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RESEARCH ARTICLE

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

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ABSTRACT

This study investigated the effect of gender on attitude 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 drawn 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 Attitude to Thermal Energy Questionnaire (ATEQ) was used for data collection. The data collected from this instrument were analyzed using Statistical Package for Social Science (SPSS). The research question was 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 had better attitude towards thermal energy than their counterparts in the control group. Also, male physics students did not have a better attitude towards thermal energy than their female counterpart when taught usingmetacognitive 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.

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INTRODUCTION

Physics concepts 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 refrigerators, air-conditioners, 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 Programmes in the university. As a result of these, students aspiring to study physics, engineering and technology programs in the university must obtain a grade level of credit and above in the subject.

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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 shows that students' achievement in physics has been low over the years. 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 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 problem of mathematical physics task, the lack of the use of modeling to demonstrate experiment in the class may also affect students' cognition and attitude to learning.

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's mental state in respect to what they think about a particular subject Attitude to learning contributes to students' learning outcome. The outcome of attitude can be either positive or negative and this outcomeis believed to correlate to students' achievement. A person who thinks positively towards a subject is likely to be determined and may actively participate in classroom activities more 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 in a positive way.

In order to ensure that students' excel in thermal energy, over dependent on the use of conventional teaching method by teachers should be minimized. Wood and Gentile (2003) opined that in conventional teaching method, there isno teacher-students interaction as the teacher dominates all the class activities right from the beginning of the lesson to the end. Conventional teaching method also has the attribute of brief teaching, which hinders collaborative thinking that promotes reflection and metacognition. Many researchers have opined that conventional teaching method may cause students to result 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 overreliance on conventional teaching method in the teaching of physics may affect students' attitude toward the study of physics.

Agommuoh and Ifeanacho (2013) pointed out that for teaching to be effective in impacting on students' attitude, 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 tasks. 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 tasks 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 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 and 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 attain 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 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 uses think aloud and questioning techniques while during problem solving, the teacher assists physics students 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 their 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 report of Uzoechi and Gimba (2015) who found out that male performed better than girls in physics. Jbeili (2012) posited that scaffolding teaching strategy assist students to manage their thinking and adjust 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 gender on attitude among secondary school students taught physics concept using metacognitive scaffolding teaching strategy in Federal Capital Territory (FCT), Abuja, Nigeria.

Research Questions

The following research questions guided the study:

- What are the mean attitude scores of physics students towards thermal energy taught using metacognitive scaffolding teaching strategy and those taught using conventional teaching method?
- What are the mean attitude scores of male and female physics students towards thermal energy taught 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 attitude scores of physics' students towards thermal energy when taught using metacognitive scaffolding teaching strategy and those taught using conventional lecture method.

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

METHODOLOGY

This research design for this study was quasi-experimental research design involving non randomized control group pretest-posttest design. It employed 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 given to the two sampled schools after which 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 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 Attitude to Thermal Energy Questionnaire (ATEQ). The instrument was used to measure physics students' attitude towards thermal energy and it contains twenty statements structured in accordance with 4 points Likert-type rating scale format. The ATEQ was given to two science education experts and one measurement and evaluation expert for validation. The reliability of ATEQ was determined by trial testing at Government Secondary School (GSS) 2, Jikwoyi in FCT-Abuja. The data collected was analyzed using Cronbach's Alpha Reliability methods to obtain a reliability coefficient of 0.79. Physics students in the experimental group were taught using metacognitive scaffolding teaching strategy, while physics students in the control group were taught using conventional method. Both groups were taught for eight weeks. At the end of the eight weeks, 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.

RESULTS

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

The data that answered this research question is presented in table 2:

Table 2 indicates that the mean score of physics students in the treatment group were higher than the mean score of physics students in the control group. The relative standard deviations of the control group were higher than that of the treatment group. This shows that the mean attitude score of the control group in physics were more widespread and in agreement with the mean of the treatment group.

Research Question 2

What are the mean attitude scores of male and female physics students towards thermal energy taught using metacognitive scaffolding teaching method? The data that answered this research question is presented in table 3. Table 3 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 more widespread and in agreement with the mean than their female counterparts.

Hypothesis 1: There is no significant difference in the mean attitude scores of physics students towards thermal energy taught using metacognitive scaffolding teaching strategy and those taught using conventional teaching method. 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 ($P<0.05$). The null hypothesis is therefore rejected. This implies that there was a significant difference in the attitude of physics students towards thermal energy taught using metacognitive scaffolding teaching strategy and those taught using conventional teaching method.

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%

Table 2. Means and Standard Deviations of Attitude Scores of Physics Students taught using Metacognitive Scaffolding Teaching Strategy and Conventional Lecture Method

Groups	Tests	N	Means	SD	Relative SD	Standard Error
	Pre-Attitude	30	58.41	4.125	0.105	1.012
Treatment	Post-Attitude	30	63.87	4.238	0.066	1.018
	Pre-Attitude	36	42.65	6.234	0.134	0.634
Control	Post-Attitude	36	46.25	5.575	0.125	0.706

Table 3. 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: ANCOVA Analysis of the Mean Attitude Scores of Physics Students to Thermal Energy Taught Using Metacognitive Scaffolding Teaching Strategy and Conventional Teaching Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4353.714[a]	2	3246.025	415.032	.000
Intercept	57.657	1	48.738	6.159	.001
Pretest	3798.433	1	5437.347	674.387	.000
Group	196.426	1	145.301	18.278	.000

Error474.354635.209
Total48597.13266
Corrected Total6587.46865
a. R Squared = .898 (Adjusted R Squared = .890)

Table 5. 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)

In essence, those taught using metacognitive scaffolding teaching strategy would develop more positive attitude to the study of thermal energy more than those taught using the conventional method.

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. The result of this test is presented in table 5.

Table 5 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 developed an improved attitude towards thermal energy when taught using metacognitive scaffolding teaching strategy.

DISCUSSION

The test of hypothesis one shows that physics students had a more positive attitude to thermal physics when taught using metacognitive scaffolding teaching strategy than their counterpart who were taught using the conventional teaching method. This finding agrees with the outcome of Sonleitner (2005) whose finding showed that there was a positive relationship between students' achievement score and their attitude. The reason for this finding might be that metacognitive scaffolding teaching strategy which engages students in collaborative thinking had a greater impact on students' thinking ability which might have also changed their attitude towards the physics. 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 was retained. This result indicated that male physics students did not have more positive attitude towards thermal energy than their female counterparts when taught using metacognitive scaffolding teaching strategy. 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 outcome may be that both male and female physics students had an improved attitude towards thermal energy when taught using 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 a more positive attitude to thermal energy than their counterparts taught using the conventional lecture method. This shows that metacognitive scaffolding teaching strategy is more effective in teaching thermal energy than the use of the conventional lecture method.

Recommendation

The study therefore recommends that:

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

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