Effects of Mayer's Problem Solving Instructional Model with Visual Representation Component on Student's Academic Performance and Retention in Algebra among Senior Secondary School Students in Katsina Central Senatorial District of Katsina State.

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ABSTRACT

The research is on the effects of Mayer's problem solving instructional model with visual representation component on students' academic performance and retention in algebra among senior secondary school students in Katsina Central Senatorial District of Katsina State.The model was embedded with visual representation component to make it very suitable and practicable in teaching some abstract concepts in Mathematics. The senatorial district comprises of eleven (11) local governments out of which five were randomly selected and they were Batagarawa, Dutsin Ma, kaita, Kurfi and Katsina local governments and the research work lasted for four (4) months. In these 5 local governments, there were 21,188 students comprising of 12,220 male and 8,968 female in the public schools. In each of the selected local governments, 2 classes of 40 students each were selected from the randomly selected public schools as experimental and control groups giving a total of 400 students. Mayer's problem solving model was used to teach the experimental groups while the control groups were taught using the conventional teaching method. Algebra Performance Test (APT) was used by the researchers and its coefficient of reliability was determined to be 0.73. Descriptive statistics, t-test and ANCOVA at alpha level of 0.05 was used for the hypotheses testing.The results show that in all the 5 local governments, there is a statistical difference between the experimental and control groups in favour of those taught using Mayer problem solving model. It was also discovered that there is no statistical difference in the academic performance of males and females taught using the Mayer's problem solving model.It was recommended that the government and other stakeholders should assist in training the teachers and provide ICT components that support Mayer's visual presentation in senior secondary schools

Keywords: Academic performance, Algebra, Retention, Mayer's Problem Solving Model with Visual Representation Component.

INTRODUCTION

Mathematics is one of the core subjects in our educational system. It is an area of knowledge that includes the topics of numbers, formula and related structures, shapes quantities and their changes. These topics are represented in modern Mathematics with the major sub disciplines of number theory, algebra, geometry and analysis. The importance of mathematical knowledge in our daily human life and its activities cannot be jettisoned. It is very essential in engineering, natural and social sciences and business. We use Mathematics in various applications and forms without being noticed or directly aware whether in entertainment, office, transportation and kitchen. It also plays an important role in psychological levels of every student and it aids in developing an analytical mind, arrangement of ideas and coherent communication (Abdalgani, 2019).

It was observed that most of students did not see the uses or applications of Mathematics to their lives and the world around them and why should they be troubled with the study of the subject. To this category of students, Mathematics still remains a mystery that has no place in reality (Anaduaka&Okafor, 2013). There is no doubt

that modern society depends solely on physical and life science, technology, business, financial services and area of Information and Communication Technology (ICT).

In recognition of these uniqueness and importance of Mathematics in our national development, the Federal Republic of Nigeria made the subject a compulsory cross-cutting subject in Senior Secondary Education (Federal Republic of Nigeria, 2014). As a result of this, Mathematics became imperative for all Nigeria students in all secondary schools. That is, it is a core part of the curriculum and at least a credit is required for a student to be deemed to have passed WASSCE. Adeniji and Abubakar (2019) enumerated three impeding factors to students' performance in Algebra in Katsina as personal based, home and cultural based, and social based. They further noted that the teachers' attitude towards students, non -usage of instructional material and poor teaching techniques contribute to the poor performance of students in Mathematics and their findings echoed the conclusion of Mbugna, Kibet, Muthaa and Nkonke (2012). Obanya (2014) stated the following reasons for mass failure in Mathematics viz: (i) shallow knowledge of subject matter (ii) incorrect interpretation of questions (iii) lack of mathematical or manipulating skills (iv) poor knowledge of examination techniques (v) illegible handwriting and spelling mistakes (vi) inefficient preparation.

Ayebale, Habaasa and Tweheyo (2020) enumerated four factors impacting student's performance in Mathematics as student's attitude, teacher's attitude, teaching methods, and gender factor. They further utilized the findings of Odogwu and Benedicta (2018) to suggest that students approached Mathematics as procedural and rule oriented which has seen the students unable to develop competence in the subject. They further noted that teacher's disposition to Mathematics leads the students to form their own attitude. Also teaching methods not favoring understanding is allied to student's poor performance in Mathematics. This buttressed the findings of Mohd, Nasir, Aperar and Cheong (2020). Gender factor also plays into student's performance. Girls perceive Mathematics as a male dominated subject and this mentality serves a role in girl's comparative poor performance in Mathematics.

Another important factor for poor performance could be attributed to low utilization and sometimes non - availability of instructional materials (especially audio- visual aids in particular) for teaching and learning of algebra in schools, the pattern of teachingadopted by teachers today is mostly abstract in form, without being supported by the use ofappropriate aids, inability to select appropriate audio - visual materials and sometimes its irregularuse as support to the teaching of algebra in classrooms by its teachers was observed to bea strong hindrance to students achievement (Usman, Olaoye&Audu 2023). To solve these problems, students should be encouraged to adopt some problem solving methods such as: making a model, drawing a diagram/picture, looking for patterns, making an organized list, making a table, guessing and checking, working backwards and using logical reasoning. Adoption of these methods will help students to answer WASSCE Mathematics better. Mathematics teachers should also be encouraged to update their skills by attending seminars and workshops. Teachers and teaching profession need to be re-profiled. Adequate facilities, conducive atmosphere for learning and essential instructional materials should be provided.

In teaching and learning of Mathematics in which Algebra is also part of, we have various problems solving models or teaching strategies to enhance poor performance in teaching and learning of Mathematics. Zalmon (2021) listed some major approach of problem solving models such as: Deway (1933), Polya (1957), Mason, Briton and Stacey (1982), Braisford and Stein (1984), Schoenfeld (1985), Krulick and Rudrick (1989), Mayer (1992), Perkins (2000), Ozailkan (2010), Kolawole (2013), Ekwuence (2013) and Zalmon(2021). These models have occupied an important aspect of Mathematics in problem solving.

In this study, we are adopting Mayer's problem solving instructional models. The investigation will focus on poor performance and retention in Mathematics, in particular, it will center on students' performance in Algebra. We strongly believe if suitable teaching and learning strategies are adopted (like Mayer's model) it will lead to significant improvement in students' performance.

The concept of algebra is more of abstract and it has remained a big challenge among almost all the students due to its abstractness. The Mayer's model has visual representation component which past studies proved that it is an effective strategy to improve students' problem solving ability.

Retention is the ability to recall known information after a period of time. Nneji (2013) said retention is the act of holding or absorbing facts or things learned in the past. According to Okeke (2015), retention of learning is the learners' abilities to transfer information earlier learnt or learners ability to repeat behaviours previously acquired after a short period of time.

Therefore, this study also employ visual representation into every stage of Mayer's problem solving model in order to improve students' problem solving ability and to make the concept of algebra less abstract and more real or concrete.

Statement of the Problem

Algebra as a topic in Mathematics has been considered as one of the difficult areas by students in secondary schools. The reason for this is not farfetched. The issue of students' poor performance and retention among students in Mathematics in which Algebra takes an appreciable percentage has remained a problem that needs urgent attention. Different factors and reasons have been identified and suggested by researchers like Merek (2003), Mbugna, Kibet, Muthaa and Nkonke (2012), Adeniyi (2014), Obanya (2014), Odogwu and Benedicta (2018), Adeniji and Abubakar (2019), Ayebale (2020), Mohd, Nasir, Aperar and Cheong (2020) and Usman, Olaoye&Audu (2023). From table 1 below, regardless of the importance of Mathematics, students' performances in English andMathematics in Katsina state have been consistently below average.

Table 1: Students Performance in May/June WASSCE 5 Credit and above including English andAlgebra (2016-2021) in Katsina State

Year	Total who sat for WAEC					5 Credit including English andAlgebra					
	Male	**%**	**Female**	**%**	**Total**	**Male**	**%**	**Female**	**%**	**Total**	**%**
2016	13,738	67.33	6,666	32.67	20,404	5,187	37.80	2,603	39.00	7,790	38.20
2017	14,598	67.22	7,119	32.78	21,717	7,566	51.83	4,046	56.83	11,612	53.47
2018	15,216	63.62	8,700	36.38	23,916	4,388	28.84	2,800	32.18	7,188	30.06
2019	13,264	59.17	9,151	40.83	22,415	5,879	44.32	3,338	36.48	9,217	41.11
2020	13,423	57.13	10,072	42.87	23,495	5,663	42.19	4,220	41.90	9,883	42.06
2021	8,136	58.22	5,838	41.78	13,974	3,818	46.93	3,053	52.30	8,871	49.17

Source: National Bureau of Statistics (NBS) (2019) and National Bureau of Statistics (NBS) (2022)

These show that there are problems yet to be solved in Mathematics. The search for an explanation for students' poor performance in schools is far from being concluded as it remains one major contemporary issue in Nigerian education. From various findings, the means of passing these ideas and instructional materials utilized have remained a critical determinant in students' performance and retention levels**.** In particular, the researchers intended to determine academic performance and retention of senior secondary school students in Algebra. The investigation will be carried out among selected secondary school

students in Katsina Central Senatorial District of Katsina State. The poor academic performance in Algebra has remained a serious issue in our society and educational sector. The significance of this subject to nation building and human endeavors has called for continuous efforts from various scholars. Researchers have identified a number of factors of poor performance and retention in Mathematics; such as weakness and difficulty in understanding mathematical concepts, abstractness of some aspect like algebra, lack of confidence and poor teaching methods. The researchers strongly believe that if appropriate instructions coupled with seasoned educational media is adopted, it will have a great positive impact on students' performance and retention in Algebra. Therefore, the study will investigate the effectiveness of Mayer's problem solving Instructional model with visual representation in teaching of algebra among senior secondary schools students.

Purpose of the study

The purpose of the study was to investigate the effects of Mayer 's problem solving strategies on academic performance and retention in Algebra of senior secondary school students in Katsina senatorial district of Katsina state. Specifically, the study sought to:

1. Find out if there is any difference between the academic performance of senior secondary school students taught algebra with Mayer's problem solving instructional model with visual representation and those taught with the conventional teaching method.
2. Find out if there is any difference between academic performance of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.
3. Investigate the difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.
4. Find out the difference in the retention of male and female students taught algebra using Mayer's problem solving instructional model

Research Questions

The following research questions guided the study

1. What is the difference between the academic performance of senior secondary school students taught algebra with Mayer's problem solving instructional model with visual representation and those taught with the conventional teaching method?
2. What is the difference between academic performance of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation?
3. What is the difference in the retention level of student taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method?
4. What is the difference in the retention of male and female students taught algebra using Mayer's problem solving instructional model with visual representation?

Research Hypotheses

The following research Hypotheses guided the study

H_{o1}: There is no statistical difference between the academic performance of senior secondary school students taught algebra with Mayer's problem solving instructional model with visual representation and those taught with the conventional teaching method.

H_{o2}: There is nostatisticaldifference between academic performance of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.
H_{o3} There is no statistical difference in the retention level of student taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.
H_{o4}: There is no statistical differencein the retention of male and female students taught algebra using Mayer's problem solving instructional model with visual representation.

LITERATURE REVIEWED

Here, we reviewed some relevant and existing works on Problem solving models as media of teaching and learning in educational system. Richard Mayer made huge contributions to problem solving around 1980s. Mayer (1983) claimed that problem solving is a complex, multi-step cognitive system which demands one to associate previous experiences to the problem at hand and further act upon the solution. He further argued that a problem had to be properly paraphrased, comprehensively understood, and then visually integrated into a theoretically correct and complete schematic structure in order to attain the required solution. The model explains the problem-solving process which involves four basic stages, in particular, problem translation, problem integration (student' representation of the problem), solution planning and solution execution (specific strategies used in the problem). The indispensable problem-solving process requires students to first acquire the meaning of the problem and implications of the text. Then, the student develops suitable representation of the problem. This approach centered on representations and it could be expressed in the form of symbolic, verbal and visual. This could motivate students' algebraic ideas, especially in problem solving ability. In the first stage, students extract concepts from the textual description of the problem using linguistic and semantic knowledge. Problem integration: students need to integrate the problem concepts with an illustration from the information provided by the problem. At the stage of solution planning and monitoring, students develop a plan to solve the problem and monitor the solution according to their understanding of the problem. The last step is solution execution; students finally execute the solution to get the answer.

Daso, Zalmo and Otikor (2012) investigated the effect of Mayer's problem solving strategy on Senior Secondary Students academic performance and retention in Geometry. The investigation centered on 95 selected students drawn from two intact classes (SS3) in Obio-Akpor Local Government, Rivers state. A special Geometry Retention Test (GRT) was designed for data collection and it was administered as pre-test, post-test and post-posttest. This enables the investigators to ascertain the effects of two different methods of teaching adopted, i.e. Mayer's problem solving strategy and deductive method. Mean and standard deviation were used to answer the two research questions while Analysis of Covariance (ANCOVA) was used to test the two null hypotheses at 0.05 level of significance. ANCOVA was considered appropriate in testing the hypotheses because it takes care of the initial retention difference in the subjects of the study due to non-randomization of sample selected. The following findings were discovered from their investigation: the students taught geometry using Mayer's approach had higher retention than those taught with deductive method and there is statistical difference between the retention levels. It showed that those taught with Mayer's approach had higher retention level. This research was carried out in one branch of Mathematics geometry. We intend to replicate similar study in algebra due to its abstractness and to measure students' performance and retention in algebraic process. We believe due to visual representation component in Mayer's model, it will make teaching and learning of algebra less abstract and more real and practicable. This research work was done in southern part of the country where students were a little bit inclined in education. We intend to carry out our own in Northern part of the country in less developed education area.

Sharmila and Norjoharuddeen (2021) also carried research on the effectiveness of Mayer's problem solving model with visual representation among year four pupils. The researchers investigated the ability of solving mathematical non-routine problem among Malaysian students. A sample of 175 year four pupils was drawn using sampling technique. A quasi-experimental non-equivalent pre-test and posttest design was administered to these pupils. It consisted of two experiment groups namely Mayer's problem solving Model (MM) group and Mayer's Problem solving Model with Visual Representation (MMVR) group and control group. The first two groups were taught with Mayer's problem solving strategy MM group without visual treatment and MMVR group with visual treatment and third group i.e. control group were taught with traditional methods. After data analysis, the following findings were discovered, mathematical problem solving ability of year 4 students in MMVR group improved after students had undergone Mayer's problem solving model with visual representation teaching strategy treatment. This study reveals that visual representation has a major impact in teaching and learning process. It was carried out among young pupils to check their mental and solving ability in a foreign land. The researchers intend to carry out the research work on Mayer's Problem solving model with visual representation in senior secondary schools II to ascertain whether it will solve the issue of poor

performance and improve retention of students in Algebra, Katsina State since no such research work is visible in the state.

METHODOLOGY

This study adopted quasi-experimental non-equivalent control group design, made use of pre-test (before the treatment), post-test (after the treatment) and post-posttest (two weeks after treatment). This design was based on the fact that students in the classes were taught with Mayer's problem solving model with visual representation or the conventional teaching method.

The study used one experimental group and a control group each for the public schools. The population for this study consist of all the senior secondary school students II (SS II) in Katsina central senatorial district of Katsina state. The target population of the study was all SS II students in Public secondary schools in Katsina central senatorial district numbering 21,188 students comprising of 12,220 male and 8,968 female in public schools (Katsina state Ministry of Education 2023).

The total number of public senior secondary schools in Katsina central senatorial district was fifty one (51). This investigation was carried out in Katsina central senatorial district of Katsina state. It consist of eleven (11) local governments out of which five were randomly selected and they were Batagarawa, Dutsin-ma, Kaita, Kurfi and Katsina local governments of Katsina state and the research work lasted for four (4) months. In each of the 5selected local governments, 2 classes of 40 students each were selected from the randomly selected public schools as experimental and control groups giving a total of 400 students. The instrument used for the study was Algebra Performance Test (APT) which consists of 20 multiple-choice objective questions with four options (A - D). Algebraic process was taught for six weeks in line with the senior secondary school syllabus for SS II (Federal Ministry of Education, 2012). The APT was used for both pre-testing, post testing and delayed post-test retention testing of students' cognitive achievement.

Before the commencement of the teaching, the students in each class were given a pre-test (first administrations of APT) to determine the level of homogeneity of students' knowledge. The researchers organized training for Research Assistants to get them acquainted with the instruments to be used in the experiment. For the period of the study, the Research Assistants meticulously used the lesson plans prepared by the researcher for both experimental and control groups to cover the algebraic aspect of Mathematics curriculum content for the six weeks. The post-test (that is, the second version of the APT) was administered at the end of the period when the two groups had covered the expected contents and two weeks after, delayed post-test of APT was administered. The APT was scored 100 percent in all versions.

The data collected was analysed using descriptive statistics (mean and standard deviation), t-test and ANCOVA to test the 4 hypotheses at 0.05 level of significance using SPSS version 23.

Data Analysis

Batagarawa local government

Hypothesis one: There is no statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method.

Dependent Variable: BTGPOST

Variable	N	Mean	SD
EXPTBTG	40	71.25	9.724
CRTLBTG	40	44.12	5.649

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The mean difference between the academic performance in algebra of senior secondary school students taught at Batagarawa LG with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 27.13 which shows a very significant difference.

Source	Sum of Squares	df	Mean Square	F	Sig.
BTGPRE	54.292	1	54.292	0.857	0.357
EXP1CRTL2BTG	14736.398	1	14736.398	232.636	0

From the table above, the results indicated that there is no statistical difference between pre-test at Batagarawa LG for experimental and control groups since $F(1, 77) = 0.857$, $p > 0.05$. Also, we found a statistically significant effect of Mayer's problem solving model on senior secondary school 2 students taught Algebra at Batagarawa local government since $F(1,77) = 232.636$, $p < 0.357$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 27.147 in favour of Mayer's problem solving instructional model with visual representation.

Pairwise Comparisons

Dependent Variable: EXPBTGPRE

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXPT	CRTL	27.147	1.78	0
CRTL	EXPT	-27.147	1.78	0

Hypothesis Two: There is no statistical difference between the academic performance in algebra of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.

Dependent Variable: EXPBTGPOST

Gender	N	Mean	SD
Female	20	70	8.736
Male	20	72.5	10.699

The mean difference between the academic performance in algebra of male and female senior secondary school students at Batagarawa LG taught using Mayer's problem solving model with visual representation is 2.5, which is very small.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPBTGSEX	70.776	1	70.776	0.731	0.398

From the above table, the results indicated that there is no statistical difference between the female and male performance at Batagarawa LGfor the experimental group since $F(1, 77) = 0.731$, $p> 0.05$.The Bonferroni adjustment for multiple comparisons in table below gave a mean difference of 2.669 which is very small in

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favour of the male.

Pairwise Comparisons

Dependent Variable: EXPBTGPOST

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
Female	Male	-2.669	3.12	0.398
Male	Female	2.669	3.12	0.398

Hypothesis Three: There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.

Dependent Variable: BTG_POST_POST

Group	Mean	N	SD
EXPT	64.25	40	6.751
CRTL	37.25	40	5.183

The mean difference of retention between the academic performance in algebra of senior secondary school students at Batagarawa LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 27.00 which is very significant.

Dependent Variable: BTG_POST_POST

Source	Sum of Squares	df	Mean Square	F	Sig.
BTG_POST_POST	14588.134	1	14588.134	399.204	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Batagarawa LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 399.204$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 27.010 in favour of Mayer's problem solving instructional model with visual representation

Pairwise Comparisons - Dependent Variable: BTG_POST_POST

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Sig.
EXPT	CRTL	27.01	0
CRTL	EXPT	-27.01	0

T – Test for Retention in the Experimental Group

Group	Mean	N	SD
EXPBTG_POST	71.25	40	9.724
EXBTG_POST_POST	69.88	40	9.022

The table above shows an insignificant mean difference of 1.37 which shows a minute difference in the retention level of students taught Algebra with Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date.

Group Comparison	N	Mean	SD	t	df	Sig.
EXPBTG_POST – EXBTG_POST_POST	78	1.375	6.886	1.263	39	0.214

The table above showed that there is an insignificant difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date since $t(78) = 1.263$, $p>0.05$

T-Test for Retention in the Conrol Group

Group	Mean	N	SD
CTRLBTG_POST	44.13	40	5.649
CTRLBTG_POST_POST	33.38	40	4.855

The table above shows a significant mean difference of 10.75 which shows that there is statistical difference in the retention level of students taught algebra using conventional method immediately after the treatment and in a later date.

Group Comparison	N	Mean	SD	t	df	Sig.
CTRLBTG_POST – CTRLBTG_POST_POST	78	10.75	4.606	14.76	39	0

There is statistical difference in the retention level of students taught algebra using conventional method immediately after the treatment or in a later date since $t(78) = 14.760$, $p<0.05$.

Hypothesis Four: There is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

RETEXPBTGSEX	N	Mean	SD
FEMALE	20	68.5	8.127
MALE	20	71.25	9.851

The mean retention difference between academic performance of male and female senior secondary school students of post – post-test taught algebra using Mayer's problem solving model with visual representation is

2.75 which is very low. This shows that there is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Dependent Variable: RETEXPBTGSEX

Source	Sum of Squares	df	Mean Square	F	Sig.
RETEXPBTGSEX	90.127	1	90.127	1.115	0.298

From the table above, the results indicated that there is no statistical difference between the retention level of the female and male for the experimental group since $F(1,77) = 1.115$, $p > 0.05$ The Bonferroni adjustment for multiple comparisons also testifies to the 3.012 insignificant mean difference in favour of the male.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
Female	Male	-3.012	2.852	0.298
Male	Female	3.012	2.852	0.298

BIRCHI IN KURFI LG

Hypothesis one: There is no statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
Female	Male	-3.012	2.852	0.298
Male	Female	3.012	2.852	0.298

The mean difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 31.00 which shows a very statistical difference.

Source	Sum of Squares	df	Mean Square	F	Sig.
BRCPRE	61.869	1	61.869	0.73	0.395
EXP1CRTL2BRC	19178.328	1	19178.328	226.384	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Birchi in Kurfi LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 226.384$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 30.971 in favour of Mayer's problem solving instructional model with visual representation

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(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	30.971	2.058	0
CTRL	EXP	-30.971	2.058	0

Hypothesis Two: There is no statistical difference between the academic performance in algebra of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.

Dependent Variable: EXPBRCSEX

Gender	N	Mean	SD
Female	20	77.5	10.195
Male	20	77	12.397

The mean difference between the academic performance in algebra of male and female senior secondary school students taught using Mayer's problem solving model with visual representation is 0.5, which is very insignificant.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPBTGSEX	70.776	1	70.776	0.731	0.398

From the above table, the results indicated that there is no statistical difference between the female and male performance at Birchi in Kurfi LG for the experimental group since $F(1, 77) = 0.731$, $p > 0.05$. The Bonferroni adjustment for multiple comparisons in table below gave a mean difference of 2.669 which is very small in favour of the male.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
Female	Male	-2.669	3.12	0.398
Male	Female	2.669	3.12	0.398

Hypothesis Three: There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.

Group	N	Mean	SD
EXP	40	77.38	8.986
CTRL	40	33.63	6.697

The mean difference of retention between the academic performance in algebra of senior secondary school

students in Birchi in Kurfitaught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 43.75 which is very significant.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXP1CRTL2BRC	38,219.45	1	38,219.45	608.392	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Birchi in Kurfi LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 608.392$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 43.721 in favour of Mayer's problem solving instructional model with visual representation

Dependent Variable: BRCRETN

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	43.721	1.77	0
CTRL	EXP	-43.721	1.773	0

T – Test for Experimental Group

Group	Mean	N	SD
EXPBRCPOST	77.25	11.206	1.77
EXPBRCPOSTPOST	77.38	8.986	1.421

The table above shows an insignificant mean difference of 0.13 which is still minimal and this show that there is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date.

N	Mean	SD	t	df	Sig.
40	-0.125	6.454	-0.122	39	0.903

The table above showed that there is a insignificant difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date since $t(39) = -1.222$, $p>0.903$

T-Test for the Conrol Group

Group	Mean	N	SD
CTRLBRCPOST	46.25	40	6.578
CTRLBRCPOSTPOST	33.63	40	6.70

The table above shows an insignificant mean difference of 12.62 which shows a statistical difference in the retention level of students taught algebra using the conventional method either immediately after the treatment or in a later date.

N	Mean	SD	t	df	Sig.
40	12.625	5.062	15.774	39	0

There is statistical difference in the retention level of students at Birchi in Kurfi LG taught algebra using the conventional method either immediately after the treatment or in a later date since $t(78)=15.774$, $p<0.005$.

Hypothesis Four: There is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Group	N	Mean	SD
FEMALE	20	78	7.678
MALE	20.00	76.75	10.30

The mean retention difference between academic performance of male and female senior secondary school students of post – post- test taught algebra using Mayer's problem solving model with visual representation is 1.25 which is insignificant. This shows that is no statistical difference in the retention levels of male and female students at Birchi in Kurfi LG of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Dependent Variable: RETNEXPBRC

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPSEXBRC	15.931	1	15.931	0.188	0.667

From the table above, the results indicated that there is no statistical difference between the retention level of the female and male for the experimental group since $F(1,77) = 0.188$, $p > 0.05$ The Bonferroni adjustment for multiple comparisons also testifies to the 1.263 insignificant mean difference in favour of the male.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	1.263	2.911	0.667
MALE	FEMALE	-1.263	2.91	0.667

DUTSIN-MA

Hypothesis one: There is no statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method.

Group	N	Mean	SD
EXP	40	76	9.621
CTRL	40.00	46	6.33

The mean difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 30.0 which is very significant.

Source	Sum of Squares	df	Mean Square	F	Sig.
DTMPRE	241.916	1	241.916	3.78	0.056
EXP1CRTL2DTM	18,000.00	1	18,000.00	281.245	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Dutsinma LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 281.245$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 30.00 in favour of Mayer's problem solving instructional model with visual representation

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	30	1.789	0
CTRL	EXP	-30	1.79	0

Hypothesis Two: There is no statistical difference between the academic performance in algebra of male and female senior secondary school students at Dustin Ma LG taught algebra using Mayer's problem solving model with visual representation.

Group	N	Mean	SD
FEMALE	20	78	10.183
MALE	20	74	8.826

The mean difference between the academic performance in algebra of male and female senior secondary school students at Dustin Ma LG taught using Mayer's problem solving model with visual representation is 4.0, which is not very significant.

Dependent Variable: EXPDTMSEX

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPDTMSEX	174.967	1	174.967	1.92	0.174

From the above table, the results indicated that there is no statistical difference between the female and male

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performance at Dutsinma LG for the experimental group since F(1, 77) = 1.920, p> 0.05. The Bonferroni adjustment for multiple comparisons in table below gave a mean difference of 2.811 which is very small in favour of the male.

Dependent Variable: EXPDTMSEX

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	4.193	3.026	0.174
MALE	FEMALE	-4.193	3.026	0.174

Hypothesis Three: There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.

Group	N	Mean	SD
EXP	40	76	10.077
CTRL	40	33.5	5.335

The mean difference of retention between the academic performance in algebra of senior secondary school students at Dustin Ma LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 42.50 which is very significant.

Dependent Variable: DTMPOSTPOST

Source	Sum of Squares	df	Mean Square	F	Sig.
EXP1CRTL2DTM	36,125.00	1	36,125.00	558.473	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Dutsinma LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since F(1, 77) = 558.473, p < 0.05. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 42.50 in favour of Mayer's problem solving instructional model with visual representation

Dependent Variable: DTMPOSTPOST

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	42.5	1.80	0
CTRL	EXP	-42.5	1.798	0

T – Test for the Experimental Group

Group	N	Mean	SD
EXPDTMPOST	40.00	76	9.62
EXPDTMPOSTPOST	40	76	10.077

The table above shows 0.00 mean difference and this means that there is no statistical difference in the retention level of students at Dustin Ma LG taught algebra using Mayer's problem solving instructional model with visual representation either immediately or after the treatment or in a later date.

Group Comparison	N	Mean	SD	t	df	Sig.
EXPDTMPOST – EXPDTMPOSTPOST	80.00	0	4.08	0	39	1

There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date since $t(78)=0.000$, $p>0.005$.

T – Test of Retention for the Conrol Group

Group	N	Mean	SD
CTRLDTMPOST	40.00	46	6.33
RETCTRLDTM	40	33.5	5.335

The table above shows a significant mean difference of 12.5 which means that there is statistical difference in the retention level of students at Dustin Ma LG taught algebra using conventional method either immediately after the treatment or in a later date.

Group Comparison	N	Mean	SD	t	df	Sig.
CTRLDTMPOST – RETCTRLDTM	80.00	12.5	7.60	10.408	39	0

From the table above, there is statistical difference in the retention level of students at Dustin Ma LG taught algebra using conventional method either immediately after the treatment or in a later date since $t(78)=10.408$, $p>0.05$.

Hypothesis Four: There is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Group	N	Mean	SD
FEMALE	20.00	77.5	10.70
MALE	20	74.5	9.445

The mean retention difference between academic performance of male and female senior secondary school students of post – post- test taught algebra using Mayer's problem solving model with visual representation is 3.0 which is very low. This shows that is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Dependent Variable: EXPDTMPOSTPOST

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPDTMSEX	104.97	1	104.97	1.038	0.315

From the table above, the results indicated that there is no statistical difference between the retention level of the female and male for the experimental group since $F(1,77) = 1.038$, $p > 0.05$ The Bonferroni adjustment for multiple comparisons also testifies to the 3.248 insignificant mean difference in favour of the male.

Dependent Variable: EXPDTMSEX

Group (I)	Group (J)	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	3.248	3.19	0.315
MALE	FEMALE	-3.248	3.187	0.315

FOR KAITA

Hypothesis one: There is no statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method.

Group	N	Mean	SD
EXP	40.00	81.88	8.30
CTRL	40	41.63	5.592

The mean difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 40.25 which is very significant.

Dependent Variable: KTAPOST

Source	Sum of Squares	df	Mean Square	F	Sig.
KTAPRE	70.76	1	70.76	1.421	0.237
EXP1CRTL2KTA	32,461.89	1	32,461.89	652.119	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Kaita LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 652.119$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 40.305 in favour of Mayer's problem solving instructional model with visual representation

Dependent Variable: KTAPOST

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	40.305	1.58	0
CTRL	EXP	-40.305	1.58	0

Hypothesis Two: There is no statistical difference between the academic performance in algebra of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.

Group	N	Mean	SD
FEMALE	20.00	81.25	9.16
MALE	20.00	82.5	7.52

Dependent Variable: EXPKTAPOST

The mean difference between the academic performance in algebra of male and female senior secondary school students taught using Mayer's problem solving model with visual representation is 1.25, which is insignificant.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPSEXKTA	8.92	1	8.92	0.129	0.721

From the above table, the results indicated that there is no statistical difference between the female and male performance at Kaita LG for the experimental group since $F(1, 77) = 0.129$, $p > 0.05$. The Bonferroni adjustment for multiple comparisons in table below gave a mean difference of 0.948 which is very small in favour of the male.

Dependent Variable: EXPKTAPOST

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	-0.948	2.64	0.721
MALE	FEMALE	0.948	2.64	0.721

Hypothesis Three: There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.

Group	N	Mean	SD
EXP	40.00	82.5	6.70
CTRL	40.00	34	5.21

Dependent Variable: KTARETN

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The mean difference of retention between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 48.50 which is very significant.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXP1CRTL2KTA	47,052.78	1	47,052.78	1295.893	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Kaita LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 1295.893$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 48.524 in favour of Mayer's problem solving instructional model with visual representation

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXP	CTRL	48.524*	1.35	0
CTRL	EXP	-48.524*	1.35	0

T-Test for the Experimental Group at Kaita

Group	N	Mean	SD
EXPKTAPOST	40.00	81.88	8.30
RETNEXPKTA	40.00	82.5	6.70

The table above shows an insignificant mean difference of 0.62 which shows that there is no statistical difference in the retention level of students at Kaita LG taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date.

Variable	N	Mean	SD	t	Df	Sig.
EXPKTAPOST – RETNEXPKTA	40.00	-0.625	4.11	-0.961	39	0.342

From the table above, there is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date since $t(78)=-0.961$, $p>0.05$.

Variable	N	Mean	SD
CTRLKTAPOST	40.00	41.63	5.59
RETCTRLKTA	40.00	34	5.21

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The table above shows an insignificant mean difference of 7.63 which shows that there is statistical difference in the retention level of students taught algebra using conventional method either immediately after the treatment or in a later date.

Variable	N	Mean	SD	t	df	Sig.
CTRLKTAPOST – RETCTRLKTA	40.00	7.625	4.53	10.652	39	0

From the table above, tthere is statistical difference in the retention level of students taught algebra using conventional method either immediately after the treatment or in a later date since $t(78)=10.652$, $p<0.05$.

Hypothesis Four: There is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Dependent Variable: EXPKTAPOSTPOST

Gender	Mean	SD	N
Female	83.25	7.304	20.00
Male	81.75	6.129	20.00

The mean retention difference between academic performance of male and female senior secondary school students of post – post-test taught algebra using Mayer's problem solving model with visual representation is 1.5 which is a low difference. This shows that is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Dependent Variable: EXPKTAPOSTPOST

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPSEXKTA	29.42	1	29.42	0.654	0.424

From the table above, the results indicated that there is no statistical difference between the retention level of the female and male for the experimental group since $F(1,77) = 0.654$, $p > 0.05$ The Bonferroni adjustment for multiple comparisons also testifies to the 1.722 insignificant mean difference in favour of the male.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	1.722	2.13	0.424
MALE	FEMALE	-1.722	2.13	0.424

KATSINA LG

Hypothesis one: There is no statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method.

Dependent Variable: KTNPOST

Variable	N	Mean	SD
EXPTKTN	40.00	69.38	10.08
CRTLKTN	40	44.88	8.879

The mean difference between the academic performance in algebra of senior secondary school students taught at Katsina LG with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 24.5 which shows a very statistical difference.

Source	Sum of Squares	df	Mean Square	F	Sig.
KTNPRE	113.34	1	113.34	1.261	0.265
EXP1CRTL2BTG	12057.01	1	12057.01	134.152	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Katsina LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 134.152$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 24.561 in favour of Mayer's problem solving instructional model with visual representation

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Sig.
EXPT	CRTL	24.561	0.00
CRTL	EXPT	-24.561	0

Hypothesis Two: There is no statistical difference between the academic performance in algebra of male and female senior secondary school students taught algebra using Mayer's problem solving model with visual representation.

Dependent Variable: EXPKTNSEX

Gender	N	Mean	SD
Female	20.00	70.25	10.06
Male	20	68.5	10.273

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The mean difference between the academic performance in algebra of male and female senior secondary school students at Katsina LG taught using Mayer's problem solving model with visual representation is 1.75, which is small.

Dependent Variable: EXPKTNPOST

Source	Sum of Squares	Df	Mean Square	F	Sig.
EXPSEXKTN	30.67	1	30.67	0.289	0.594

From the above table, the results indicated that there is no statistical difference between the female and male performance at Katsina LG for the experimental group since $F(1, 77) = 0.289$, $p > 0.05$. The Bonferroni adjustment for multiple comparisons in table below gave a mean difference of 1.752 which is very small in favour of the male.

(I) Group	(J) Group	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	1.752	3.26	0.594
MALE	FEMALE	-1.752	3.259	0.594

Hypothesis Three: There is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation and those taught with conventional teaching Method.

Dependent Variable: RETKTN_POST_POST

Group	Mean	N	SD
EXPT	70.75	40	11.52
CRTL	31.75	40	6.36

The mean difference of retention between the academic performance in algebra of senior secondary school students at Katsina LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method is 39.00 which is very significant.

Dependent Variable: KTNRETN

Source	Sum of Squares	df	Mean Square	F	Sig.
EXP1CRTL2KTA	30,483.73	1	30,483.73	352.044	0

From the table above, the result showed that there is a significant difference in retention by senior secondary school 2 students at Katsina LG taught with Mayer's problem solving instructional model with visual representation and those taught with conventional teaching method since $F(1, 77) = 352.044$, $p < 0.05$. Bonferroni adjustment for multiple comparisons in the table below also shows a mean difference of 39.054 in favour of Mayer's problem solving instructional model with visual representation

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
EXPT	CRTL	39.054	2.08	0
CRTL	EXPT	-39.054	2.081	0

T – Test for Retention in the Experimental Group

Variable	Mean	N	SD
EXPKTNPOST	69.38	40	10.08
RETNEXPKTN	70.75	40	11.522

The table above shows an insignificant mean difference of 1.37 which shows an instatistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date.

Variable	N	Mean	SD	t	Df	Sig.
EXPKTNPOST – RETNEXPKTN	38.00	-1.375	10.25	-0.848	39	0.401

From the table above, there is no statistical difference in the retention level of students taught algebra using Mayer's problem solving instructional model with visual representation either immediately after the treatment or in a later date since $t(78)=-0.848$, $p>0.05$.

T-Test for Retention in the Conrol Group

Variable	Mean	N	SD
CTRLKTNPOST	44.88	40	8.88
RETCTRLKTN	31.75	40	6.36

The table above shows a significant mean difference of 13.13 which shows that there is statistical difference in the retention level of students taught algebra using conventional method immediately after the treatment and in a later date.

Variable	N	Mean	SD	t	df	Sig.
CTRLKTNPOST – RETCTRLKTN	40	13.125	7.901	10.507	39	0

From the table above, there is statistical difference in the retention level of students taught algebra using conventional method immediately after the treatment or in a later date since $t(78)=10.507$, $p<0.05$..

Hypothesis Four: There is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

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Gender	Mean	N	SD
FEMALE	68.5	20	12.471
MALE	73.00	20	10.31

Dependent Variable: EXPKTNPOSTPOST

The mean retention difference between academic performance of male and female senior secondary school students of post – post-test taught algebra using Mayer's problem solving model with visual representation is 4.5 which is low. This shows that there is no statistical difference in the retention levels of male and female students of post – post-test taught algebra using Mayer's problem solving instructional model with visual representation.

Source	Sum of Squares	df	Mean Square	F	Sig.
EXPSEXKTN	204.714	1	204.714	1.529	0.224

From the table above, the results indicated that there is no statistical difference between the retention level of the female and male for the experimental group since $F(1,77) = 1.529$, $p > 0.05$ The Bonferroni adjustment for multiple comparisons also testifies to the 4.525 insignificant mean difference in favour of the male.

(I) GROUP	(J) GROUP	Mean Diff. (I-J)	Std. Error	Sig.
FEMALE	MALE	-4.525	3.659	0.224
MALE	FEMALE	4.525	3.66	0.224

DISCUSSION OF FINDINGS

The results show that in all the 5 local governments, there is a statistical difference between the academic performance in algebra of senior secondary school students taught with Mayer's problem solving model with visual representation and those taught with conventional teaching method. This very statistical difference favour those taught using Mayer problem solving model.

For the academic performance of males and females taught using the Mayer's problem solving model, there is an insignificant difference in favour of the males in all the local governments except Dutsinma where the difference slightly favours the female.

In all the local governments, there is a statistical difference in the retention in favour of the students taught using the Mayer's model. The t test shows that students taught using the Mayer's model maintain retention long after being taught while those taught using conventional teaching method do not maintain retention.

In all the local governments analysed, the difference between the retention of males and females was insignificant in favour of males in Batagarawa and Katsina and in favour of females in Dutsinma and Kaita. The results show that any difference in academic performance and retention of males and females is not significant. Our results are in accord with Adebule and Ayoola(2016) who found that male and female students perform equally when taught under the same condition because intelligence is not gender specific using Mayer's model.Our findings are also in line with the findings of Dasoet al.(2012) and Shamilaet al.(2021) who found that there is significant difference on academic performance and retention of students who are exposed to Mayer problem solving model in geometry and solving ability.

CONCLUSION

The study concludes that the use of Mayer's problem solving model with visual representation is essential to students' academic performance and retention in algebra. Students taught with this model have their interest aroused and their senses stimulated which serves to increase academic performance and retention. Use of the Mayer's model has no effect based on gender. When the Mayer's model is used in schools, academic performance will surely improve.

RECOMMENDATION

On the basis of the findings from the study, the following recommendations were made:

1. The use of Mayer's problem solving instructional model with visual representation seems to be appropriate in improving the performance of students in senior secondary school algebra particularly in algebra concepts as investigated in this study. It should therefore be incorporated into the mainstream of pedagogy in the teaching of algebra and other related science subjects at senior secondary schools in Katsina senatorial district.
2. It is recommended that Mayer's problem solving instructional model with visual representation component should be used in teaching of algebra since it is gender friendly.
3. For the students to have a better and higher retention level, the Mayer's problem solving instructional model with visual representation component is therefore recommended.
4. Mayer's problem solving instructional model with visual representation component is recommended because its applications make males and females to have the same retention level.
5. There is need for ministries of education to train pre-service and in-service teachers on the pedagogical element that focus on the use of Mayer's visual component in teaching algebra in secondary schools by organizing conferences, seminars and workshops.
6. The government and other stakeholders should assist by providing ICT components that support Mayer's visual presentation in senior secondary schools.

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