EFFECT OF GENDER ON ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS TAUGHT THERMAL ENERGY USING METACOGNITIVE SCAFFOLDING TEACHING STRATEGY

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Abstract: This study investigated the effect of gender in achievement among secondary school students taught physics concept using metacognitive scaffolding teaching strategy in Federal Capital Territory (FCT), Abuja, Nigeria. The study asked two research questions and postulated two null hypotheses which were 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 fromSS II classes as sample for the study. One instrument consisting of Thermal Energy Achievement Test (TEAT) was used for data collection. The data collected from this instrument was analyzed using Statistical Package for Social Science (SPSS). The research questions were answered using mean and standard deviation while the null hypotheses were tested using Analysis of Covariance (ANCOVA). Findings 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. Also, male physics students did not perform better than their female counterpart when taught using metacognitive scaffolding teaching strategy. Based on these findings, 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.

Keywords: Effect, gender, achievements, physics, metacognitive scaffolding, teaching strategy, thermal energy.

Introduction

The knowledge of physics can be applied in the field 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, military hardware, refrigeration and air-conditioning.

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 and in particular thermal energy 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	Pass Grade Levels		Fail Grade Levels	
		(A1-C6)	%	(D7-F9)	%
2010	387,380	148,599	38.36%	238,781	61.64%
2011	374,958	162,769	43.41%	212,189	56.59%
2012	386,449	190,210	49.22%	196,239	50.78%
2013	423,146	153,137	36.19%	270,009	63.81%
2014	402,228	140,056	34.82%	262,172	65.18%
2015	398,870	145,747	36.54%	253,123	63.46%
2016	416,580	174,432	41.9%	242,148	58.1%
2017	422,110	183,020	43.4%	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 fail thermal energy may be because it contains mathematical physics 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 the problem of mathematical physics 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 averted. 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 have opined that conventional teaching method may cause students to resort 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 can enhance mental thinking skills among which ismetacognitive 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 referred 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 would promote their self cognition are referred to as metacognitive scaffolding teaching strategy.

The termsmetacognitive scaffolding teaching strategy emanate from the concept of metacognition which is referred 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, scaffolding teaching strategy can be defined as a teaching framework that utilizes several innovative teaching models used to assist students attain a mental thinking level where they can develop their own cognition needed to solve difficult tasks. 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) and Hall (2015) may include advanced organizer, modeling, worked examples, explicit and problem solving approach, concept/mind maps, instructing, prompts, hints and questioning. In this study, three teaching models were used in metacognitive scaffolding teaching strategy, the experiment lessons in thermal energy were taught using modeling teaching strategy while mathematical physics lessons were taught using explicit mathematics/problem solving strategy. Advanced organizer was used to introduce physics concepts in thermal energy and then linked to students' prior knowledge. During teaching using modeling and explicit mathematics/problem solving models, the teacher used think aloud and questioning techniques while during problem solving, the teacher further assisted physics students by using cueing and hints strategies.

Gender consideration in the learning of physics is very important because gender discrimination against female has been observed to be prevalent at home. At home, female children are mostly used for domestic works. These domestic works make them tired due to stress. This eventually results in lack of concentration in the class. As a result of this, most female students tend to shy away from science, engineering and technology programes due to its tedious nature which requires enormous concentration efforts. This may also be the reason why most female students tend to go for professions that do not require more energy and brain tasking such as courses in arts and humanities (Owuamanan&Babatunde, 2007). Apart from the stress condition faced by female students at home, Abosede (2010) opined that another reason why male dominated science could be adduced to cultural and social orientation from parents and the society. Therefore, female students who study science courses may likely face the intimidation of male dominancy. In the class, male dominancy is seen in questioning and general classroom interactions (Katcha&Yabogi, 2015). This may affect female students' academic achievement in science and their attitude towards science courses including physics (Bello &Oluwatosin, 2014). This contention is also supported by the outcome of Uzoechi and Gimba (2015) who found out that malesperformed better than females in physics.

Jbeili (2012) posited that scaffolding teaching strategy assist students to manage their thinking and adjust it to a positive way when they are confused. An and Cao (2014) also 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). Further finding into the effect of metacognitive scaffolding teaching strategy showed that it has 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 tasks in design problem solving and analytical skills in other subject areas, but not many studies have reported its effect in physics. It is in view of this, that this study investigated the effect of gender on achievement among secondary school students taught thermal energy using metacognitive scaffolding teaching strategy in Federal Capital Territory (FCT), Abuja, Nigeria.

Research Questions

The following research questions guided the study:

i. What are the mean achievement scores of physics students taught thermal energy using metacognitive scaffolding teaching strategy and those taught using conventional teaching method?

ii. What are the mean achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy?

Hypotheses

The following null hypotheses were 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.
H_{02}: There is no significant difference in the mean achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy.

METHODOLOGY

The research design adopted for this study is quasi-experimental research design involving non-randomized control group pretest-posttest design. 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 given 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 contained 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 were 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) were 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 contained questions on temperature and its measurement, thermometer, absolute scale of temperature, specific heat capacity, latent heat capacity, evaporation, boiling and sublimation, 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 in Government Secondary School (GSS) 2, Jikwoyi in FCT-Abuja. The data collected was analyzed using Kuder-Richardson $(K\text{-}R)_{21}$ method to obtain a reliability coefficients of 0.92.

Physics students in the experiment group were 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 hypotheses were 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 2: 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 2 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 counterparts. This shows that the control group had physics scores that were more widespread and in agreement with the mean than the treatment group.

Research Question 2: What are the mean achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy?

Table 3: Means and Standard Deviations of Achievement Scores of Male and Female Physics Students Taught Using MetacogntiveScaffolding Teaching Strategy

Groups	Tests	N	Mean	SD	Relative SD	Standard Error
Male	Pretest	47	26.73	8.228	0.346	1.345

	Posttest	47	23.87	9.622	0.403	1.404
Female	Pretest	19	21.81	9.432	0.457	2.174
	Posttest	19	22.74	9.955	0.448	2.284

Table 3 indicates that the mean achievement score of male physics students were higher than the mean achievement score of female physics students. The relative standard deviations of the male physics students were higher than their female counterpart. This shows that the female physics students had physics scores that were more widespread and in agreement with the mean than their male counterpart.

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.

Table 4: 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 4 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 scaffolding teaching strategy.

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy.

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

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3456.654[a]	2	1768.675	154.768	.000
Intercept	45.311	1	43.308	36.076	.004
Pretest	5543.221	1	5543.221	164.125	.000
Group	122.321	1	121.321	10.543	.100
Error	450.231	63	4.309		
Total	3568.000	66			
Corrected Total	5467.567	65			

a. R Squared = .654 (Adjusted R Squared = .650)

Table 5 shows that at the group level, the P significant value of 0.100 is greater than P at 0.05 level of significance ($P>0.05$).The null hypothesis is therefore retained. This implies that there was no significant difference in the achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy. Thus the use of scaffolding teaching strategy does not result in sex dependent characteristics.

Discussion

The result from hypothesis 1 showed that physics students had better achievement scores when taught thermal energy using scaffolding teaching strategy than their counterparts 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) who reported that metacognitive instructional strategy improved students' achievement compared with the conventional teaching method. The reason for this finding might be that metacognitive scaffolding teaching strategy helps in improving the quality of instruction and students' innovative thinking skills that might have led to better achievement scores in thermal energy.

The result from hypothesis 2 reveals a P value of 0.100 greater than P at 0.05 level of significance. Therefore the null hypothesis is therefore retained. This result indicated that male physics students did not have a better achievement scores than their female counterpart when taught thermal energy using metacognitive scaffolding teaching strategy and it disagrees with that of Uzoechi and Gimba (2015) who reported that male physics students had a better achievement scores than their female counterparts using metacognitive explicit teaching method. The difference in their findings with the present finding may be that male physics students had a better understanding of physics using explicit teaching method in Uzoechi and Gimba (2015), while the use of three teaching models in the present study enabled female physics students to improve their knowledge. Further reason for this finding might be that physics students irrespective of gender difference were able to attain a higher mental thinking level when taught using these three teaching models in metacognitive scaffolding teaching strategy.

Conclusion

Based on the findings of the study, it is concluded that Physics students taught using metacognitive scaffolding teaching strategy had higher achievement scores than their counterpart taught using the conventional teaching method. Also, there was no gender dominance in the study since both male and female physics students performed equally the same when taught using metacognitive scaffolding teaching strategy.

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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