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GENDER DIFFERENCE IN ACHIEVEMENT AND ATTITUDE AMONG SECONDARY SCHOOL PHYSICS STUDENTS TAUGHT THERMAL ENERGY USING METACOGNITIVE SCAFFOLDING TEACHING STRATEGY

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Abstract

This study investigated gender difference in achievement and attitude among secondary school physics students taught thermal energy using metacognitive scaffolding teaching strategy in Federal Capital Territory (FCT), Abuja, Nigeria. The study investigated four research questions and four null hypotheses 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. Two instruments consisting of Thermal Energy Achievement Test (TEAT) and Attitude to Thermal Energy Questionnaire (ATEQ) were used for data collection. The data collected from these instruments were 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; Male physics students did not perform better than their female counterpart when taught using metacognitive scaffolding teaching strategy; Physics students taught using metacognitive scaffolding teaching strategy had better attitude towards thermal energy than their counterpart in the control group; Male physics students did not have a better attitude towards thermal energy 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: Gender, achievement, attitude, thermal energy, metacognitive scaffolding, teaching strategy

Introduction

Science discipline deals with the occurrence in the natural world and its various laws, facts, principles, concepts and conventions associated with it (Faye and Mclean, 2014). These several bodies of knowledge are segmented into several studies that include physics, chemistry and biology. Physics as a body of science

knowledge is concerned with matter and energy and the relationship between them (Okeke, Okeke and Akande, 2008). 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 and bombs. Thermal energy also called heat energy is a branch of physics that deals with thermodynamic quantities such as heat and temperature, energy transfer which are associated with matter in physics. Energy transfer is associated with conduction, convention and radiation. The application of thermodynamics is useful to mechanical heat energy and chemical compound reactions.

Despite the benefits of physics to the society Student's 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 showed that students' achievement in physics has been low over the years.

Table 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)

Physics students' achievement at SSCE has remained low over the years. In some years, failure rate in physics is as high as 65%. WAEC (2017) showed that the general results of students that wrote May/June WASSCE Physics examination from 2010 to 2017 had a failure rate above 50%. 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 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 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 and Freeman, 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.

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 uses think aloud and questioning techniques while during problem solving, the teacher further assisted physics students using cueing and hints strategies.

Apart from metacognitive scaffolding teaching strategy, the study also investigated the achievement and attitude dependent variables. Achievement is referred to students' scores in a test/examination. Students that have the required grade in an examination were classified as high achievers while students that failed to reach the required grade in an examination were classified as low achievers. The reason for relating metacognitive scaffolding teaching strategy with achievement is that students who had low grade in physics due to their inability to solve difficult questions may get their thinking abilities improved to enable them understand and solve difficult tasks. Metacognitive scaffolding teaching strategy also encourages collaborative thinking between teacher and learners which enable learners develops their mental thinking to understand difficult topics and task. When students are able to solve difficult tasks their achievement in physics may be enhanced.

Attitude is defined as an internal desire of a person which dictates the choice of his personal actions towards a thing. Cracker (2006) defined attitude as a person mental state in respect to what they think about a particular subject. A person who thinks positively towards a subject is likely to be determined and actively participate in classroom activities than a person who thinks negatively. Positive thinking also enables students to think through what they understand in a topic and also reflect on it. Attitude also brings about the stimulant for the acquisition of knowledge. Since metacognitive scaffolding teaching strategy is geared towards creative and reflective thinking, students may get interested in difficult topics and modify their thinking to a positive ways.

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 makes 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 and 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 faced the intimidation of male dominancy. In the class, male dominancy is seen in questioning and general classroom interactions (Katcha and Yabogi, 2015). This may affect female students' academic achievement in science and their attitude towards science courses including physics (Bello and Oluwatosin, 2014). This contention is also supported by the outcome of Uzoechi and Gimba (2015), who found out that male performed better than girls in physics.

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 and 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 gender difference in achievement and attitude among secondary school physics 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:

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

Hypothesis

The following null hypotheses were tested in the study.

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

H_{02}: There is no significant difference in the mean attitude scores of male and female physics students towards thermal energy taught using metacognitive scaffolding teaching strategy

Methodology

This research design for this study consists of 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 assign to control and experimental groups. Before embarking on the treatment, pretest were 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) 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) and Attitude to Thermal Energy Questionnaire (ATEQ). 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.ATEQ was used to measured physics students' attitude towards thermal energy and it contains twenty statements structured in accordance with 4 points Likert-type rating scale format. The TEAT and ATEQ were given to two science education experts and one measurement and evaluation expert for validation. The reliability of TEAT and ATEQ were determined by trial testing Government Secondary School (GSS) 2, Jikwoyi in FCT-Abuja. The data collected were analyzed using Kuder-Richardson $(K\text{-}R)_{21}$ and Cronbach's Alpha Reliability methods to obtain a reliability

coefficients of 0.92 and 0.79 for TEAT and ATEQ respectively.

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 and ATEQ were 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 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 Metacognitive Scaffolding 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 are more widespread and in agreement with the mean than their male counterpart. This further indicates that female physics students had more consistent scores than their male counterpart.

Research Question 2

What are the mean attitude scores of male and female physics students towards thermal energy taught using metacognitive scaffolding teaching method?

Table 4: Means and Standard Deviations of Attitude Scores of Male and Female Physics Students Taught Using Metacognitive Scaffolding Teaching Strategy

Groups	Tests	N	Means	SD	Relative SD	Standard Error
	Pre-Attitude	47	54.04	10.248	0.184	1.435
Male	Post-Attitude	47	55.19	10.356	0.188	1.511
	Pre-Attitude	19	50.56	9.134	0.165	2.015
Female	Post-Attitude	19	51.95	9.228	0.178	2.117

Table 4 shows that the mean score of male physics students were higher than the mean score of female physics students. The relative standard deviations of male physics students were higher than their female students' counterpart. This shows that the male physics students had physics scores that are more widespread and in agreement with the mean than their female counterpart. This further indicates that male physics students had more consistent scores than their male counterpart.

Hypothesis 1: 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 metacognitive scaffolding teaching strategy does not result in sex dependent characteristics. This further implies that irrespective of students' gender difference, metacognitive scaffolding strategy is useful in enhancing physics students' achievement scores.

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

Table 6: ANCOVA Analysis of the Mean Attitude Scores of Male and Female Physics Students to Thermal Energy Taught Using Metacognitive Scaffolding Teaching Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6578.113[a]	2	3987.976	498.245	.000
Intercept	65.776	1	56.879	7.254	.000
Pretest	4576.542	1	4679.254	724.246	.000
Group	201.524	1	187.236	19.113	.062
Error	346.325	63	4.189		
Total	54789.325	66			
Corrected Total	5769.346	65			

a. R Squared = .769 (Adjusted R Squared = .760)

Table 6 shows that at the group level, the P significant value of 0.062 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 attitude of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy. In essence, both male and female physics students develop an improved attitude towards thermal energy when taught using metacognitive scaffolding teaching strategy. Also, an improved attitude tends to develop students' mental thinking towards physics which is evident in students' achievement scores in physics.

Discussion

The test of hypothesis one reveals a P value of 0.100 greater than P value at 0.05 level of significance. The null hypothesis is therefore retained. The result showed that there is no significant difference in the mean achievement scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy. The result indicates that male physics students did not had a better achievement scores than their female counterpart which is supposed to be contrary. This result disagrees with the finding 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 may be that male physics students had a better understanding of physics using explicit teaching method as in Uzoechi and Gimba (2015), whereas the present study utilizes metacognitive scaffolding teaching strategy which nullifies the male dominancy in physics subject. Furthermore, the 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.

The test of hypothesis two reveals a P value of 0.062 greater than P at 0.05 level of significance. Therefore the null hypothesis is therefore retained. The result showed that there is no significant difference in the mean attitude scores of male and female physics students taught thermal energy using metacognitive scaffolding teaching strategy. The result indicates that male physics students did not had a better attitude scores than their female counterpart which is supposed to be contrary. This showed that metacognitive scaffolding teaching strategy is an effective innovative teaching strategy that enhances students' mental thinking irrespective of gender differences. This finding agrees with that of Gamze (2010) who found that there was no significant effect of gender on students' attitude. The reason for this similarity may be that the teaching strategies utilized by both the reviewed study and the present study had significant impact on male and female physics students.

Conclusion

Based on the findings of the study, gender difference in achievement and attitude to thermal energy among senior secondary physics students taught using metacognitive scaffolding teaching strategy is insignificant as there was no male dominant factor in the outcome of the results from the achievement and attitude scores.

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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