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EFFECTS OF FOUR MODE APPLICATION TECHNIQUE ON PHYSICS STUDENTS' ACADEMIC ACHIEVEMENT AND RETENTION IN MECHANICS IN UNGOGO LOCAL GOVERNMENT, KANO STATE-NIGERIA

[1]TASIU AMINU; [2]MOHAMMED ABDULLAHI; [3]EMMANUEL ABUBAKAR SOJE; [4]SADDIQA ALIYU LAWAL; & [5]SUMAYYA ALIYU HAMZA

[1,2,3]Kaduna State College of Education Gidanwaya.
[4]Bayero University, Kano, [5]Kano State College of Education and Preliminary Studies

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ABSTRACT

This study examined the effects Four Mode Application Technique on Physics students' academic achievement and retention in Mechanics in Ungogo Local Government, Kano state-Nigeria. A pretest, posttest and posttest quasi-experimental research design was adopted for the study. A population of 6,317 SS II students was used for the study. Stratified

INTRODUCTION

The technological advancement of any nation depends on science and technology. Without a concrete foundation in the science, no nation can attain its developmental goals in this scientific world. One of the major pure science subjects in the secondary schools system in Nigeria is physics. Physics is the part of science that deals with the behaviour of matter (Nelkon, 2013). According to Akpokiniovo (2022), Physics is the study of the basic laws of nature, their applications to the real world and the relationships among the laws. Physics is a branch of pure science that deals with the study of

random sampling technique was used to select four (4) schools out of 26 with two male intact classes and two female intact classes with sample size of 194 students (95 male and 99 female). Instrument titled Mechanics Achievement Test (MAT) was faced and content validated by experts; the reliability coefficient of the instrument was found to be 0.81 via test retest using PPMC. Mean and standard deviation were used to answer the research questions, while ANCOVA was used to test the hypotheses at 0.05 level of significance. The results revealed that students taught using 4MAT performed better than those taught using traditional method, it also revealed that there is significant difference in the achievement scores of male and female students taught using 4MAT in favour of male students. Students taught using 4MAT have higher retention than those taught using traditional method. Based on the findings, it was recommended that physics teachers should include the use of 4MAT in teaching Physics in senior secondary schools.

Keywords: 4MAT, Academic achievement, Gender, Mechanics, Retention.

matter in relation to energy. Physics have many branches of which some are electricity, heat, sound, properties of matter, waves and wave optics and atomic physics among others. Many of the invention, appliances, tools, and buildings we live with today are made possible by the applications of physics principles. Above all, Physics is a prerequisite for admission into universities to read science related courses such as medicine, engineering, computer science, pharmacy, building and many others.

One of the major branches of physics in secondary school is Mechanics. Mechanics is the branch of physics that deals with the study of motion, forces and energy. It is concerned with the analysis of the motion of bodies or objects, the forces that cause this motion, change the direction of the motion or even stop the motion, it is also concerned with the energy auspicated with the motion. Mechanics has four branches: kinematics (which deals with the study of motion without considering the forces that causes it), Dynamics (deals with the study of motion under the action of forces), Statics (which deals with the study of body at equilibrium or at rest) and thermodynamics (focus on the study of heat, temperature and energy

transfer. Mechanics is that branch of Physics that goes hand in hand with mathematics, so, to teach Physics effectively precisely mechanics, teachers needs to employ methods including students-centered methods that will enable the students to learn more, retain more and apply what is learned by engaging in significant activities, 4 Mode Application Technique teaching strategy can be good in this aspect.

Four Modes Application Technique (4MAT) is a conceptual framework of teaching and learning that operates based on experiential learning theory by David Kolb 1984 (Joan & Susan, 2010). Guzman and Guzman (2011) define 4MAT as a process for delivering instruction in a way that appeals to all types of learners and engages, informs, allows for practice and creative use of material learned within each lesson. It is based on the fact that different individuals perceives and process experience in different preferred ways. Nikolaou and Koutsouba (2012) stated that 4MAT operates with a cyclic environment using 8-steps lesson plan that is followed in logical order. These steps could be named as create an experience, examine, image, define, try, extend, redefine and integrate. 4MAT asserts that individuals learn basically in one of the four different but complementary learning styles (McCarthy & McCarthy, 2006). It is a system of conveying information or instruction in a way that involves permits and informs practice and creative use of materials learned within the class. The model considered learning process as a journey by asking four simple questions. Why? What? How? and If? Why question seeks a reason or motivation for learning, what question seeks for information and knowledge, how question seeks to find a way of applying the knowledge or information gained and if question develops extensions for the students to bring out new experiences from the learned materials (Osama, Fahad & Ayman, 2016). This teaching strategy is of the view that, there are four (4) learning styles to recognize and process the received information.

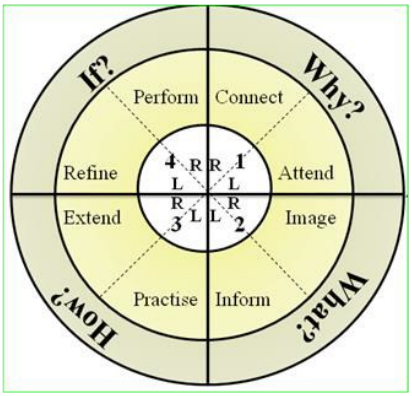

Figure 1: Cycle showing steps of 4MAT teaching strategy. (Handan & Vedat, 2015)

In this study the process or steps involves in Four Modes Application Techniques (4MAT) used by Protoomtong (2011) and Handan and Vedat (2015) was used to prepare Mechanics learning activities and ascertain its effects on the students' achievement and retention in Mechanics among

Physics secondary schools in Ungogo local government of Kano State.

Academic achievement is the extent to which learners have gained from a particular course of instruction. According to Lucy (2015), Academic Achievement is a measure of what a person has accomplished after might have expose to educational program. Ezeudu (2013) and Okoye (2012) opined that active participation of students during teaching and learning increases students' academic achievement and retention. Jimoh (2010) observed that students' academic achievement corresponds to their performance in school subjects as symbolized by a score on an achievement test. Fatokun, Egya and Okeke (2011) observed that the students' achievement is dependent on several factors among which are learning environment and instructional methods. Teachers with good teaching strategy challenge students to work at higher intellectual level, attain sound academic achievement and better knowledge retention.

Retention is an individual's ability to remember and recall learned information, materials and experiences over a time. Okoye (2012) defines retention as the process of maintaining the available new meaning or part of them. Human memory is imperfect and fragile as a result periodic review is required for the long-term retention of knowledge, information and skills. The learned materials in mind need to be preserved in form of image. If retention needs to be maintained, a stimulating situation must occur, so that the retained image can be easily revived or reproduced to make memorization and understanding possible. Teachers could improve retention of concepts and information after teaching, by explicitly creating memorable events involving auditory or visual images and actively engaging the students during teaching and learning (Saeed, Shankats, Ali, Majoka & Muhammad, 2011; Okurumeh, 2016).

Statement of the Problem

Despite the huge resource, both human and material that has been committed to education, the achievement of students in science subjects, particularly Physics has remained low. Analysis of results conducted by the West African Examinations Council (WAEC) has consistently remained below expectation. According to Kano Educational Resource Department (2024), a high rate of students' failure in WAEC Physics result was recorded from 2020-2023 in Kano secondary schools as shown in the table 1.

Table 1: WAEC Physics results of Ungogo Local Government Secondary Schools Kano state, 2020-2023.

YEAR	TOTAL NUMBER OF STUDENTS SAT FOR WAEC	TOTAL NUMBER OF STUDENT PASS WITH CREDIT AND ABOVE	TOTAL NO OF STUDENT FAIL
2020	655	147	506
2021	639	238	395
2022	597	200	397
2023	804	267	531

Source: Kano Educational Resource Department and Kano State Senior Secondary School Management Board (2024)

Teachers have neglected teaching approaches and strategies that promote students participation in classroom dialogue. Most of the teachings in our Physics classrooms are still traditionally oriented with the teacher assuming the role of information provider and dominating the classroom teaching with the doing students doing nothing in terms of contributing through classroom dialogue and engagements, which in turn leave students in the world of imagination and confusion. This happens because teachers do not consider the nature of thinking approaches students brings to the Physics classroom. Most teachers fail to notice this trend which calls for a variation of the forms of engaging students during teaching, particularly in a manner that would suit all forms of thinking style in the classroom. As such this study tends to find the effectiveness of 4MAT on Physics students' academic achievement and retention in Mechanics in Ungogo Local Government, Kano State.

Research Questions

1. What is the mean achievement score of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught using conventional method of teaching?
2. What is the difference in the mean achievement score of male and female Physics students taught Mechanics using 4MAT?
3. What is the mean retention score of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught using conventional method of teaching?

Hypotheses

1. There is no significant difference in the mean achievement scores of Physics students taught Mechanics using 4MAT instructional strategy and those taught using conventional method.
2. There is no significant difference in the mean achievement score of male and female Physics students taught Mechanics using 4MAT.
3. There is no significant difference in the mean retention score of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught using conventional method of teaching.

Methodology

This study employed quasi-experimental research design. Specifically, pretest, posttest and post-posttest nonequivalent control group design. A quasi-experimental design is a type of experimental design that does not provides for full control of extraneous variables, primarily because of the lack of random assignment of subjects to groups. The design is considered appropriate for this study because intact classes were used to avoid disruption of normal lessons. In the design, both the experimental and the control groups were pre-tested to ensure group equivalence, thereafter exposed to treatment for 6 weeks to find the students' academic achievement, then two weeks later, post posttest was administered to determine their retention level.

Population

The population of the study consists of 6,317 SS II Students from 26 Secondary Schools in Ungogo local Government Area. The choice of this population (SSII) was because they are academically more stable, and not on the stress of any immediate external examination.

Sample Size and Sampling Techniques

The sample size of the study is 194 students which comprises of 95 males and 99 females. Stratified random sampling technique was used to select four (4) schools out of twenty six (26) schools. An intact class of SSII was picked out of the arms in the schools using simple random sampling. The schools were assigned in to experimental (schools L and J) and control (Schools C and K) groups, (letters were assigned to schools for confidentiality). The experimental groups were exposed

to treatment using 4MAT instructional strategy while the control group was taught using conventional method of teaching. The sample is shown in Table 2.

Table 2: Sample Size for the Study.

S/N	Type	Schools	Male	Female	Total
1	Experimental	L	53	-	53
2	Experimental	J	-	43	43
3	Control	C	42	-	42
4	Control	K	-	56	56
	Total		95	99	194

Instrumentation

The instrument used for data collection was an achievement test titled Mechanics Achievement Test (MAT). The instrument contained thirty (30) items. These items (questions) were selected from past West Africa Senior School Certificate Examination. The items covered Mechanics. Face and content validity was used to check the validity of the instruments by experts, after which the corrections were effected. The test retest method was used to test the reliability of the instrument, during pilot testing; thirty (30) students were used, which were taken from the population out of the sampled schools. The reliability coefficient (0.81) was determined using the Pearson Product Moment Correlation Coefficient (PPMCC).

Results

Research Question One: What is the mean achievement scores of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught using conventional method of teaching?

Table 3: Mean achievement scores of Physics students taught Mechanics using 4MAT and those taught using conventional methods.

Group	N	Mean (X)	S.D	M.D	Std Error Mean
Control	98	18.92	2.77	2.82	.28
Experimental	96	21.74	3.76		.38

Table 3 shows that, students taught using conventional method of teaching has the mean achievement score of 18.92 and the standard deviation of 2.77, while

those exposed to 4MAT has the mean score of 21.74 and the standard deviation of 3.76. The mean difference between the groups is 2.82; this clearly shows that those taught using 4MAT have high mean achievement scores than those taught using conventional method.

Hypothesis One: There is no significant difference in the mean achievement scores of Physics students taught Mechanics using 4MAT instructional strategy and those taught using conventional method.

Table 4: ANCOVA analysis of mean achievement scores of the experimental and control groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	
Corrected Model	102.206[a]	2	51.103	7.577	.001	.074	
Intercept	282.801	1	282.801	41.932	.000	.180	
Pretest	87.696	1	87.696	13.003	.000	.064	
Group	40.079	1	40.079	5.943	.016	.030	**Rejected**
Error	1288.166	191	6.744				
Total	67602.000	194					
Corrected Total	1390.371	193					
a. R Squared = .074 (Adjusted R Squared = .064)							

Table 4 revealed the ANCOVA result for the differences in the academic achievement of between control group (taught using conventional method) and experimental group (taught using 4MAT). The observed p-value is 0.016 which is less than 0.05 therefore the null hypothesis is hereby rejected because the observed p-value is less than the significant level p-value (0.05). Hence, there is significant difference in the mean achievement scores of secondary school Physics students taught Mechanics using 4MAT and those taught using conventional method of teaching, in favour of experimental group (taught using 4MAT), ($p=0.016<0.05$).

Research Question Two: What is the difference in the mean achievement scores of male and female Physics students taught Mechanics using 4MAT?

Table 5: Mean achievement scores of Male and female Physics students taught using 4MAT.

Gender	N	Mean (x)	S.D	MD	Std Error Mean
Male	53	22.82	2.84	2.15	.39
Female	43	20.67	1.14		.63

Table 5 shows the mean achievement score of male and female students exposed to 4MAT, where male scores is 22.82, with standard deviation of 2.84, while the female students' mean score is 20.67 and standard deviation of 1.14. The mean difference between the two groups is 2.15 in favour of male students. This shows that the male students in Ungogo Local government have higher scores than their female counterpart in Mechanics.

Hypothesis Two: There is no significant difference in the mean achievement score of male and female Physics students taught Mechanics using 4MAT.

Table 6: ANCOVA analysis of mean achievement scores of male and female physics students taught Mechanics using 4MAT.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	.061[a]	2	.031	.017	.983	.001	
Intercept	269.586	1	269.586	151.582	.000	.723	
Pretest	.056	1	.056	.031	.860	.001	
Gender	.008	1	.008	.005	.000	.003	**Rejected**
Error	103.152	58	1.778				
Total	30917.000	61					
Corrected Total	103.213	60					
a. R Squared = .001 (Adjusted R Squared = .034)							

Table 6 revealed the ANCOVA result for the differences in the academic achievement of male and female students taught Mechanics using 4MAT. The observed p-value is 0.000 which is less than 0.05 therefore the null hypothesis is hereby rejected because the observed p-value is less than the significant level p-value (0.05). Hence, there is significant difference in the mean achievement scores of male and female secondary school Physics students taught Mechanics using 4MAT in Ungogo Local government, in favour of experimental group ($p=0.000<0.05$).

Research Question Three: What is the mean retention score of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught conventional method of teaching?

Table 7: Mean retention scores of Biology students taught using cooperative Instructional Strategy and those taught using conventional method of teaching.

Gender	N	Mean (x)	S.D	MD	Std Error Mean
Control	98	17.83	2.77	2.28	.38
Experimental	96	20.11	1.78		.18

Table 7 shows the mean retention scores of Physics students taught using conventional method of teaching and those taught using 4MAT. The results revealed that those taught using conventional method of teaching have mean retention score of 17.83 with the standard deviation of 2.77 whereas those taught using 4MAT have mean retention score of 20.11 with the standard deviation of 1.78. This shows that those taught using 4MAT have high retention scores compare to those taught using conventional method of teaching.

Hypothesis Three: There is no significant difference in the mean retention score of secondary school Physics students taught Mechanics using 4MAT teaching strategy and those taught conventional method of teaching.

Table 8: ANCOVA analysis of mean retention scores of the experimental and control groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	335.029[a]	2	167.514	25.088	.000	.208	
Intercept	530.902	1	530.902	79.512	.000	.294	
Pretest	49.308	1	49.308	7.385	.007	.037	
Group	201.221	1	201.221	30.136	.000	.013	**Rejected**
Error	1275.306	191	6.677				
Total	88895.000	194					
Corrected Total	1610.335	193					
a. R Squared = .208 (Adjusted R Squared = .200)							

Table 8 revealed the ANCOVA result for the differences in the retention scores of control and experimental groups. The observed p-value is 0.000 which is less than 0.05 therefore the null hypothesis is hereby rejected because the observed p-value is less than the significant level p-value (0.05). Hence, there is significant difference in the mean retention scores of secondary school Physics students taught Mechanics using 4MAT and those taught using conventional method of teaching, in favour of experimental group (taught using 4MAT), ($p=0.000<0.05$).

Discussions

The findings of this study revealed that there is a significant difference in the mean academic achievement scores of Physics students taught Mechanics using 4MAT and those taught using conventional teaching methods in favour of those taught using 4MAT. This implies that the use four modes application technique in teaching Mechanics enhances students' academic achievement. This finding is in agreement with the findings of Ganze and Hulya (2017), Ramida and Boonyaras (2017), Sibel and sabiha (2016), Osama, Fahad and Ayman (2016), Aktas and Bilgin (2015), Uyangor (2012) and Alanazi (2020) who found that students learning activities based on 4MAT teaching have higher achievement than students who learned through the conventional method of teaching. The reason for this finding may be as a result of nature and process involved in the teaching strategy used, which is 4MAT. In 4MAT lesson the students were given equal opportunity and allowed to manipulate the learned materials in each lesson. The finding of this study contradicts that of Mutlu and Okufu (2012) which observed no significant difference in the mean achievement scores of experimental and control groups. The reason for this disagreement might be the fact that this study and some previous studies have compared 4MAT with the teacher-centered teaching model whereas the study with the conflicting result made a comparison between two child-centered teaching models that is 4mat and constructivist.

It was also observed in this study that, there is significance gender difference in mean achievement scores of the students when exposed to 4MAT teaching strategy in favour of the male students. The result of this study is in accordance with the findings of Muhammad (2015) where it was found that there is significant difference with respect to gender in favour of male students. The findings contradicts with the that of Oluwatosin & Ogbeba (2017), Fatokun , Egya & Uzoechi, (2016), Okoyefi (2014); Daniel (2012); Oyenuga (2010), who found out that

there is no significant difference in the achievement of male and female students taught using 4MAT. In 4MAT lesson students were given equal opportunity to explore and manipulate learnt materials in a creative ways and there was more interactive form of learning than mere giving information. This might be their reason which results to the equal performance across the gender in this study.

It was also found from the study that there is a significant difference in the mean retention scores of Physics students taught using 4MAT and conventional teaching methods in favour of those taught with the 4MAT teaching method. This means that when 4MAT is used to teach Mechanics, it enhances the students' retention ability. This finding is in agreement with the findings of (Abdelsalam, (2017), Sibel & sabiha, (2016); Nurman, (2015); Kanadi, 2016). This observation could be attributed to manner in which lesson was delivered. In this model (4MAT), learners' active participation was ensured, activities stimulating both left and right brain were embodied in the learning process; and to ensure retention memorable events that aids in quick remembering as suggested by Lasis, Alabi and Salaudeen (2016) was also considered.

Conclusions

Findings from the study revealed that the use of 4MAT in teaching Mechanics improves students' academic achievements, as indicated there is significant difference in the academic achievement scores between experimental group and control group in favour of the experimental group. It also revealed that there is significant difference in academic achievement of male and female students in physics taught mechanics using 4MAT, in favour of the male students. Finally it was found that 4MAT improves students retention in mechanics, because it was found that there is significant different in the achievement of the students taught using 4MAT and those taught using conventional method of teaching, in favour of those taught using 4MAT.

Recommendations

The recommendations from the study are as follows:

i. Physics teachers in Ungogo Local Government and other areas should try to implement the use 4MAT so as to encourage students' active participation during the teaching and learning procedure, in terms of academic achievement and retention.

ii. Measures should be taken in order to prevent differences between different groups while teaching and learning of physics.
iii. Physics teachers should try to carry along all the students during lessons irrespective of their ability and gender.

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