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EFFECT OF METACOGNITIVE SCAFFOLDING TEACHING STRATEGY ON SECONDARY SCHOOL PHYSICS STUDENTS' ACHIEVEMENT IN THERMAL ENERGY

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Abstract
This study investigated the effect of metacognitive scaffolding teaching strategy on secondary school physics students' achievement in thermal energy in Federal Capital Territory (FCT), Abuja, Nigeria. The study investigated one research question and one null hypothesis tested at 0.05 level of significance. Quasi experimental research design involving non randomized control pretest-posttest design was utilized. The study population consisted of 2699 Senior Secondary II (SSII) physics students from 54 public SSII physics students in FCT, Abuja. Multistage random sampling technique was used to select 75 SSII physics students from two SS as sample for the study. One instrument consisting of Thermal Energy Achievement Test (TEAT) was used for data collection. The instrument was given to two science education experts and one measurement and evaluation expert for validation and trial tested at GSS Jikoyi. The reliability coefficient was analyzed using Kuder-Richardson $(K-R)_{21}$ to obtain a reliability coefficient of 0.92. The data collected from the instrument were analyzed using Statistical Package for Social Science (SPSS). The research question was answered using mean and standard deviation while the null hypothesis was tested using Analysis of Covariance (ANCOVA). Finding from the analyzed data showed that physics students taught using metacognitive scaffolding teaching strategy performed better in their achievement scores than those physics students taught using conventional teaching method. Based on the finding, it was recommended among others that physics teachers should be encouraged to teach using metacognitive scaffolding teaching strategy. Government and educational agencies, curriculum planners and developers should encourage the training of physics teachers on metacognitive scaffolding teaching during seminars, workshops and conferences.

Key words: Effect, Metacognitive scaffolding teaching strategy, Physics, Thermal energy, Achievement

Introduction

Science is a body of knowledge that has laws, facts, principles, concepts and conventions associated with it (Faye & Mclean, 2014). The body of knowledge contains several studies that include physics, chemistry and biology. Physics is concerned with matter and energy and the relationship between them (Okeke, Okeke & Akande, 2008). The knowledge of physics can be applied in the field of agriculture, automobile, water supply, irrigation, civil works, electrical and electronics. Many inventions emanating from these fields which require the knowledge of physics for their understanding consist of electric kettle, petrol engine, diesel engine, jet engine, clinical thermometer, electric bulbs, X-ray machine, camera, car, radio, computer, television, batteries, electricity, speakers and bombs. As a result of the importance of physics to the society, physics is further studied at an advanced level in the university as a degree programme. Physics knowledge at secondary school level is also made a prerequisite course for some other core courses in engineering and technology programes in the university. As a result of these, physics students aspiring to study physics, engineering and technology programs in the university must obtain a grade level of credit and above in the subject.

Despite these recommended grades level for physics students, students' achievement in the subject remains low. Physics students' achievement at Senior Secondary Certificate Examination (SSCE) in Nigeria has been low over the years (Saage, 2009). Statistics of students' achievement in May/June West African Senior Secondary Certificate Examination (WASSCE) Physics examination from 2010 to 2017 as presented in Table 1.1 showed that students' achievement in physics has been low over the years.

Table 1.1: Students' Achievement in May/June2010-2017 WASSCE Physics in Nigeria

Year	**Total Entry**	**Accepted Grade Levels**		**Unaccepted Grade Levels**				
		(A1-C6)	**%**	**D7**	**D8**	**F9**	**(D7-F9)**	**%**
2010	387,380	148,599	38.36%	28,134	34,986	175,661	238,781	61.64%
2011	374,958	162,769	43.41%	49,516	15,202	147,471	212,189	56.59%
2012	386,449	190,210	49.22%	10,121	42,300	143,818	196,239	50.78%
2013	423,146	153,137	36.19%	15,313	38,150	216,546	270,009	63.81%
2014	402,228	140,056	34.82%	10,115	12,164	239,893	262,172	65.18%
2015	398,870	145,747	36.54%	14,885	19,995	218,243	253,123	63.46%
2016	416,580	174,432	41.9%	16,040	21,668	204,440	242,148	58.1%
2017	422,110	183,020	43.4%	22,444	23,845	192,801	239,090	56.6%

Source: West African Examinations Council (2017)

Low achievement in physics at SSCE is reported to be attributed to difficult topics in physics including thermal energy (Mustafa, 2006). The reasons why most physics students failed thermal energy may be because it contains mathematical concepts which require background knowledge of mathematics principles to solve it. Therefore physics students find it difficult to understand thermal energy due to their poor knowledge of mathematics. Apart from problem of mathematical task, the lack of the use of modeling to demonstrate experiment in the class may also affect students' cognition and achievement. In order to ensure that students' excel in thermal energy, over dependent on the use of conventional teaching method by teachers should be prevented. Wood and Gentile (2003) opined that in conventional teaching method, there are no teacher-students interactions as the teacher dominates all the class activities right from the beginning of the lesson to the end. Conventional teaching method also has the attributes of brief teaching, which hinders collaborative thinking that promotes reflection and metacognition. Many researchers opined that conventional teaching method may cause students to results to rote learning and memorization instead of reflective thinking that is more effective in enhancing their cognition (Nworgu, 2012). Rote learning hinders students' thinking initiatives during class activities and also prevents them from fully exploring and understanding complex principles in thermal energy. Duyilemi, Olangunju and Olumide (2014) remarked that the overreliance on conventional teaching method in the teaching of physics may affect students' achievement in the subject.

Agommuoh and Ifeanacho (2013) pointed out that for teaching to be effective to impact on students' achievement and retention, the minds of students need to be exposed to varieties of innovative teaching and learning activities that will stimulate students' mental thinking to develop their own cognition. There are varieties of innovative teaching strategies that enhance mental thinking skills and among them is metacognitive scaffolding teaching strategy. Metacognitive scaffolding teaching strategy is a teaching strategy that emanated from the word-scaffolding in the field of construction. Scaffolding is used as a support structure that assists construction workers to execute difficult task. Typical scaffolding consists of tightly fitted horizontal, vertical and diagonal members that are either made of wood or steel materials to form a rigid structural framework. In the field of education, these scaffolding members are refers to as teaching models used to assist students solve difficult task beyond their dependent abilities (Wolf, 2003). These teaching models when used to develop students' mental thinking abilities to a higher one that will promote their self-cognition, it is referred to as metacognitive scaffolding teaching strategy.

Also the term metacognitive scaffolding teaching strategy emanated from the concept of metacognition which is refers to as the cognitive functioning of a person. This cognitive functioning involves series of mental thinking processes involved in knowledge internalization in a learner (Nodoushan, 2008 & Franco-Castillo, 2013). Therefore, metacognitive scaffolding teaching strategy can be defined as a teaching framework that utilizes several innovative teaching models used to assist students attains a mental thinking level where they can develop their own cognition needed to solve difficult task. In order to achieve the effect of metacognitive scaffolding teaching strategy several scaffolds models are planned in order to make the teaching of difficult topics easier. These scaffolds according to Many (2002), Denton (2014), Hall (2015) and Wikipedia (2018) may includes advanced organizer, modeling, worked examples, explicit and problem solving approach, concept/mind maps, instructing, prompts, hints and questioning. Jbeili (2012) posited that metacognitive scaffolding teaching strategy assist students to manage their thinking and adjust it to a positive way when they are confused. An and Cao (2014) reported that metacognitive scaffolding teaching strategy improves students' metacognition through knowledge planning, monitoring and evaluation. Metacognitive scaffolding teaching strategy has been shown to enhance students' metacognitive learning skills (Wolf, 2003). Another finding into the effect of metacognitive scaffolding teaching strategy also showed that it has a positive effect on students' learning outcome (Azevedo & Hadwin, 2005). James and Okpala (2010) found that metacognitive scaffolding teaching strategy had significant effect on students' literacy skills in reading comprehension. Metacognitive scaffolding teaching strategy has been reported to be effective in solving difficult task in design problem solving and analytical skills in other subject areas, but not many studies have reported its effect in physics. However, it is in view of this, that this study investigated the effect of metacognitive scaffolding teaching strategy on senior secondary physics students' achievement in thermal energy in Federal Capital Territory, Abuja, Nigeria.

Research Questions

The following research questions guided the study:

1. What is the mean difference in achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching

strategy and those taught using conventional teaching method?

Hypothesis

The following null hypothesis was tested in the study.

H_{01}: There is no significant difference in the mean achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching method.

Methodology

This research design for this study is the quasi-experimental research design involving non randomized control group pretest-posttest design. It employs non randomized control group pretest-posttest design deals with the use of intact classes. Two intact classes from two senior secondary two (SSII) offering physics were randomly assigned to control and experimental groups. Before embarking on the treatment, pretest was giving to the two sampled schools, then the control and experimental groups were exposed to metacognitive scaffolding teaching strategy and conventional teaching method respectively for a period of 8 weeks. After 8 weeks, posttest which contains the same questions as the pretest was administered to the two sampled schools after the treatment. The study population consisted of 2699 SSSII physics students (1609 male and 1090 female) from 54 Senior Secondary Schools that are public and co-educational in Federal Capital Territory (FCT), Abuja. A sample size of 75 SSII physics students from two intact physics classes (40 and 35 physics students) was selected out of a population of 2699 SSII physics students in FCT-Abuja using multistage random sampling.

The instrument for data collection consists of Thermal Energy Achievement Test (TEAT). The TEAT was used to measure physics students' achievement in thermal energy. The questions were adapted from SSCE past questions and contains questions on temperature and its measurement, thermometer, absolute scale of temperature, specific heat capacity, latent heat capacity, evaporation, boiling and sublimation and relative humidity and dew points.

The TEAT was given to two science education experts and one measurement and evaluation expert for validation. The reliability of TEAT was determined by trial testing Government Secondary School (GSS) 2, Jikwoyi in FCT-Abuja. The data collected were analyzed using Kuder-Richardson $(K\text{-}R)_{21}$ method to obtain a reliability coefficients of 0.92.

Physics students in the experiment group was taught using metacognitive scaffolding teaching strategy, while physics students in the control group were taught using conventional teaching method. Both groups were taught for eight weeks. At the end of the eight weeks, TEAT was administered as posttest to physics students in the two groups. The data collected from the instruments were analyzed using Statistical Package for Social Science (SPSS) model. The research questions were answered using mean and standard deviation, while the hypothesis was tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Result

Research Question 1: What are the mean achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching method?

Table 3: Means and Standard Deviations of Achievement Scores of Physics Students Taught Using Metacognitive Scaffolding Teaching Strategy and Conventional Teaching Method

Groups	**Tests**	**N**	**Mean**	**SD**	**Relative SD**	**Standard Error**
Treatment	Pretest	30	23.55	6.356	0.233	1.344
	Posttest	30	26.30	8.510	0.324	1.554
Control	Pretest	36	20.19	9.760	0.567	1.784
	Posttest	36	21.25	10.061	0.474	1.677

Table 3 indicates that the mean achievement scores of physics students in the treatment group were higher than the mean achievement scores of their control group counterparts. The relative standard deviations of the treatment group were lower than their control group counterpart. This shows that the control group had physics scores that are more widespread and in agreement with the mean than the treatment group .

Hypothesis 1: There is no significant difference in the mean achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching method.

In testing this hypothesis, ANCOVA was used to analyze the significant difference in the achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching strategy.

Table 5: ANCOVA Analysis of the Mean Achievement Scores of Physics Students taught Using Metacognitive Scaffolding Teaching Strategy and Conventional Teaching Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4939.977[a]	2	2469.988	138.889	.000
Intercept	803.357	1	803.357	45.173	.000
Pretest	4522.663	1	4522.663	254.312	.000
Group	370.555	1	370.555	20.837	.000
Error	1120.387	63	17.784		
Total	42650.000	66			
Corrected Total	6060.364	65			

a. R Squared = .815 (Adjusted R Squared = .809)

Table 5 shows that at the group level, the P significant value of 0.000 is lesser than P at 0.05 level of significance ($P<0.05$). Based on these results, the null hypothesis is therefore rejected. This implies that there was a significant difference in the achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching method in favour of those taught using metacognitive scaffolding teaching strategy.

Discussion

The result showed that physics students had a better achievement scores in their achievement scores when taught thermal energy using metacognitive scaffolding teaching strategy than their counterpart who were taught using the conventional teaching method. The outcome of this result showed metacognitive scaffolding teaching strategy provides collaborative and reflective mental thinking skills which enable physics students improves in their learning effort and comprehension. This enhanced learning and comprehension may have enabled physics students had a higher achievement scores than their counterpart who were taught using the conventional teaching method. This finding is in agreement with those of Fouche (2013), Jayapraba and Kanmani (2015) and Uzoechi and Gimba (2015) where they reported that metacognitive instructional strategy improved students' achievement compared with the conventional teaching method. The reason for the similarity in the findings from the literatures reviewed and the present study may be that since reviewed literatures employed metacognition concept in their teaching strategy, physics students may have excelled irrespective of the teaching strategy itself. This showed that Metacognition concept which dwells on improving students' mental thinking during teaching contributes greatly in the enhancement of physics students' mental thought which enables physics students improves their comprehension and achievement in the subject.

Conclusion

Based on the findings of the study, it is concluded that Physics students taught using metacognitive scaffolding teaching strategy had higher achievement scores and attitudinal scores than their counterpart taught using the conventional teaching method. This shows that metacognitive scaffolding teaching strategy is more effective in teaching thermal energy than the use of the conventional teaching method.

Recommendations

The study therefore recommends that:

1. Physics teachers should be encouraged to teach physics using metacognitive scaffolding teaching strategy for classroom instruction in both single and coeducational schools.
2. Curriculum planners and developers should consider the introduction of metacognitive scaffolding teaching strategy in senior secondary school physics curriculum.

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