USING FOUR-MODE APPLICATION TECHNIQUES IN ENHANCING SENIOR SECONDARY STUDENTS' INTEREST IN GEOMETRY IN JOS METROPOLIS, PLATEAU STATE, NIGERIA

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Abstract: This study investigated the use of Four-Mode Application Techniques in enhancing senior secondary students' interest in Geometry in Jos Metropolis, Plateau State. The study employed quasi-experimental, non-randomized pre-test post-test control group design. The study population consisted of 3,631 with a sample size of 141 Senior Secondary one (SS1) students. Through a purposive sampling technique, two out of 42 co-educational public secondary schools were selected in the study area and randomly assigned as experimental and control groups. The experimental group was taught selected topics in Geometry using 4MAT while the control group was taught the same topics using the conventional method. Three research questions and their corresponding hypotheses were asked and tested respectively. Instrument of study, Geometry Interest Inventory (GII), was validated by experts and trial-tested using 30 SS1 students and a Cronbach Alpha reliability co-efficient of 0.79 was obtained. Research questions were answered using mean and standard deviation while inferential statistics, ANCOVA, was used to test the hypotheses at 0.05 level of significance. The study found that interest in Geometry of students in the experimental group increased significantly more than their counter-parts in the control group. It was also found that 4MAT was not gender bias in terms of students' interest in Geometry. Results of the study further revealed that there was no significant interaction effect of methods and gender on students' interest in geometry. The study recommended among others, that 4MAT instructional model should be used to teaching difficult concepts in Mathematics since its use has been found to enhance students' interest.

Key Words: Geometry, Interest, Four-Mode Application Techniques, Senior Secondary.

Introduction

The word 'Geometry' is derived from an ancient Greek word 'geometron'. The word 'geo' meaning 'Earth' and 'metron' meaning measurement. Hence, geometry means earth measurement (Definition of Geometry – Future School, 2017). The functions of geometry are so fundamental to human lives that its study is as old as the civilization of man. Geometry originated from human need for measuring land and quantity. In the ancient days, people sought to know the volume of solid shapes to store goods and also for construction purposes. Geometry was used in land surveying, pyramid construction by the ancient Egyptians. Today, a basic knowledge of geometry concepts, their attributes and relations, which forms a large part of the Nigerian secondary school Mathematics Curriculum, is fundamental to the learner to interact effectively with his environment and also grow interest in the study of geometry itself and other areas of learning. Mathematics is the science that is concerned with the logic of shape, quantity and arrangement. Mathematics seeks out patterns, formulates new conjectures and establishes truth by rigorous deductions from appropriately chosen axioms and definitions ("Mathematics - What Is Mathematics," 2024)

Thus, Geometry is a vital branch of Mathematics that deals with the study of sizes, shapes, positions, angles and dimension of things (Jonah & Dogo, 2019). The word geometry was coined by early Mathematicians who synthesized Mathematics into a discipline to refer to the sciences of the properties and relations of lines, figures, angles, surfaces and solids (Iji, Ogbole & Uka, 2014). Similarly, geometry is said to be a science of space involving describing and measuring figures, theory of ideas and methods by which one can construct and study idealized model of the physical world as well as other real-world phenomenon. Thus, we have Euclidean projectile, hyperbolic and elliptic geometry. Also included are topology (non-Euclidean) and combinational geometry. Furthermore, geometry as an aspect of Mathematics involves ideas for example graphs, bar charts and histogram. Geometry is a meeting point between Mathematics theory and Mathematics as model resources (Iji, *et al*. 2014).

Geometry permeates all areas of the secondary school Mathematics curriculum, because it plays a major role in other mathematical fields such as topology, the study of various different spaces and trigonometry. Geometry provides many foundational skills and helps to build the thinking skills of logic, deductive reasoning, analytical reasoning and problem solving. Understanding geometry gives students a far better understanding of numerous branches of Mathematics as well as the skills required to solve geometrical mathematical problems in a variety of different settings ("Definition of Geometry – Future School," 2017). However, Paula and Makondo (2020) observe that the teaching and learning of geometry as a critical branch of Mathematics are in dismal state which often results in poor achievement. In their view, students find it difficult to understand geometry and stressed that the teaching of geometrical contents as being practiced today has been found to be ineffective. Sergei, Arcadii and David (2019), also maintain that some of the persistent poor achievement in geometry topics may be as a result of lack of interest by the students or teachers wrong instructional

approaches or strategies. An effective Mathematics teacher must be on the lookout for instructional approaches that promote students interest. Ale and Adetula (2009), emphasize that the instructional approaches adopted by teachers can make learners develop positive or negative interest towards the learning task. The need to therefore explore appropriate instructional approaches that could enhance students' interest in geometry has continued to be an issue that is critical to Mathematics Educators.

Over the years, Mathematics Educators and other stake holders in the Education sector have been focusing attention on how to improve instruction in schools by going beyond the stereotypical methods of obtaining knowledge in the educational system. In particular, an area that has continued to generate concern among researchers and Mathematics educators is the problem of instructional approaches. The uninspiring teaching approach that a teacher applies could make the attainment of instructional objectives illusive (Ale & Adetula, 2009). Hence, Mathematics educators around the globe are searching for a desirable teaching strategy that will engage students with the cognitive task that could influence them to learn Mathematics successfully (Ale & Adetula, 2009). Iji, Abah, and Uka (2013), reported that the conventional teaching strategy has not been able to meet learners needs particularly in promoting students' interest in learning Mathematics, considering the recurring mass failure of students in Mathematics. Hence, there have been emphases on active involvement of students in the teaching learning processes. The Nigerian National Policy on Education (2014), which has Mathematics as a core and compulsory subject throughout the Secondary School curriculum sees the Mathematics as a practical and inquiry oriented subject that should be taught practically involving students in the art of doing as there are hardly any area of human endeavor that is void of practical applications of Mathematics. Therefore, the adoption of innovative, student-centered instructional strategies like 4MAT model in teaching and learning processes may enhance students' interest in Mathematics due to the students activities involved in the model.

Literature Review

Four-Mode Application Techniques (4MAT)

4MAT is an instructional model that provides a systematic approach to organizing and delivering instructions in a manner that addresses the learning styles and hemispheric preferences of students (McCarthy, 1987). It is an eight-step instructional model that capitalizes on individual learning styles and Inherent in the 4MAT are two major premises: one is that people have major learning styles and hemispheric (right mode and left mode) processing preferences; secondly, teachers should design and use multiple instructional strategies in a systematic framework to teach to these preferences in other to improve teaching and learning. The 4MAT is a conceptual brain dominance processing preferences framework of teaching and learning that is grounded in the works of John Dewey (experiential learning), Carl Jung (theory of individualization), and, most directly, David Kolb (experiential learning theory) (McCarthy, 1987). 4MAT identifies four interrelated learning styles based on how individuals perceive and process new information. Its premise is that individuals learn primarily in one of the four different, but complementary ways based on how they perceive and process information (McCarthy & McCarthy, 2006). McCarthy identified these four learning styles as Imaginative Learners (Type One Learners); Analytic Learners (Type Two Learners); Common Sense Learners (Type Three Learners); and Dynamic Learners (Type Four Learners), based on Kolb's experiential learning theory that is, divergent, assimilative, convergent and accommodative learning styles respectively. These four types of learners would learn best if they are taught how to learn like each other at the same time in order to make learning successful, When using the model, teachers can implement a number of steps in their teaching. The eight steps involved in 4MAT include; connect, explain, image, inform, practice, extend, refine and perform. As the lesson goes on, instructions that can stimulate the function of the two hemispheres of the brain are introduced into the lesson. The learning activities are structured in a way that will address the eight steps as proposed by the model. The 4MAT model developed by McCarthy is among many efforts made over the years by concerned educational researchers to improve the teaching- learning processes. To this effect, this study sought to find out if the model could enhance the interest of students in Geometry owing to the nature of students' activities involved in it.

Interest is described as the feeling of intentness, concern or curiosity about an object or responsiveness with a sense of concern, lively understanding or inquisitiveness, and the influence to excite or hold such attention (Obodo, 2002). Interest is also seen as a subjective feeling of concentration or curiosity over something. It is preference for particular type of activities and could be expressed through simple statements made by individuals of their likes and dislikes (Imoko & Agwagh, 2006). Interest has been pointed out by many researchers as one of the factors responsible for dismal achievement of students in Mathematics (Iji & Uka, 2012). Research has shown that, interest is a critical factor in the teaching and learning of Mathematics since learning can only be meaningfully achieved within the context of optimal disposition of the learner towards the task in question (Imoko & Agwagh, 2006).

In view of the critical role interest plays in the teaching and learning processes as well as in motivating students towards the successful attainment of the goals of teaching and learning, it has become important for researchers to explore ways and means of engendering student's interest in Mathematics. Administrator (2016), identify four types of interest associated with the teaching and learning of Mathematics in general. These include Expressed Interest, Manifest Interest, Inventoried Interest and Test interest. Expressed interest refers to students' verbal declaration of their likes or dislikes or indifference to participate in mathematics activities. Manifest Interest involves students' professing of interest in Mathematics and going ahead to show their interest by actively participating in mathematics activities. Inventoried interest is an estimate of individual student's performance on a large number of mathematical activities listed in an interest Inventory while Test Interest

is the type of interest measured by students' achievement test score in Mathematics.

According to Ale and Adetula (2009), interest has a powerful influence on academic performance as it has the function of fostering remembering, understanding material, and stimulating students' positive attitude towards a topic or subject. Obodo, 2002, asserted that interest is a psychological factor that has the tendency to make or mar students' participation or achievement in Mathematics. This, according to him, is because the degree and the direction of attitude towards Mathematics is largely determined by the kind of interest developed by students for Mathematics. He lamented that there is low interest among students in the study of Mathematics and Mathematics related disciplines in all levels of education in Nigeria which has been identified as one of the principal causes of low achievement in Mathematics.

On the other hand, the teaching of Mathematics determines to a great extent whether a student takes or loses interest in the subject (Cowan, 2014).

From the fore going, the necessity of the interest of the learner for the successful attainment of the goals of teaching and learning processes cannot be over emphasized. The Inventoried Interest was used in this study because the response of the students to the list of a number of geometry interest related activities was weighed in order to determine the students' Individual scores which indicated the various levels and patterns of their interests in geometry. Therefore, this study aimed to find out if the use of 4MAT instructional approach could enhance students' interest and achievement in geometry, being a major branch of Mathematics which is a core and compulsory subject at all levels in the Nigerian secondary school education.

Tembe, Anyagh, & Abakpa (2020), carried out a study on "Students Mathematics Interest as correlate of achievement in Mathematics in Gboko Metropolis, Benue State, Nigeria. Three research questions were asked and three hypotheses formulated. The study adopted a correlational design. The population of the study was 3,682 with a sample size of 400 Basic 9 students was drawn from ten secondary schools using multistage sampling procedure made up of 200 male and 200 female students. Two research instruments Mathematics Interest Inventory (MII) and Students Mathematics Achievement Test (SMAT) were adapted. The instruments were validated by three experts and trial-tested, on a population outside the study area. Cronbach Alpha reliability coefficient was used to get the reliability coefficient of MII which was 0.83. While that of SMAT was 0.65 using Kuder-Richardson 21 formula. The research questions were answered using Pearson Product Moment Coefficients and hypotheses were tested at 0.05 level of significance using p-values of Pearson Product Moment Coefficient. This study and the current study are similar in the areas of having Mathematics as the subject area of study, Interest and Achievement in Mathematics as variables of study and instrument for data collection. The two studies are different in location, study population, research design and method of data analysis. Therefore, the aim of this study was to find out if senior secondary students' interest could be enhanced through the use of Four-Mode Application Techniques.

Specifically, the objectives of the study were to:

I. Find out if SS1 students would improve on their interest in Geometry due to the use of Four-Mode Application Techniques (4MAT).
II. Determine whether there were differences in interest of male and female SS1 students in Geometry due to the use of Four-Mode Application Techniques (4MAT).
III. Find out the interaction effect of methods of instruction and gender on students' interest in Geometry.

Research Questions

The following research questions were asked as guide for this study:

I. What are the mean interest ratings of SS1 students taught Geometry using 4MAT and those taught using the conventional method?
II. What are the mean interest ratings of male and female SS1 students taught Geometry using 4MAT?
III. What is the interaction effect of methods of instruction and gender on students' interest in Geometry?

Research Methodology

The design deployed for the study was Quasi-experimental design, specifically the pre-test, posttest, non-randomized, non-equivalent control group design. The two schools sampled out of 42 and assigned as experimental and control groups schools were co-educational and were located in different schools in Jos North and Jos South LGAs that make up the Jos Metropolis.

The study involved one hundred and forty one (141) senior secondary one (SS1) students selected from a population of 3,631 using multi-staged sampling technique. The instrument used for data collection was the Geometry Interest Inventory (GII). The question section consisted of 31 items structured in four-point rating scale thus: Strongly Agree (SA) =4, Agree (A) =3, Disagree (D) = 2, and Strongly Disagree (SD) =1. The instrument was validated by experts: two from the Department of Mathematics Education, two from the Educational Foundations Department, all of the College of Agricultural and Science Education, Joseph Sarwan Tarka University, Makurdi, Benue State and one Mathematics teacher from BSU technical secondary school, Makurdi. Their useful suggestions on both face and content validity trimmed the GII from 40 to 31 items. The instrument was tried-tested on 30 SS1 students of ECWA secondary school North Bank, Makurdi. Using The Cronbach Alpha coefficient, the reliability index obtained for the GII was 0.79. The GII was administered to students in both the experimental and control groups as pre-test and posttest. The mean cut off point for the GII was 2.5. The basis for decision was therefore, any positive item with a mean of 2.5 or above was accepted, while below 2.5 was not accepted. The hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The choice of ANCOVA was because of the Quasi-experimental pre-test,

posttest, non-randomized, non-equivalent control group design. This is because the design permits the use of pre-test, which acts as covariate, therefore, ANCOVA helps to establish the homogeneity or equivalence of the two groups before treatment. Besides this, since intact classes were used for the study, ANCOVA also helps to increase the power of the test because of error that may occur because of non-randomization of the subject of the study (i.e. Type1 error was reduced). The decision rule here was, reject Ho of the p-value is less than 0.05 and do not reject Ho if otherwise.

Results

The results were presented in tables according to research questions and their corresponding hypotheses.

Research question 1

What are the mean interest ratings of SS1 students taught Geometry using 4MAT and those taught using the conventional method?

TABLE 1: MEAN INTEREST RATINGS AND STANDARD DEVIATIONS OF STUDENTS IN EXPERIMENTAL AND CONTROL GROUPS

Groups	N	Pre-GII Mean	SD	Post- GII Mean	SD	Mean Gain
Experimental	78	1.34	0.20	3.63	0.23	2.29
Control	63	1.27	0.18	2.74	0.40	1.47
Mean Difference		0.07		0.89		0.82
Total	141					

Results for Table 1 revealed that the pretests mean interest ratings of 78 students in experimental group is 1.34 with standard deviation of 0.20 and 63 students in the control group is 1.27 with standard deviation of 0.18. The mean difference of both groups at pretest is 0.07. The small difference noticed between the groups at pretest means that interest in Geometry of both groups before commencements of treatment were similar. The posttest mean interest ratings for the experimental group is 3.63 with standard deviation of 0.23 while the posttest mean interest ratings for the control group is 2.74 with standard deviation of 0.40. The mean difference of both groups at posttest is 0.89. The large difference noticed between the groups at posttest is an indication of the effect of 4MAT on interest in Geometry of the experimental group. Also, it can be seen that mean gain of experimental is 2.29 while that of control is 1.47 giving mean gain difference of 0.82 in favor of the experimental group. The implication of this result is that SS1 students taught Geometry using 4MAT gain higher interest in Geometry than SS1 students taught Geometry using conventional method.

Hypothesis 1

There is no significant difference in the mean interest ratings of SS1 students taught Geometry with 4MAT and those taught with conventional method.

TABLE 2: ANCOVA RESULTS OF GEOMETRY INTEREST RATINGS OF SS1 STUDENTS IN EXPERIMENTAL AND CONTROL GROUPS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	27.773[a]	2	13.887	135.891	.000	.663
Intercept	26.146	1	26.146	255.856	.000	.650
PRE-GII	.151	1	.151	1.481	.226	.011
Group	**26.240**	**1**	**26.240**	**256.780**	**.000**	.650
Error	14.102	138	.102			
Total	1513.680	141				
Corrected Total	41.876	140				

Results from Table 2 shows that the table values for group is F(1, 138) =256.78, Sig =0.00 =p. Since p <0.05 the null hypothesis is rejected. This means that there is significant difference between the mean interest ratings of SS1 students taught Geometry using 4MAT and those taught using conventional method. This result implies that the SS1 students taught Geometry using 4MAT improved on their interest in Geometry more than SS1 students taught Geometry using conventional method.

Research question 2

What are the mean interest ratings of male and female SS1 students taught Geometry using 4MAT?

TABLE 3: MEAN AND STANDARD DEVIATIONS OF INTEREST RATINGS OF MALE AND FEMALE SS1 STUDENTS TAUGHT GEOMETRY USING 4MAT

Groups	N	Pre-GII Mean	SD	Post-GII Mean	SD	Mean Gain
Male	43	1.32	0.20	3.63	0.23	2.31
Female	35	1.36	0.21	3.62	0.24	2.26
Mean Difference		0.04		0.01		0.05
Total	78					

Results for Table 3 revealed that the pretests mean interest ratings of 43 male SS1 students in experimental group is 1.32 with standard deviation of 0.20 and 35 female SS1 students is 1.36 with standard deviation of 0.21. The mean difference of male and female at pretest is 0.04. The small difference noticed between male and female at pretest means that interest in Geometry of both groups before commencements of treatment were similar. The posttest mean interest ratings for male students is 3.63 with standard deviation of 0.23 while the posttest mean interest ratings for female students is 3.62 with standard deviation of 0.24. The mean difference of both groups at posttest is 0.01. The smaller difference noticed between male and female at posttest is an indication that 4MAT has no differential effect on interest in Geometry of male and female SS1 students. Also, it can be seen that mean gain of male is 2.31 while that of female is 2.26 giving small mean gain difference of 0.05. The implication of this result is that interest in Geometry of SS1 students taught Geometry using 4MAT does not depend on gender.

Hypothesis 2

There is no significant difference in the mean interest ratings of male and female SS1 students taught Geometry using 4MAT.

TABLE 4: ANCOVA RESULTS OF GEOMETRY INTEREST RATINGS OF SS1 MALE AND FEMALE STUDENTS TAUGHT GEOMETRY USING 4MAT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.089[a]	2	.045	.837	.437	.022
Intercept	20.210	1	20.210	378.777	.000	.835
Pre-GII	.086	1	.086	1.608	.209	.021
Sex	**.008**	**1**	**.008**	**.148**	**.701**	.002
Error	4.002	75	.053			
Total	1031.107	78				
Corrected Total	4.091	77				

Results from Table 4 shows that the table values for groups is F(1, 75) =.148, Sig =.701 =p. Since p >0.05, the null hypothesis is not rejected. This means that there is no significant difference between the mean interest ratings of male and female SS1 students taught Geometry using 4MAT. This indicates that both male and female SS1 students taught Geometry using 4MAT equally improved on their interest in Geometry. The result implies that 4MAT instructional model is not gender dependent in terms of SS1 students' interest in in geometry.

Research question 3

What is the interaction effect of method and gender on SS1students' interest in Geometry?

Figure1:

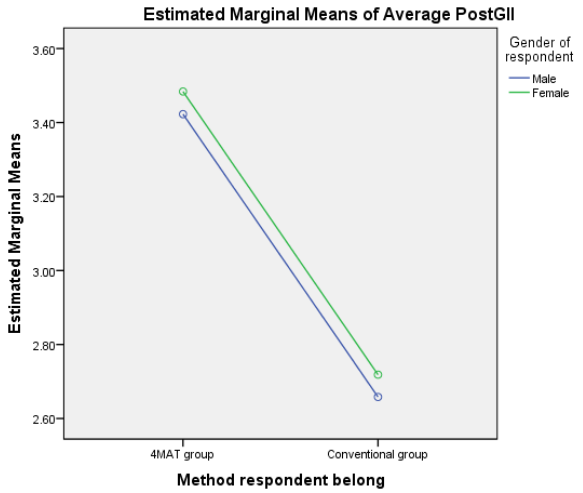

Figure 1 shows that there is a linear relationship in the interest ratings of male and female students in learning geometry using 4MAT. In the interaction graph of method and gender, the two lines representing interest ratings of the male and female variables of gender are both

parallel to one another. The parallel lines are indications that there is no interaction effect of method and gender on students' interest in learning Geometry. In other words, it is an indication that SS1 students' interest in learning geometry using 4MAT is not dependent on gender.

Hypothesis 3

There is no significant interaction effect of methods and gender on SS1 students' interest in Geometry.

TABLE 5: ANCOVA RESULTS OF INTERACTION EFFECT OF METHOD AND GENDER ON SS1 STUDENTS' INTEREST IN GEOMETRY

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Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	33.131[a]	4	8.283	63.722	.000	.652
Intercept	2.087	1	2.087	16.053	.000	.106
Method	18.875	1	18.875	145.215	.000	.516
Pre-GII	7.715	1	7.715	59.354	.000	.304
Method * Gender	.124	2	.062	.477	.621	.007
Error	17.678	136	.130			
Total	1411.204	141				
Corrected Total	50.809	140				

a. R Squared = .652 (Adjusted R Squared = .642)

Results from Table 5 reveals that the interaction Method * Gender: F(2, 136) = 0.477, Sig = 0.621 = P > 0.05, $\eta^2_{partial}$ = 0.007. The $\eta^2_{partial}$ = 0.007 shows 0% variance in male and female mean interest ratings in Geometry due to the use of 4MAT. Thus, the null hypothesis is not rejected. This indicates that there is no significant interaction effect of method and gender on SS1 students' interest in geometry. The implication of this result is that SS1 students' interest in Geometry was either little or not affected by their gender factor when they were taught the subject using 4MAT instructional model. In other words, with the use of 4MAT instructional model, SS1 students' interest in learning Geometry is not dependent on gender.

Discussion of Findings

The findings of this study showed that SS1 students improved on their interest in Geometry due to the use of 4MAT instructional model during the period of this study in the course of their Geometry class lessons. Results for table 2 revealed that there is significant difference between the mean interest ratings of SS1 students in the experimental group taught Geometry using 4MAT and the mean interest ratings of SS1 students in the control group taught Geometry using conventional method. This result indicates that 4MAT instructional model is a significant factor and a better method in enhancing students' interest than the conventional method. This finding agrees with the study conducted by Onah (2015), who found that significant difference in mean interest ratings existed between the experimental and control groups in favor of the experimental group, when senior secondary students were taught set theory using an an innovative instructional method like 4MAT. Similarly, the result is in agreement with the research conducted by Age (2021), with the finding that there was significant difference between the mean interest ratings of SS1 students taught Geometry using GeoEnZo method of instruction, and those taught without it.

Furthermore, the findings in this study revealed that both male and female students' interests in Geometry were equally significantly enhanced in the experimental group. In other words, the use of 4MAT instructional model to teach Geometry favored both male and female SS1 students, though, with a slightly higher mean interest rating of the male students than their female counter parts noticed in table 3. Results in table 4 however, confirm that this difference is not statistically significant. This finding agrees with Studies such as Onah (2015), Fiase (2016), who found in their various studies that gender has no significant effect on students' interest in the various school subjects of their studies.

Finally, the findings of this study showed that there is no interaction effect of method and gender on students' interest in Geometry. Evidence from table 5 and interaction graph Fig.1 revealed that there is no statistically significant interaction effect of methods of instruction and gender on SS1 students' interest in Geometry. This indicates that the interest of SS1 students in Geometry was not affected by their gender factor irrespective of the method used in the teaching of Geometry. In other words, the combined effect of 4MAT model and Conventional method did not have a significant differential gender effect on SS1 students' interest in geometry. Therefore shows that 4MAT instructional model is not gender bias. This result is in agreement with the study conducted by Age(2021), who found that gender had no significant interaction effect on senior secondary students' interest in Geometry using GeoEnZo instructional strategy. The result, however, is in contrast with the study conducted by Onah (2015), who found that there was a significant interaction effect of methods and gender on students' interest when a Multimedia Projection method was used to teach Set theory to senior secondary students.

Conclusion

Based on the results of the study, it was concluded that: The use of Four-Mode Application Technique (4MAT) model in the teaching and learning of Geometry proved to be better than the conventional method in enhancing students' interest in Geometry. Also there was no significant interaction effect of gender on students' mean

Interest rating scores in Geometry when taught using 4MAT.

Recommendations

Based on the findings of this study, it was recommended that

I. Mathematics teachers should be encouraged to use 4MAT instructional model in teaching difficult concepts like geometry since its use has been found to enhance students' interest.

II. School Administrators and Mathematics teachers should focus on more effective teaching strategies that promote students' interest which results in better understanding, especially through their involvement in the learning activities.

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