2008). According to Vygotsky 2008) the characteristics of a constructivist classroom should make the learners to be actively involved. The environment should be democratic. The activities are interactive and students' centered. The teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous. Further, in the constructivist classroom, students work primarily in groups and learning and knowledge are interactive and dynamic. There is a great focus and emphasis on social and communication skills, as well as a collaboration and exchange of ideas. This is contrary to the traditional classroom in which students work primarily alone, learning is achieved through repetition and subjects are strictly adhered to and guided by textbooks. Constructivism is a more recent and acceptable view of how knowledge is acquired in science (Iloputaife, 2001) which holds that: scientific knowledge (concept and theories) are personally constructed and reconstructed by the learner based on his prior experience. Learners bring new ideas, which affect any new information they receive. What a student learns therefore, results from interaction between what is brought to the learning environment (by the learner) and what he experienced while in it. This result in constructing and reconstructing of existing conceptions. Some of the implications of this view (constructivism) include what a learner already knows (Prior knowledge) is important in science instruction.

Empirical Framework

Status of Achievement and Retention in Chemistry

Researchers have revealed that innovative teaching strategies generally confer significant positive achievement in topics of students' interest and retention in their studies. There are three categories of gender achievement, interest and retention reported in some studies. The first category was those who found significant difference in academic achievement and retention in favour of males. The second category were those who found significant difference in achievement and retention in favour of females while the third category were those who found no significant difference in favour of either of the sexes.

Nworgu, (1990) evaluated the effect of resource material type relative to students' cognitive achievement, interest and retention in integrated science which is related to Chemistry. The design of the study is pre-test- post-test quasi experimental research. Research questions were

asked and answered using mean and standard deviation while the hypotheses were formulated and tested using ANCOVA analysis. The author reported a significant effect of resource material in favour of males and females while there was no significant difference in the mean retention of males and females.

Ezeudu (1995) in her study titled effect of concept mapping on students' achievement, interest and retention in organic Chemistry. The design of the study was pre-test post-test quasi experimental research. The author used mean and standard deviation to answer the research questions while the hypotheses were tested using ANCOVA analysis. Results obtained indicated that there was a significant difference in the overall achievement and retention between students exposed to concept mapping against students exposed to conventional methods. Gender was consistently insignificant relative to achievement and retention.

Anaekwe (1997) research on the effect of students' interaction patterns (SIP) on students' achievement, interest and retention in chemistry. The design of the study was pre-test post-test quasi experimental research. Mean and standard deviation were used to answer research questions while hypotheses were tested with ANCOVA analysis. The researcher reported a significant effect of SIP on students' achievement in favour of females and insignificant effect of retention in favour of males.

In addition Ezeh (1992) studied the effect of advance organizer on students' achievement, interest and retention in integrated science. He used 356 JSS student in their intact classes, who were randomly drawn from five secondary schools in Isi-Uzo local Government Area of Enugu State. Two Instruments were used. ANCOVA was used for data analysis. The result showed that advanced organizer had significant effect on the students' mean achievement score and retention score were not significant.

Therefore, from the reports reviewed above. It may not be out of place to presume that the so called conventional teaching method (CTM) has not adequately delivered the goods. Perhaps the innovative teaching technique MMTS could be of greater help in facilitating students' achievement, interest and retention in secondary school chemistry. Hence there is the need to evaluate the effect of MMTS on students' academic retention in chemistry of senior secondary schools.

Research Methodology

Research Design

This study adopted quasi experimental non-equivalent pretest-posttest 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 design way symbolically represented below

Table 1: Design

Design	Retention
Experimental group (MMTS)	O ₁
Control group (CTM)	O ₁

X = Treatment using MMTS (experimental)

C = CTM (control)

O₁ = post post-test (retention)

Population of the Study

All the SS2 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 in all made up of 11 single sex (4 male and 7 female) schools and 12 co-educational 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. 1st, 2 LGA out of 3 in the Education zone were sampled out by random sampling (balloting). 2nd, 11 single sex schools were purposively sampled of chemistry classes and gender is an independent variable of this study. 3rd, the single sex schools were stratified. Out of 4 male schools 2 were sampled and out of 7 female schools 2 were sampled by random sampling (balloting). 4th, out of the two streams from each school one class were assigned treatment (MMTS) and the other control (CTM) by random sampling (toss of coin). 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

Instrument for Data Collection

The chemistry achievement test (CAT) was for collection of retention test score.

Development of Instrument

The 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 as shown below. The table contains specification used in selecting the items. 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 (Appendix H). 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 = $25 + 15 = 40$ questions of 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 in building 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.

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 instrument was 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.

Content Validation of Instruments

To ensure content validity of the CAT, a table of specification for chemistry achievement test (CAT) was developed 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.

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. 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 Kuder Richardson's formula 20 (K-R20) procedures. The reliability coefficients for the CAT were 0.8359.

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 was issued and retrieved.

Methods of data analysis

The two research questions were answered using mean and standard deviation scores while the three 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 $F\text{-Cal}$ is equal to or greater than the critical or table value ($F - \text{Cal} \geq F \text{ critical}$) 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 retention score of students taught using MMTS and those taught without it?

Table 4: Mean (X) and Standard deviation (S) of subjects mean retention scores by gender (MMTS and CTM)

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

As shown in Table 4 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 student 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 1 was tested.

Hypothesis 1

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

Table 5: Summary of ANCOVA on subjects' mean retention score by gender (MMTS and CTM)

Sources of variation	Sum of squares	Degree of freedom (DF)	Mean square	F-Cal	F Critical	Decision at $P \leq 0.05$ 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 5 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 1 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. The sex of the students had no influence on their mean retention score.

Research Question 2

What is the difference in mean retention score of male and female students taught using MMTS?

As shown in Table 4 above, mean retention score of male students taught using MMTS is $X = 29.06$ while the mean retention score of female students taught using same MMTS is $X = 32.14$. The difference in mean retention score of male and female students taught using MMTS is 3.08 in favour of the females. This suggests that the female students taught using

MMTS retained chemistry concepts and principles more than their male counterparts taught using MMTS. Furthermore the female students taught using MMTS obtained standard deviation score of 3.51 while the male students taught with same MMTS obtained standard deviation score of 3.99. This is an indication that the female students taught using MMTS obtained lower spread out of scores about their mean than the male students taught using same MMTS that obtained higher spread out of scores about their mean. In order to make a valid decision on whether the students difference in mean retention score of male and female students taught based on the use of MMTS in teaching senior secondary chemistry was due to variance or error. Null hypothesis 2 was tested.

Hypothesis 2

Gender does not significantly influence the mean retention score of students taught using MMTS

As shown in Table 5 above, the calculated F-ratio for gender influence on mean retention score of students taught using MMTS is 9.01 against the F-critical value of 3.84 at 0.05 level of significance, 1df numerator and 193df denominator. Since F-calculated value of 9.01 is greater than the F-critical of 3.84. Null hypothesis 6 of no significant influence of gender on mean retention score of students taught using MMTS was rejected. This implies that the observed gender influence on mean retention score was due to variance and not attributed to error.

Hypothesis 3

The interaction effect of gender and treatment on mean retention score of students taught using MMTS and those taught without it is not significant.

As shown in Table 5 above, the calculated F-ratio for interaction effect of gender and treatment on mean retention score was 2.97 against the F-critical value of 3.84 at 0.05 level of significance, 1df numerator and 193df denominator. Since F-calculated of 2.97 is less than F-critical of 3.84. Null hypothesis 3 of no significant interaction effect of gender and treatment on mean retention score was upheld. This implies that there was no observed interaction effect of gender and treatment on mean retention score of students taught using MMTS and CTM. Any interaction effect was not significant and may be due to error and not attributed to variance.

Summary of Result

The major findings in this report are shown below.

1. Mean retention score of students taught using MMTS was higher than those taught without it but not significantly different from those taught without it.
2. Gender influenced mean retention score of students taught using MMTS significantly.
3. No significant interaction effect of gender and treatment on mean retention score of students taught using MMTS and those taught without it was observed.

Conclusion

This study has shown that MMTS has significant effect on students' cognitive retention in Chemistry. The influence of gender on mean retention score was not significant.

Recommendations

This study recommends that Chemistry teachers should adopt MMTS as a teaching strategy in chemistry classrooms and laboratories. The teacher training institutions should include the use of MMTS in their chemistry method course content to ensure the training of the pre-service chemistry teachers. Authors of chemistry text-books should include MMTS in their texts for easy access for students and teachers. Finally, the curriculum planners should include MMTS in senior secondary chemistry scheme for teachers and students.

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