Effects of Four-Mode Application Technique (4MAT) on Students' Academic Performance in Basic Science and Technology in Uyo, Akwa Ibom State

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Abstract
This study investigated the effects of Four – Mode Application Techniques (4MAT) on Students' Academic Performance Basic Science and Technology in Uyo. To achieve the objectives of this study, three research questions and three hypotheses were formulated to guide the study. The pre-test post-test control group design was adopted for the study. One hundred and thirty (130) junior secondary two (JSS2) students from two intact classes in two public secondary schools in Uyo formed the sample of the study. The instrument used for data collection was Basic Science and Technology Performance Test (BSTPT) on Simple Machines. The instrument was validated and subjected to split half method for reliability determination. Its reliability co-efficient was 0.80 obtained using Spearman Brown Formula. The BSTPT was used for pretest and posttest. Students in the experimental group were taught simple machines using 4MAT while those in the control group were taught using expository technique. The data obtained after treatment were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). All the hypotheses were tested at 0.05 level of significance. The results showed that students taught simple machines using four mode application technique performed significantly better than those taught using expository technique. Gender had no significant effect on students` academic performance in the concept of simple machines when taught using 4MAT and expository technique. Based on the findings, it was recommended among others that Basic Science and Technology Teachers should always make effective use of 4MAT in teaching perceived difficult concepts in Basic Science and Technology curriculum such as simple machines.

Key Words: Four -Mode Application Techniques (4MAT), Students' Academic Performance, Basic Science and Technology.

Introduction

Science is the regular observation of all the events that occur in nature. It is the foundation upon which the bulk of present-day technological breakthrough is built (Onasanya & Omosewo, 2011). Buseri (2013) defined science as knowledge acquired by careful observation and deduction of the laws which govern changes and conditions and by testing these deductions through experiment. Owolabi (2014) noted that science is an integral part of human society. Its impact is felt in every sphere of human life, so much that it is intricately linked with a nation's development. Science as a field of study has done a lot for mankind. For instance, life has been made a lot easier for man as a result of the advancements in science. Onasanya and Omosewo, (2011) stated that, through science, man has been able to better

understand his environment and this has enabled him to manipulate the conditions of his environment to suit his own benefit and acquire his desired needs easily.

Science education in the same vein is the application of learning theories especially those based on the philosophical, sociological and psychological perspectives in the endless search for knowledge, resulting in the development of the cognitive, affective and psychomotor domains through systematic processes involving careful observation, deduction and testing by empirical means (Buseri, 2011). Science education comprises of five basic disciplines. These are; Physics, Chemistry, Mathematics, Biology and Integrated science (basic science and technology).

Basic science and technology formally known as integrated science is a beginners' science course taught in primary and junior secondary schools in Nigeria. It combines both science and technology practices to enable the Nigerian child develop powerful tools for understanding and interpreting the world as well as providing solutions to the problems of human adaptation to the environment (Archibong, 2014). Pius (2013) stated that Basic science and Technology is a course that relates to basic discovery/inventions in the field of science. It is the knowledge of knowing about facts. The goal of Basic Science and Technology is to provide a sound foundation for the study of science in the junior secondary school level and beyond (Senese, 2010). A lot of activities are centered on the study of Basic science and Technology in the sense that Basic science and Technology play a key role in everyday life such as; information technology revolution, development of sophisticated machines, understanding of the molecules and atoms, development of drugs and inventions of medical devices use in curing and alleviating diseases, prolong life span and making of tools (Janet, 2012 and Caleb, 2015).

It is observed that despite the importance of Basic Science and Technology and government efforts to encourage and sustain the teaching of science in secondary schools starting from the Junior level, there had been public outcry on students' poor academic performance in the subject in both internal and external examinations. The question now is, what are the factors responsible for the poor academic performance of students in Basic Science and Technology and how can it be remedied? According to John (2014), many factors are responsible for the poor academic performance of students in science subjects. These factors are teacher related, school related and students related.

Among the teacher related factors is the aspect of teaching method. According to Wilfred (2013), Basic science and technology teachers have used a number of teaching strategies in the past, such methods include, expository, questioning and discussion methods which have not yielded positive results. This may be because they are all teacher centered and do not arouse the interest of the learners. Ahmed and Abimbola (2011) asserted that the teacher centered methods adopted by teachers at junior secondary school level in Nigeria have led to abstractness. This makes the students less active in the learning process and more prone to rote memorization which makes it difficult for them to understand most basic science and technology concepts and apply the knowledge and skills to solve their day-to-day problems. Etukudo (2009), highlighted some teaching and learning techniques that could be employed in the teaching and learning of science concepts effectively. One of these techniques is the four-mode application technique (4MAT).

The four-mode application technique (4MAT) is a conceptual model of teaching and learning developed by Bernice McCarthy in 1987. Its premise is that individuals learn primarily in one of four different, but complementary ways based on how they perceive and process information (McCarthy & McCarthy, 2006). It is a process for conveying instructions in a way that involves, informs, and permits practice and creative use of material learned within each class (Lee & Lee, 2013).

The 4MAT teaching model is grounded in the works of John Dewey (experiential learning), Carl Jung (theory of individualization), and, most directly, David Kolb (experiential learning theory). The 4MAT system aids instructors to organize their teaching based on individual differences in the way people learn. It reflects the learning process as a journey by asking four simple questions; **why? what? how? and if?**

Why question pursues a reason or motivation for learning,

What question searches for knowledge and information,

How question tries to find a way for applying the knowledge and

If question develops extensions for the learners to generate new experiences regarding the learned material (Guild & Garger, 2010).

4MAT system is made up of eight step cycle of instruction that capitalizes on individual learning styles and brain dominance processing preferences. These steps could be named as create an experience (connect), examine (attend), imagine, define (inform), try (practice), extend, refine and perform (Nicoll-Senft & Seider, 2012).
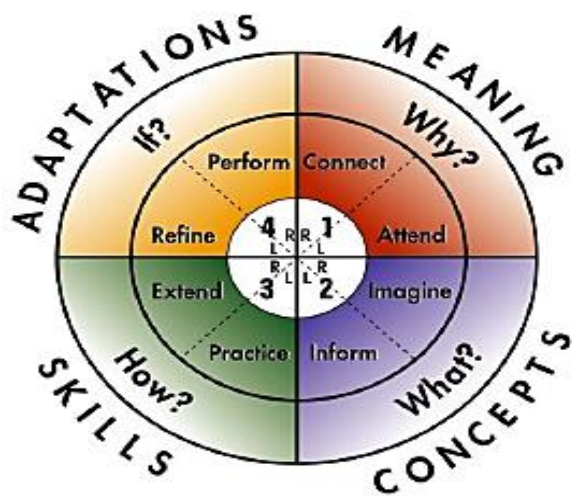

Figure 1: The 4MAT Teaching Mode
Source: www.4matonweb.com, 2013

Figure 1 shows the eight quadrants of 4MAT system. The system considers the style that each student brings to the classroom and helps the students to develop learning skills by mastering the entire cycle of learning in the model (McCarthy, 1997). The first quarter and the first step is "connect", and its second step is "attend or examine"; the second quarter includes the third step, "imagine" and the fourth step, "inform or define". Its third quarter includes the fifth step: "practice", and the sixth step, "extend". Its fourth quarter includes the seventh step, "refine", and the eighth step, "perform or integrate". The first and second steps of the first

quarter are where students use their experiences. The aim of this stage is to make connections between the student's environment and concepts. The fundamental question at this stage is "**Why?**" The third and fourth steps of the second quarter are where individuals learn what a concept is. Students analyze their experiences and shape concepts. The fundamental question at this stage is "**What?**" The fifth and sixth steps of the third quarter are the stages where students implement the concepts and learning is individualized. The fundamental question at this stage is **"How?"** The seventh and eighth steps of the fourth quarter are the stages where practice and experience are integrated. The fundamental question of this stage is **"If?"** (Şeker & Dikkartın, 2018).

McCarthy and McCarthy, (2006) stated that during the application of the 4MAT, several methods and techniques like; sample case, brainstorming, concept cartoons, group-work, experiment, project assignments, worksheets should be used. The features and application of the steps of 4MAT teaching method highlighted by McCarthy & McCarthy, (2006) is as explain below:

Step 1 (Connect/create an experience): The activities to be chosen for this step should help to reveal alternative opinions of the students. During the application, the students should participate in activities individually or in groups. They should be asked to exchange ideas using activities such as; sample case, motivational stories, concept cartoons among others. They should also be asked to write the things they know about the concept being discussed.

Step 2 (Attend/ Examine): In this step, the aim is to make students share their opinions across the classroom about the activity in Step 1. In this way, the misconceptions that the students have will emerge. During this application, the students should enrich the topic by giving examples other than the activity and associate the topic with daily life more deeply.

Step 3 (Imagine): This step is a step for transformation of personal experience into scientific knowledge. In this step, the teacher should foster the cognitive struggle by exposing the students with different examples that contradict the explanations of the students. Techniques like, lecturing, question/answer, discussion and modeling should be used.

Step 4 (Inform/define): In this step, the teacher should explain scientific information by using techniques such as lecturing, problem solving and concept maps.

Step 5 (Practice): The students should be allowed to work together. In this way, various activities should be introduced in order for the students to practice using the knowledge given during the previous steps to deal with continuing misconceptions effectively. These activities can be in form of worksheets, concept cartoons, open-ended problems and sample case etc. The students should be given time to think about the activities done during the lesson and opportunity to make joint decisions.

Step 6 (Extend): The students should be organized to do experiments in groups and report their findings in prepared experiment sheets. Then they should be expected to associate the things they learned with the results of the experiments.

Step 7 (Refine): The aim of this stage is to make students apply what they have learned in their daily life. During the application, the teacher assigned the students to research by giving open-ended questions, explanations about the situations faced in daily life, performance and project tasks and made them to present the research results. This step anticipates that during their research students will be able to overcome the misconceptions they have via facing with their false ideas and realizing the scientific facts again and again.

Step 8 (Integration/perform): This step is the step students teach themselves and their friends. In this step, the students gave presentations and answered the questions from other students. The prepared assignments should be put on the classroom walls so that they can be available. It is assumed that students learn better when they are teaching their peers.

The use of the 4MAT teaching model is supported by research in elementary and secondary levels of education and more recently in higher education classrooms (Uyangor, 2012; Osama *et al.,* 2015; Şeker, & Ovez, 2018). Uyangor (2012) investigated on the effectiveness of the 4MAT teaching model upon 7th grade level students` achievement and attitude in mathematics in Turkey and reported that 4MAT method of instruction was more efficient in enhancing students' achievement than the traditional method.

Seker and Ovez (2018) investigated the Integration of the 4MAT Teaching Model with the Interdisciplinary Structure in primary school level and found that the attainment level of pupils and their mean scores significantly favoured the 4MAT group. They also found that education with the 4MAT model effectively and fully attained the learning aims and achievement and that the scores differed in the control group according to their learning styles.

Osama, *et al.* (2015) examined the effect of 4MAT method on academic achievement and attitudes toward engineering economy for undergraduate students and concluded that students who are guided through 4MAT were exposed to a variety of learning experiences and increased chances for academic achievement and attitudes toward engineering economy. Osama *et al*. (2015) added that, the application of 4MAT in engineering classroom led to renewed interest for the educational process and a greater commitment to teaching and learning. It was on these bases that the researcher needed to experiment the effectively of this great teaching/learning technique on the academic performance of students in Basic Science and Technology.

Statement of the Problem

In spite of the importance of Basic Science and Technology and its applications to everyday life, its teaching and learning as well as students' poor academic performance have become a source of concern to all educational stakeholders. It is observed that students in junior secondary schools are performing below expectation in the subject in both internal and external examinations owing to improper teaching methods use by teachers to deliver instructions. Most basic science and technology teachers in our schools used lecture and discussions methods most frequently in their classrooms. They present facts and principles contained in textbooks and students are rarely involved in practical exercises. This may weaken the concentration of students in the class as they are not actively involved in the learning process and as such do not understand the lesson being taught so that they can apply the knowledge when needed. The question now is: can the use of Four Mode Application Techniques (4MAT) enhance students` concentration in the learning process and improve their performance in Basic science and technology? Thus, this study is conducted to determine the effects of Four Mode Application Techniques (4MAT) on students' academic performance in Basic science and technology in Uyo Local Government Area.

Purpose of the Study

The purpose of this study is to determine the effect of Four Mode Application Techniques (4MAT) on students` academic performance in Basic science and technology in Uyo Local Government Area.

Specifically, the study sought to:

1. Find out the mean differences in the academic performance of students taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository method.
2. Assess the mean difference in the academic performance of male and female students taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository method.
3. Find out the interaction effects of techniques and gender on students` academic performance in the concept of simple machines.

Research Questions

The following research questions guided the study

1. What differences exist between the mean academic performances of students` taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository method?
2. What differences exist between the mean academic performance of male and female students taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository technique?
3. What is the interaction effect of techniques and gender on students' academic performance in the concept of simple machines?

Research Hypotheses

The following hypotheses were formulated to guide this study

1. There is no significant difference between the mean academic performance of students taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository technique.
2. There is no significant difference between the mean academic performance of male and female students taught simple machines using Four Mode Application Techniques (4MAT) and those taught using expository technique.
3. There is no significant interaction effects of techniques and gender on students' academic performance in the concept of simple machines.

Methodology

The design of the study was quasi-experimental research design. Specifically, the non-randomized pre-test- posttest control group design was used. The study was carried out in Uyo Local Government Area of Akwa Ibom State. The population size of this study was six thousand one hundred and twenty-three (6123). It consisted of all the JSS2 Students in the fourteen public secondary schools in Uyo Local Government Area in the 2019/2020 academic session. The choice of upper basic two (JSS2) students for this study is based on the fact that the concept simple machines is taught in this class. The sample size of the study was 130 JSS2 students. The students were drawn from two (2) intact classes in two (2) public secondary schools in Uyo Local Government. Simple random sampling technique was used in selecting

the two schools from the existing fourteen public secondary schools in Uyo. The two randomly selected schools were assigned as experimental and control groups respectively by balloting, which pieces of paper serve as ballot.

A researcher-made instrument tagged: Basic Science and Technology Performance Test (BSTPT) was used for data collection. BSTPT was designed to measure the students' performance in the concept of simple machines. It contained 20 multiple choice items with four options A–D and two sections. The first section contained the student details such as serial number, gender, class and school name, while the second section consisted of four options multiple choice items. The objectives of the sub-topics in the Basic science and Technology curriculum served as a guide for developing the questions.

The draft of the Basic Science and Technology Performance Test (BSTPT) was subjected to face and content validation and difficulty and discrimination indices determination. The face validation was done by subjecting the draft of the instrument which contains thirty (30) items to thorough scrutiny by experts-two experienced basic science and technology teachers, two lecturers in the Department of Science Education University of Uyo and a specialist in test, measurement and evaluation in the Department of Educational Foundations Guidance and Counselling University of Uyo to check for appropriateness of the items in terms of the clarity of language used, content coverage, appropriateness to the level of the students and adequacy in addressing the objectives and problems being investigated. Their comments, suggestions and corrections were used in selecting and restructuring some of the items. The content validation of the Basic Science and Technology Performance Test was carried out using the Table of Specification.

The reliability of the Basic Science and Technology Performance Test (BSTPT) was carried out using the split half method of reliability determination. Its reliability co-efficient was 0.80 obtained using Spearman Brown Formula. The researcher visited the two schools selected for the study and obtain permission from the school authorities to use their schools for the study and also solicited for the co-operation of the Basic Science and Technology teachers in each of these schools to assist as research assistants.

The research assistants were trained for one week on how to teach their respective groups using the validated lesson packages developed by the researcher. This is to ensure compliance and effective lesson delivery. In order to account for possible pre-existing differences in overall knowledge level of students in concept of simple machines between the two groups, the Basic Science and Technology Performance Test (BSTPT) were administered as pretest to the two groups and the data were used as covariate measures. After that, the students in the two groups were taught simple machines by the research assistants using the validated lesson packages prepared by the researcher. Students in experimental group were taught simple machines using 4MAT technique while those in the control group were taught with expository method. The teaching of the concept lasted for two weeks.

After the teaching, the re-shuffled version of the BSTPT used as pretest was administered as posttest to the two groups to measure the effect of the treatment on students' performance. The test scripts were collected, scored and analyzed. The entire exercise was strictly monitored by the researchers. The data collected from the study were analyzed using Mean and Standard Deviation to answer the research questions and Analysis of Covariance (ANCOVA) were used to test the hypotheses at 0.05 level of significance.

Results

The Results of this study is organized under research questions and hypotheses.

Answers to Research Questions

Mean and standard deviation were used to answer the research questions.

Research Question 1: What is the difference between the mean academic performance score of students taught simple machines using 4MAT and those taught using expository technique?

Table 1: Mean and Standard Deviation of Students' Posttest Scores Taught Simple Machines Using 4MAT and Expository Technique with Pretest as Covariate

Techniques	N	Pretest $\overline{X}$	Pretest SD	Posttest $\overline{X}$	Posttest SD	Mean Gain	Mean difference
4MAT	68	5.74	1.74	11.47	2.00	5.73	1.75
Expository Technique	62	6.29	1.81	10.27	2.04	3.98	

As shown in Table 1, the mean gain performance score of students taught simple machines using 4MAT is 5.73 while that of those taught using expository technique is 3.98. This indicates that students taught simple machines using 4MAT performed better than those taught using expository technique with a mean gain difference of 1.75.

Research Question 2: What difference exist between the mean academic performance score of male and female students taught simple machines using expository technique and those taught using 4MAT?

Table 2: Mean and Standard Deviation of Male and Female Students' Posttest Scores Taught Simple Machines Using Expository Technique and 4MATwith Pretest as Covariate

Technique	Gender	N	Pretest $\overline{X}$	Pretest SD	Posttest $\overline{X}$	Posttest SD	Mean Gain
4MAT	Male	33	5.70	1.83	11.73	2.16	6.03
	Female	35	5.77	1.68	11.23	1.85	5.46
Expository Technique	Male	29	6.52	1.92	10.38	1.78	3.86
	Female	33	6.09	1.72	10.18	2.27	4.09

As shown in Table 2, the mean gain performance score of males taught simple machines using 4MAT is 6.03 while that of their female counterparts is 5.46. Comparing these mean gains scores 6.03 and 5.46 of male and female students taught simple machines using 4MAT respectively indicates that the use of 4MAT is more effective for male students when compared to their female counterparts.

Table 2 also showed that the mean gain performance score of male students taught simple machines using expository technique is 3.86 while that of their female counterparts is 4.09. Comparing these mean gains scores 3.86 and 4.09 of male and female students taught simple machines using expository technique respectively indicates that the use of expository technique is more effective for female students when compared to their male counterparts.

Research Question 3: What is the interaction effect of techniques and gender on students' academic performance?
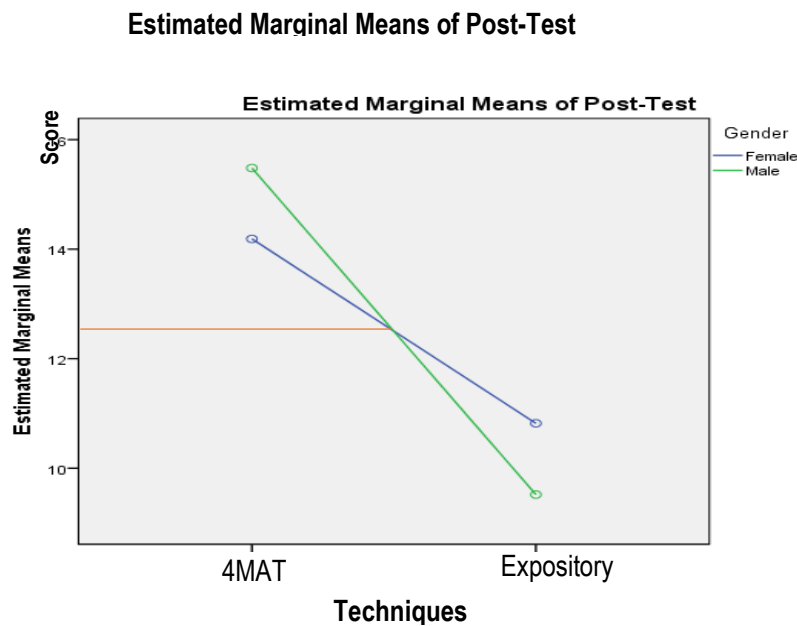
Estimated Marginal Means of Post-Test

Figure 2: Interaction Effect of Technique and Gender on Students

Source: *Field Work 2023*

As shown in Figure 2 there is interaction effect of technique and gender on students' academic performance in the concept of simple machines. The point where the two slopes crosses each other (12.45) is the point of interaction.

Hypotheses Testing

The hypotheses were tested using Analysis of Covariance (ANCOVA).

Hypothesis 1: There is no significant difference between the mean academic performance score of students taught simple machines using expository technique and those taught using 4MAT.

Table 3: Analysis of Covariance (ANCOVA) of Students` Post-test scores Classified by Technique with Pretest scores as Covariate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	265.919ᵃ	2	88.640	11.285	.000	*
Intercept	1592.949	1	1592.949	202.804	.000	*
Pretest	.066	1	.066	.008	.927	*
Technique	170.299	1	85.150	10.841	.000	S
Error	1146.774	127	7.855			
Total	52344.000	130				
Corrected Total	1412.693	129				

R Squared = .188 (Adjusted R Squared = .172)   *Significant at .05 alpha level

As shown in Table 3, the calculated P-value (.000) of the main effects of techniques is less than the significant level (.05). Therefore, the null hypothesis is rejected. This implies that there exists significant difference between the mean academic performance score of students taught simple machines using expository technique and those taught using 4MAT.

Null Hypothesis 2: There is no significant difference between the mean academic performance score of male and female students taught simple machines using expository technique and those taught using 4MAT.

Table 4: Analysis of Covariance (ANCOVA) of Students` Post-test scores Classified by Gender with Pretest scores as Covariate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	.580[a]	2	.290	.037	.963	*
Intercept	1590.210	1	1590.210	204.252	.000	*
Pretest	.289	1	.289	.037	.848	*
Gender	.304	1	.304	.039	.844	NS
Error	365.920	127	7.786			
Total	15331.000	130				
Corrected Total	366.500	129				

Source: Field data (2021).

As shown in Table 4, the calculated P- value .844 is greater than the alpha level .05. Therefore, null hypothesis two is retained. This implies that there exists no significant difference between the mean academic performance score of male and female students taught simple machines using expository technique and those taught using 4MAT.

Null Hypothesis 3: There is no significant interaction effect of techniques and gender on students' performance.

Table 5: Analysis of Covariance (ANCOVA) of the interaction effect of techniques and gender on Students` Performance with Pretest scores as Covariate.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	386.866[a]	4	96.716	8.348	.000	.326
Intercept	1140.634	1	1140.634	98.451	.000	.588
Technique	.000	1	.000	.000	.996	.000
Gender	370.618	1	370.618	31.989	.114	.317
Technique* Gender	29.757	1	29.757	2.568	.000	.036
Pretest	10.336	1	10.336	.892	.348	.013
Error	799.418	127	11.586			.326

Total	12649.000	130		.588
Corrected Total	1186.284	129		

a. R Squared = .314 (Adjusted R Squared = .295)   *Significant at .05 alpha level.

As shown in Table 5, the calculated p-value (.00) of techniques and gender is less than the significance level (.05). Therefore, the null hypothesis is rejected. This implies that there exists a significant interaction effect of technique and gender on students' performance in the concept of simple machines.

Discussion of Findings

The findings on the difference between the mean academic performance score of students taught simple machines using 4MAT and those taught using expository technique indicated a significant difference. Students taught simple machines using 4MAT performed better than those taught using expository technique. The findings could be attributed to 4MAT being able to provide opportunities for students to perform various hands-on-activities thereby enabling students to use their minds to discover general laws and principles of science. The technique promotes conceptual change, motivation and excitement for enriching the learning of the concept "simple machines" resulting in enhancement of students' performance. The ability of 4MAT to make difficult and abstract concepts real, remove misconception, ignite, increase and sustain student interest in the lesson may have enhanced students' academic performance. It may also be that 4MAT was able to develop the students as independent learners, who worked at their own pace and level. The findings of this study is in line with that of Uyangor (2012) who investigated on the effectiveness of the 4MAT teaching model upon 7th grade level students` achievement and attitude in mathematics in Turkey. The results showed that 4MAT method of instruction was more efficient in enhancing students' performance than the traditional method.

The findings on the difference between the mean academic performance scores of male and female students taught simple machines using 4MAT and expository technique indicated no significant difference. The absence of a significant difference might be due to both male and female students freely interacting in class at this level with each other which resulted to a better understanding, motivation, and development of problem-solving technique. The finding of the study is in line with that of Godpower-Echie and Wisdom, (2019) who investigated gender differences in achievement of basic science students in private secondary schools in Obio/Akpor Local Government Area of Rivers State and reported that gender did not significantly influence students' achievement in basic science in private secondary schools.

The findings on the interaction effect of strategies and gender on students' performance in simple machines indicated a significant interaction. This indicates that the effect of technique and gender on each other is the same at all levels of the other factor (academic performance). The finding of this study is in agreement with that of Ukpai *et al*., (2016), who reported interaction between gender and teaching methods on students' achievement in basic science.

Conclusion

Based on the findings of this study, it was concluded that the use of 4MAT in teaching simple machines facilitate student's academic performance than expository technique. Gender was not a significant determinant of students' academic performance in Basic Science and Technology.

Recommendations

Based on the findings and the conclusion reached, the following recommendations were made:

1) Basic Science and Technology teachers should use 4MAT in teaching the concepts simple machines in Basic Science and Technology curriculum.

2) The Government and school administrators should ensure that all schools are adequately equipped with relevant materials necessary for carrying out practical work effectively.

3) Curriculum planners should include adequate practical activities in the basic science and technology curriculum and provide teaching guides for use by Basic Science and Technology teachers to engage students with practical activities when teaching Basic Science and Technology concept.

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