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EFFECTS OF METACOGNITIVE LEARNING CYCLE MODEL ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND INTEREST IN PHYSICS.

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ABSTRACT

The Study investigated the effects of metacognitive learning cycle model on students' achievement and interest in physics in secondary schools. Four research questions and four null hypotheses guided the study. The study used quasi-experimental design. The population of study comprised 924 SS2 Physics students in Izzi LGA of Ebonyi State. Simple random sampling techniques was used to select 65 students for the study. Physics Achievement Test (PAT) and Physics Interest Scale (PIS) were used for data collection. KR20 and cronbach alpha methods were used to establish the reliabilities of instrument which yielded 0.82 and 0.73. Pretest post-test were used on the students. The research questions were answered using Mean while ANCOVA was used to test hypotheses. Findings revealed among others that metacognitive learning cycle model has significant effect on students' achievement and interest in physics. Based on findings, the study recommends that physics teachers should redesign their teaching methods.

Introduction

Physics is one of the science subjects in the senior secondary school curriculum. Like other subjects, it plays vital role in nation building. Physics is a physical science, which deals with the basic understanding of the laws of the universe. [18] defined physics as the study of the laws that determine the structure of the universe with reference to matter and energy. It is not only concerned with the forces that exist between matter and energy but also take holistic study of matter and energy. [14] also defined as the science that is concerned with the study of physical objects, substances and of natural forces such as light, heat and motion. It is the basic science subject that deals with those fundamental questions on the structure of matter and interaction of elementary constituents of nature that are susceptible to experimental investigation and theoretical inquiry.

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Specifically, the main objective of secondary school physics as contained in [7] includes: - To provide basic physics literacy for functional living in the society. To acquire essential scientific skills and attitudes as a preparation for technological application of physics. To produce scientists for national development. To introduce students to the fundamental concepts, principles and laws of physics. To stimulate and enhance creativity and to prepare the students for higher education.
The demand for technological development in Nigeria compels her to encourage students to choose careers in science especially engineering and medicine which student cannot offer without the knowledge of physics. In fact, physics can be seen as a subject that provides room for all technological development in the world. Its application to real life situation transcends above profession to everyday life. [6] said that Physics lies at the heart of science. Invention of spaceship, video machine, satellite, war missiles, x-ray machines are all based on one or more of the fundamental laws of physics. Hence, [11] saw Physics as a great triumph of human mind and essential to developing civilization.
Despite all these roles played by physicist in the field of civilization, students' performance in physics is still low at all levels [19]. Physics as one of the science subject has remained one of the most difficult subject for students in secondary school curriculum [7]. Research has revealed that the performance of Nigeria students in ordinary level physics has been generally poor and this has been attributed to many factors including the use of ineffective teaching method by physics teachers [16]. For some time now, the academic performance of secondary school students in physics as reported by WAEC officials have attracted increased attention from, parents, government and general public. Physics being a subject that exposes students to knowledge ranging from the structure of matter, its relationship with energy and the nature of the universe both physical and meta-physical, eventually turned to be the area where students exhibit poor performance.

METACOGNITIVE LEARNING CYCLE MODEL

Metacognitive learning cycle model is a revised instructional model which inserts a conscious pause known as check status in each of the early phases of the learning cycle model to ensure that all students are progressing adequately. [4] Defined Metacognitive learning cycle model as a revised learning cycle model that incorporates structured metacognitive elements and builds a stronger bridge between students' science ideas, experience and understanding. The author maintained that the model is made up of four phases: Concepts exploration, Assessment, Introduction and Application.

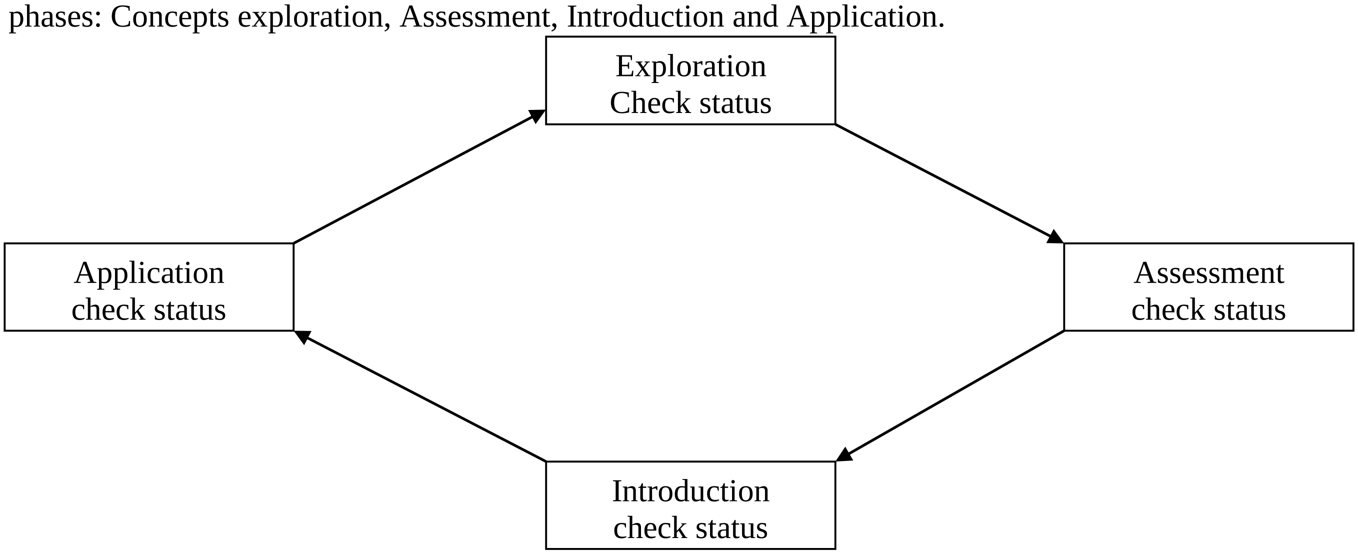

Fig I [4] Metacognitive Learning Cycle Model.

At the concept exploration phase, the teacher engages the students with a task. The task is open-ended enough to allow for various strategies yet specific enough to provide some direction. The phase allows students to employ their personal knowledge about natural phenomenon. At the concept assessment, students are asked to reflect on their science ideas of the task before the instruction begins. Students keep a concept journal in which they record their ideas and the condition of those ideas. At the concept introduction level, teacher gathers information from the students' discrepancies at the exploration level and introduces the main concept of the lesson. Materials such as textbook, audio-visual aids and other instructional materials may be used to facilitate the concept introduction. At the application phase, students are challenged with additional examples of new task which can be solved on the basis of previous exploration activities. Through this sequence, students' thinking are expected to progress from concrete thinking about science concepts to being able to deal with concept at the abstract level.

ACHIEVEMENT

There is a general consensus that physics achievement is statistically correlated with students' cognitive abilities with general intelligence being considered the strongest predictor of scholastic achievement Intelligence tests are widely used by educational psychologists to help in the diagnostic and prognostic of students' cognitive abilities and difficulties and also provide students with self-information helping them in their vocational choices.

According to Oxford English dictionary 6th edition, achievement is something accomplished, especially by superior ability, special effort or great courage or heroic deed. Achievement connotes final accomplishment of something noteworthy, after much effort and often in spite of obstacle and discouragement. Based on this definition, achievement on physics can be viewed into two perspectives; first is based on the discoveries so far made in the area of physics. For instance, the world- leading physics and astronomy research had a huge impact on the discipline. The discovery of Higgs boson at CERN- the European organization for nuclear research has had a momentous impact on the foundations of physics and also inspires future generation of physicists. Meanwhile, the University of Southampton reinforced its leading role in radio astronomy with a new LOFAR telescope, which expands our leadership transient effects and the origins of the largest scale of magnetic fields in the universe. Also tremendous achievements have been recorded in the area of electronics, computer science and photoelectric research. The second aspect of the achievement is based on the performance of students at the end of every internal or external examination with reference to the subject physics. This can be referred as academic achievement and can be accessed directly from students' grades at the end of each school term.

INTEREST

Interest seems to be the central concept when trying to understand the functional relationship between motivation and learning. Though, interest differs from other motivational variables in three aspects: It is content specific and a means of interaction between a person and their environment, and moreover it has both cognitive and affective aspects [9]. [17] proposed that students react in three ways when faced with uninteresting task. Firstly, they can quit the task. Secondly, if students are highly motivated to maintain performance, students may persist doing the task. Thirdly, students can persist in doing the task and attempt to transform the activity into something more interesting. In summary, students can self-regulate interest and therefore, it is valuable for teachers to know that they can have an effect on students' interest through regulation or choosing of task.

GENDER

The association between gender and response to physical science especially physics has been a controversial issues for years. The controversy of gender and performance in science has attracted the attention of many researchers. [10] opined that general performance of boys and girls in physical sciences were in favour of boys except in chemistry and geological studies. [5] also revealed that gender was strongly associated with physics achievement as boys significantly demonstrated better than girls did. This is in line with [2] who maintained that only few American women were seen in science and engineering profession. A study by [15] also revealed that gender has a significant impact on students' academic achievement when taught in metacognitive classroom environment as male students manifested better academic achievement.

Even though, many researchers observed that boys perform better than girls in physical sciences including physics, this study investigated whether this assumption is generally true or if there are other factors such as learning method that may be responsible for their differences.

Statement of the Problem

The increasing level of poor academic achievement of students in physics calls for further investigation. It is perceived that some factors could be responsible for this seemingly poor achievement. For instance, [20] consecutively reported the declining performance of students in ordinary level physics. Physics being an essential branch of science that has many applications in real life situations regrettably turns out to be an area where students exhibit poor performance over the years.

Many researchers are suggesting that the students' poor academic achievement in physics may be due to strategies or methods employed by physics teachers. If the poor academic achievement of students in physics remains unsolved, it could adversely affect the anticipated goal of physics education in Nigeria. It is against this backdrop that the study, verifies whether there will be differences in the academic achievement of students who received instructions in metacognitive learning cycle model classroom and those who received instructions in conventional classrooms.

Purpose of the Study

The main purpose of this study was to determine the effect of metacognitive learning cycle model on students' academic achievement and interest in physics. The study specifically determined the :

- effects of metacognitive learning cycle model (MLCM) and conventional teaching methods (CTM) on achievement of secondary school students in physics.
- effects of MLCM on achievement of male and female secondary school students in physics.
- effects of MLCM and CTM on interest of secondary school students in physics.
- effects of MLCM on male and female secondary school students' interest in physics.

Research Questions

The following research questions guided the study:

- What is the effect of metacognitive learning cycle model on the physics mean achievement scores of secondary school students when compared with those taught with conventional teaching method using their pretest and posttest scores?
- What are the effectiveness of MLCM on male and female secondary school students' achievement in physics using their pretest and posttest scores?
- What is the effect of MLCM in enhancing the interest of secondary school students taught physics when compared with those taught with CTM using pretest and posttest scores?
- What are the effectiveness of MLCM in enhancing the interest of male and female secondary school students taught physics using their pretest and posttest scores?

Research Hypotheses

The following null hypotheses were tested at 5% alpha level of significance.

- There is no significant difference in the mean achievement scores of students taught physics using the MLCM and CTM.
- There is no significant difference in the effectiveness of MLCM on the physics achievement scores of male and female secondary school students.
- There is no significant difference in the mean interest scores of students taught physics using the MLCM and CTM
- There is no significant difference in the effectiveness of MLCM on the physics interest scores of male and female secondary school students

METHODOLOGY

The design of the study was quasi-experimental design. This is because there was no randomization of the subject as intact classes were used (Nworgu, 2015). The study employed two groups: Experimental group and the control group. Experimental group was taught physics using metacognitive learning cycle model (MLCM) while the control group was taught physics using conventional teaching method (CTM)

Quasi-Experimental Design

Group	Pre-test	Treatment	Post-test
E	O_1 O_2	X_1	O_3 O_4
C	O_1 O_2	---	O_3 O_4

Where E stands for experimental group

- C = Control group
- O_1 = Pre-test of PAT
- O_2 = Pre-test of PIS
- X_1 = Treatment
- O_3 = Post-test PAT
- O_4 == Post-test PIS

The research was conducted in all co-educational public Secondary School in Izzi Local Government Area of Ebonyi state. The population of the study comprised of all 924 SSII physics students in Izzi LGA, out which 65 senior secondary two (SS2) students from two secondary schools were sampled using multi-stage sampling techniques. The researcher narrowed it down by using purposive sampling because mixed gender is of particular interest. Secondly, simple random sampling (balloting without replacement) was used to select two schools for the study while toss of coin was used to randomly assign the schools into group of either experimental or control.

The study utilized two research instruments for data collection. They are Physics Achievement Test (PAT) and Physics Interest Scale (PIS).

The Physics Achievement Test (PAT) and Physics Interest Scale (PIS) were administered to 32 SS2 physics students outside the area of the study for the purpose of establishing the reliability of the instrument.

During the study, both the instruments; PAT and PIS were administered at the beginning as pre-test to both the experimental group and control group. After four weeks of direct instructions, the same instruments were reshuffled and administered as posttest to both groups.

The scores of the students in both MLCM and CTM from the pre-test and posttest were analyzed using descriptive and inferential statistics. Mean was used to answer the research questions, while ANCOVA was used to test the research hypotheses at 0.05 level of significance.

This is because the data collected was at the interval scale of measurement.

RESULT

Research question 1;

What is the effect of metacognitive learning cycle model on the physics achievement scores of secondary school students when compared with those taught with conventional teaching method using their pretest and posttest scores?

Table1. Pretest and posttest achievement scores of students taught physics in both the experiment and control group.

Group	N	Pre-test X	Posttest X	Mean Gain Score
Exp.	28	30.43	40.64	10.21
Cont.	37	31.78	32.32	0.54

The table shows the mean achievement scores of 30.43 and 31.78 for the experimental and control groups at the pretest; 40.64 and 32.32 at the post-test respectively. The table also shows the mean gain scores of 10.21 for the experimental group and 0.54 for the control group. The experimental group had a higher mean gain score.

Research question 2

What are the effectiveness of MLCM on male and female secondary school students' achievement in physics using their pretest and posttest scores?

Table 2: Pretest and posttest achievement scores of male and female students taught physics using MLCM

Gender	N	Pretest $\bar{x}$	Posttest $\bar{x}$	Mean Gain Score
Male	17	33.41	43.29	9.88
Female	11	25.82	36.55	10.7

The table shows the pretest and posttest performance of male and female students in the experimental group. The male students had mean scores of 33.41 and 43.29 for pretest and posttest respectively while the female students had mean score of 25.82 and 36.55 for the pretest and posttest. Female students had higher mean gain score of 10.73 than the male students who had mean gain score of 9.88.

Research question 3

What is the effect of MLCM in enhancing the interest of secondary school students taught physics when compared with those taught with CTM using pretest and posttest scores?

Table 3: Pretest and posttest interest scores of students taught physics in the experimental and control group

Group	N	Pre-test $\bar{x}$	Posttest $\bar{x}$	Mean Gain Score
Exp.	28	61.82	65.54	3.72
Cont.	37	57.35	58.92	1.57

Table 3 shows the mean interest scores of 61.82 and 57.35 as pretest for the experimental group and control group respectively. It also reveals the posttest scores of 65.54 and 58.92 for the experimental and control group respectively. The table equally shows a higher interest gain score of 3.72 in favour of the experimental group while the control group had a lesser interest gain score of 1.57.

Research question 4:
What are the effectiveness of MLCM in enhancing the interest of male and female secondary school students taught physics using their pretest and posttest scores?

Table 4: Pretest and posttest interest scores of male and female students taught physics using MLCM

Gender	N	Pre-test $\bar{x}$	Posttest $\bar{x}$	Mean Gain Score
Male	17	62.59	68.18	5.59
Female	11	60.64	61.45	0.81

The table reveals the pretest interest scores of 62.59 for male and 60.64 for female. It equally shows the posttest of 68.18 for male and 61.45 for female. Consequently, the male students shows higher interest gain score of 5.59 than the female students who had the interest gain of 0.81

Hypothesis 1:
There is no significant difference in the mean achievement scores of students taught physics using the MLCM and CTM.

Table 5: Summary of ANCOVA on the students' pretest and posttest achievement scores in physics for the experimental and control group at x: 0.05.

Source	Type III sum of squares	DF	Mean Square	F	Sig
Corrected model	1666.290	2	833.145	14.812	.000
Intercept	2422.283	1	2422.283	43.065	.000
Pretest	415.389	1	415.839	7.385	.009
Method	1413.041	1	1413.041	25.122	.000
Error	3487.310	62	56.247		
Total	87532.000	65			
Corrected total	5153.600	64			

The table 5, shows that at 0.05 percent significant level, 1 degree of freedom of the numerators and 62 of denominator yielded the calculated F of 25.12 far greater than the critical F of 4.00. that is $F(1,62) = 25.12$, $P = 0.00 < 0.05$. This shows that there is significant difference between the mean achievement scores of students taught physics using metacognitive learning cycle model and those taught physics using lecture method. As a result, the null hypothesis is therefore rejected and the study concludes that there is significant difference between MLCM and CTM in favour of MLCM.

Hypothesis 2:
There is no significant difference in the effectiveness of MLCM on the physics achievement scores of male and female secondary school students.

Table 6: Summary of ANCOVA on the pretest and posttest of male and female students achievement scores in physics for experimental group.

Source	Type iii sum of squares	Df	Mean Square	F	Sig
Corrected model	373. 052	2	186.526	3.611	.042
Intercept	2725. 968	1	2725. 968	52.773	.000
Pretest	68.880	1	68. 880	1.333	.259
Gender	370.309	1	370. 309	7.169	.013

Error	1291.377	25	51. 655
Total	47916. 000	28	
Corrected total	1664. 429	27	

In table 6, a significant difference was observed for gender with respect to achievement scores in physics. $F(1,25)=7.169$, $p=0.013<0.05$. This shows that there is significant difference between male and female students taught physics using metacognitive learning cycle model in favour of male. Therefore, the null hypothesis is rejected.

Hypothesis 3:
There is no significant difference in the mean interest scores of students taught physics using the MLCM and CTM

Table 7: Analysis of covariance for pretest and posttest interest scores of students using physics interest scale.

Source	Type iii sum of squares	DF	Mean Square	F	Sig
Corrected model	2587.253[a]	2	1293.627	28.580	.000
Intercept	1060.630	1	1060.6030	23.433	.000
Pretest	1889.436	1	1889.436	41.744	.000
method	236.083	1	236.083	5.216	.026
Error	2806.285	62	45.263		
Total	253397.000	65			
Corrected total	5393.538	64			

The ANCOVA table shows that at 0.05 percent level of significant, $F(1, 62) = 5.216$, $p = .026 < 0.05$. This shows that the mean interest scores of students in physics is significant in favour of MLCM group and as a result, the null hypothesis is therefore rejected

Hypothesis 4:
There is no significant difference in the effectiveness of MLCM on the physics interest scores of male and female secondary school students.

Table 8: Analysis of covariance for pretest and posttest physics interest scale based on gender.

Source	Type iii sum of squares	DF	Mean Square	F	Sig
Corrected model	364.343[a]	2	182.171	3.055	.065
Intercept	1955.043	1	1955.043	32.789	.000
Pretest	62.577	1	62.577	1.050	.315
Gender	271.952	1	271.592	4.561	.043
Error	1490.621	25	59.625		
Total	122113.000	28			
corrected total	1854.964	27			

The ANCOVA of table 8 shows that at 0.05 percent significant level, $F(1,25)= 4.561$, $p = .043 < 0.05$. The observation indicated that student's interest towards the subject (physics) is dependent of gender in favour of male and as a result, the null hypothesis that there is no significant different between the mean interest scores of male and female students is therefore rejected.

DISCUSSIONS

The result as contained in table 1 clearly shows that students who received instruction under MCLM performed better academically than those who received instruction under conventional classroom. The

ANCOVA of table 5 also shows that the mean difference of students of the experimental and control group is significant in favour of the experimental group.

However, it is observed that before the instruction, the control group had higher mean scores in their pre-test than the experimental group but after the instruction, the posttest score shows a mean score in favour of the experimental group. The finding reaffirms the studies of [12] and [1], who opined that metacognitive learning classroom has a very high positive significant effect on students' academic achievement.

However, the finding conflicts with that of [4], [13] who contended that metacognitive learning cycle model has no significant superiority in improving students' content knowledge.

Finding on table 3 shows that students of the experimental group exhibited greater interest from the pre-test score to the post-test scores. Also, the ANCOVA table 5 buttressed that students' mean interest is significant at 5% alpha level. It also reaffirms the study of [19] whose research revealed that there is a positive relation between interest at physics and knowledge of mathematics basic concepts with student's ability to solve physics problems. However, the result of table 4 and ANCOVA table 8 showed that significant difference exists between male and female students in terms of interest towards learning of physics as male students displayed greater interest than female students.

The result of the findings in table 2 shows the academic strength of both male and female students who received instruction under MLCM model as the female students exhibited higher academic mean gain than their male counterpart. The ANCOVA table 6 also shows significant difference between male and female students' academic achievement at 5% level in favour of female students who did not show much interest on the subject (physics). The study contradicts with [3] who investigated on the effect of effective assessment in the form of situated metacognitive prompts on students' achievement and the finding shows no significant interaction effect for gender. The study also conflicts [15] who maintained that gender difference exists but in favour of males. The study equally contradicts with [8] whose findings showed that gender has significant influence on students' interest but does not have on students' achievement.

Conclusion

Metacognitive learning cycle model which entails the use of exploration learning model maintains that students who received instructions on physics under MLC model showed greater academic achievement than those who did not. This implies that there is significant difference in students' mean scores in physics in favour of the experimental group who received instruction under MLC model. Also, male and female students who were exposed to the instructions on physics under MLC model showed mean academic differences. The study therefore concludes that significant difference exists between male and female students who received instruction under MLC model as female students showed superior academic record. However, students of both experimental and control group displayed different level of interest in their mean interest scores. The study also concluded that there is significant difference between the experimental and control group in terms of mean interest scores as the experimental group showed greater interest than the control group. Male and female students who received training under MLCM model displayed different level of interest in their scores. The finding therefore affirmed that significant difference exists between male and female students in favour of male.

Recommendations

Based on the findings and implications of the study, the following recommendations were made:-

1. Physics teachers should re-examine and redesign their teaching styles to allow for various metacognitive learning cycle l models instead of relying on conventional methods.
2. Educators of physics should plan for curriculum that would allow students' active participation on task so as to foster gender friendliness rather than making them passive learners.

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