Greener Journal of Educational Research
Vol. 12(1), pp. 13-21, 2022
ISSN: 2276-7789

http://gjournals.org/GJER

Effect of Scaffolding Teaching Approach on Students' Academic Achievement in Quantum Physics in Enugu Education Zone.

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ARTICLE INFO

Article No.: *031322035*
***Type*:** *Research*
Full Text: *PDF, HTML, PHP, EPUB*

Accepted: *15/03/2022*
Published: *05/04/2022*

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Keywords: *Scaffolding Teaching Approach, Academic Achievement, Quantum Physics.*

ABSTRACT

This study investigated the effect of scaffolding teaching approach on students' academic achievement in secondary school Physics in Enugu Education Zone. Two research questions and three null hypotheses tested at 0.05 significance guided the study. A Pretest-Posttest Quasi-Experimental design was adopted. The population for the study was all the SS2 Physics students in the Zone. Multi-stage random sampling was used to select two public schools comprising 85 students. The experimental group was taught using scaffolding teaching approach while the control group was taught using conventional method. The instrument for data collection were 25 PAT adopted from WAEC-past questions which were validated by three experts and tested for reliability using Kuder-Richardson's formula-20 which yielded coefficients 0.87. The data collected were analyzed using mean, standard deviation and ANCOVA. The findings amongst others showed that students in scaffolding teaching approach group achieved better than their counterpart. Based on the findings of the study, it was recommended that physics teachers should incorporate scaffolding teaching approach in teaching.

INTRODUCTION

Physics is a science subject that studies matter, objects, energy and their interaction in a given system or environment. Physics is the most fundamental and the root of every field of science (Eryilmaz, 2016). Anyakoha (2016) defined physics as a natural science that involves the study of matter and energy and their interactions. Physics is the study of natural phenomenon at its most fundamental levels and manner. This is because, physics, being one of the core subjects offered in Nigerian schools forms the basis for the nation's technological advancement and human resource development (Abubakar, 2012). Physics knowledge has contributed immensely to the production of tools and devices of tremendous advantage to the human race

(Sani, 2012). The knowledge of physics according to Gabriel (2012) offers the learners the opportunity to think critically, reason analytically and acquire the spirit of enquiry. The researcher also stressed that the knowledge of physics develop in students, the scientific and technological knowledge, skills and attitudes which will assist them to make decisions based on the observation and experimentation. Quantum Physics, Geophysics, Medical Physics, Computing Physics, Material physics, Environmental Physics, Communication, Physics Education, Engineering and Industrial Physics to list but a few are career courses in institutions of higher learning which cannot be undertaken without the knowledge of physics at secondary school level.

Physics is divided into two broad categories: Classical Physics and Modern Physics. Classical physics is the branch of physics that studies the mechanism of a particle of length greater than 10^{-6}m while Quantum physics is the branch of physics that studies the mechanisms of a particle less than a length of 10^{-6}m (Okoli, 2019). Quantum Physics is the study of matter and energy at the most fundamental level. Quantum Physics is required to uncover the properties and behaviours of every building blocks of nature. Quantum Physics examines very small objects such as electrons and photons. These electrons and photons are all around us acting on every scale. The branches of quantum physics include uncertainty principle, wave-particle duality, energy levels, and photoelectric effect. The discovery of Quantum Physics led to the discoveries of valuable resources like computers, lasers, transistor etc.

Interestingly, as important as physics is, students' academic achievement and interest in the subject at secondary school and institution of higher learning has not been encouraging. In Nigeria, there has been a recurring unacceptable attainment of students in physics. Record of students' performance at Senior School Certificate Examination (SSCE) in physics conducted by West African Examination Council (WAEC) according to Adolphous (2018) shows that between 2001 and 2009 (except in 2006), less than 50% of the students who enrolled for physics obtained credit level pass and above to secure admission into the university in order to pursue courses that require physics. The researcher also stressed that the failure rate continued from 2007 to 2009 (42.9%, 47.1% and 46.2%) and in 2013 (46%) with an improved achievement in 2010, 2011 and 2012 (50.2%, 62.6% and 67.2%). According to Onah and Achufusi (2022) shows that the failure trends continued in 2015, 2017; and 2020 (47.83%, 41% & 36% respectively) with an improved achievement in 2016, 2018; and 2019 (71%, 87% & 80% respectively). In general, this cannot be considered an acceptable achievement as many have lamented that achievement of Nigeria students in physics at the Senior School Certificate Examination (SSCE) has been generally not so good (Adaramola & Obomanu, 2011; FME, 2009). Even the WEAC chief examiners report in physics specifies areas of students' weakness and the way forward to better achievement in the subject. They stated that many students cannot properly draw physics diagram, give correct definitions of some concepts or solve some problems, using mnemonic to master some physics equations. The Chief examiners also reported that there are challenges in Nigerian students' understanding of concepts such as wave-particle duality of photons. They opined that the wave-particle duality was poorly understood among upper secondary students in Nigeria, and some students clearly demonstrated misconceptions rooted in a classical physics worldview. They suggested as well that teachers should teach students rules guiding physics diagram and should provide teaching aids and models to help students understand physics concepts.

The students' poor achievement in physics in particular and sciences in general has been attributed to many factors. These include; poor methods of physics instruction by the teachers, insufficient number of qualified physics teachers, lack of indigenous textbooks, inadequate apparatus in the physics laboratory, poor classroom management by physics teachers, teacher's belief and attitude towards physics, physics teacher's inability to improvise, inadequate instructional materials and aids, educational background and parental expectations on the learners and finally students' related factors or variables like students' academic anxiety, academic self-efficacy, academic locus of control, academic motivation and more (Adedayo & Jegede, 2013). This study therefore is set to find out the effect of scaffolding teaching approach on students' academic achievement in physics.

Scaffolding teaching approach is the support given to a student by a teacher throughout the learning process. This support is specifically the concept map (cmap) which aimed for each student; this instructional approach allows students to experience student-centered learning, which tends to facilitate more efficient learning than teacher-centered learning (Boris, 2020). Scaffolding teaching approach promotes a deeper level of learning than many other common teaching strategies in use in most of our secondary school education.

Scaffolding teaching approach provides sufficient support to promote learning when concepts and skills are being first introduced to students. These supports may include resource, compelling task, templates and guides, and/or guidance on the development of cognitive and social skills. Instructional scaffolding could be employed through modeling a task, giving advice, and/or providing coaching. (Akani, 2015)

According to Palincsar (1986), the scaffolding support and guidance provided to the learner is synonymous to the scaffolds in building construction where the scaffolds provide both "adjustable and temporal" support to the building under construction. The support and guidance provided to learners to facilitate conceptualization of the knowledge which is needed to complete the task. This support is removed gradually until the learner becomes independent to take task

(Palincsar, 1986). These enable the students' develop autonomous learning strategies, thus promoting their own cognitive, affective and psychomotor learning skills and knowledge. According to Nwali (2014), teachers help the students to master a task or a concept by providing support to them; with the aid of relevant instructional approach. The support can take many forms such as concept map, recommended documents, mnemonics, and use of analogy, clinical interview, storyboards, or key questions.

Omoniyi & Torru (2018) defines educational scaffolding as a teaching method that enables students to solve a problem, carryout a task or achieve a goal through a gradual shedding of outside assistance. In education, scaffolding refers to variety of instructional techniques used to move a student progressively toward stronger understanding and, ultimately, greater independence in the learning process (Omoniyi & Torru, 2018).

In general, scaffolding teaching approach is the support given by a teacher to her student when performing a task that the student might otherwise not be able to accomplish. First common characteristic in the various definitions of scaffolding is contingency; often referred to as responsiveness, tailored, adjusted, differentiated, or calibrated support. The teachers' support must be to the current level of the students' performance and should either be at the same or a slightly higher level. A teacher acts contingently when s/he adapts the support in the way or another to a (group of) student(s). A tool for contingency is diagnostic strategies, to provide contingent support, that is one must first determine the students' current level of competence. Only with such knowledge can the support to be provided be adapted to the students' level of learning (i.e. made contingent). Awodun (2019) defined scaffolding teaching approach as the teaching strategies that a teacher uses to help learners to bridge a cognitive gap or process in their learning to a level they were previously unable to accomplish. These strategies evolve as the teachers evaluate the learners initial level of ability and then through continued feedback throughout the progression of the task. In the early studies, scaffolding was primarily done in oral, face-to-face learning environments.

In classrooms, scaffolding may include modeling behavior's, coaching and prompting, thinking out loud, dialogue with questions and answers, planned and spontaneous discussions, as well as other interactive planning or structural assistance to help the learner bridge a cognitive gap. This can also include peer mentoring from more experienced students. The contemporary scaffolding provided by the teacher is removed as soon as the students internalize the content and or process and are competent to assume a full responsibility for controlling the process of a given task (Awodun, 2019).

The general desire to improve teaching performance and student's academic achievement in Physics should be a concern of all stakeholders in education in Nigeria. Therefore, this study seeks to examine the effect of Scaffolding Teaching Approach on Students' academic achievement in Secondary School Physics in Enugu Education Zone, Enugu State, Nigeria.

Gender has been noted by researchers over the years as having impact on achievement in Physics and its related disciplines (Akumah, 2013). Akumah even stressed that science, technology and their related disciplines are male-reserved while Art and Humanities are female reserved. This belief makes boys appear to have a natural positive attitude towards science and technical subjects while girls show more inclination to Arts and Humanities. The problem is even compounded by the fact that most science educators give masculine outlook to science subjects such as chemistry and physics (Babajide, 2010); encouraging females to go rather for biology, agricultural science and home economics which they consider to be more female-friendly science subjects. Some other researchers (Nwankwo & Okoye, 2015; Orefor, 2016) opined that gender has no influence on students' achievement in the sciences. All these and related treatments make girls have phobia for science and science-related subjects which definitely affect their future career-choice and eventual achievement. Due to lack of consensus regarding the issue of gender and science and more importantly to capture the interest of girls, and consequently improve their achievement in physics and other science related carriers, there is a need therefore to try such innovative strategy as scaffolding teaching approach to see what effect it will have on achievement of male and female students in the sciences especially Physics.

Statement of the Problem

In Nigeria, emphasis has been placed on secondary school students' academic achievement and interest because of its direct positive impact on national development. Young students in secondary schools today are expected to be leaders of tomorrow and the quality of manpower the nation can boast of in the future. Also, students' academic achievement is measure for gaining admission into institutions of higher learning. More so, students advances in the understanding of quantum physics leads directly to the development of new products such as televisions, computers, domestic appliances and nuclear weapons that have dramatically transformed modern-day society. Advances in quantum physics led to the development of industrialization and advances in mechanics inspired the development of calculus. Physics thus makes significant contributions through advances in new technologies that arise from theoretical breakthrough. In view of the positivisms of physics to mankind, many researchers in recent time are interested in the factors affecting academic achievement and interest in physics in particular and sciences in general with a view to finding solutions to the problems of poor academic achievement. Studies on students' academic achievement have mostly pointed out that effective and innovative teaching approaches are the

major variable that enhances academic achievement, yet they have received very little attention if any, in the literature of Enugu Education Zone. In view of the on-going, the present study identifies scaffolding teaching approach whose effects on academic achievement and interest have not been so much reported in the literature of Enugu Education Zone and hence deemed it very important to find out the Effect of scaffolding teaching approach on students' academic achievement in quantum physics students in the Zone.

Purpose of the Study

The main purpose of the study is to investigate the effect of scaffolding teaching approach on students' academic achievement in quantum physics in Enugu Education Zone of Enugn State.

Specifically, the study seeks to find the:

1. Difference between the mean achievement scores of students taught quantum physics using scaffolding teaching approach and that of those taught using conventional method.
2. Difference between the mean achievement scores of male and female students taught quantum physics using scaffolding teaching approach.
3. Interaction effect of teaching approaches and gender on students' achievement in quantum physics.

Research Questions

The following research questions were designed to guide the study

1. What is the difference in the pretest and posttest mean achievement scores of physics students taught using scaffolding teaching approach and those taught using convectional instructional approach?
2. What is the difference in the mean achievement scores of male and female students taught Physics using scaffolding teaching approach?

Hypotheses

The following null hypotheses were formulated for the study; which which was tested at 0.05 level of significance

1. There is no significant difference in the pretest and posttest mean achievement scores of physics students taught quantum physics using scaffolding teaching approach and those taught using convectional approach as a method of teaching.
2. There is no significant difference in the mean achievement score of male and female students taught quantum physics using scaffolding teaching approach.
3. There is no significant interaction effect of gender and teaching methods on students mean achievement scores in physics.

METHOD

A pretest – posttest quasi-experimental research design, specifically non-equivalent control groups design was used for the study. A pretest – posttest quasi-experiment is an experiment where randomization assignment of subjects to experimental and control groups is not possible (Nworgu, 2015). The design was considered appropriate for the study because intact classes were used to avoid disruption of normal class lesson. Eighty-Five (85) SS 2 physics students (44 males & 41 females) drawn through multi-stage sampling approach from two co-educational secondary schools in Enugu North Local Government Area of Enugu State were used for the study. In stage one, simple random sampling technique was used to select Enugu North Local Government Area. In second stage, purposive sampling was used to select two co-educational schools in the local government area based on the existence in those schools of well-equipped physics laboratories and experienced physics teachers with teaching qualification. Simple random sampling technique (precisely balloting) was next used to assign experimental and control treatments to the schools. The technique was used so as to provide classes where boys and girls work together under the same classroom environment .Intact classes were used in the sampled schools so as not to disrupt the normal school activities. Four weeks were used for the experiment. Each week had two periods (double periods each) of 40 minutes per period. The control group was taught using conventional method which involves content-rich activities such as demonstrations, lecture, experiments and quantitative problem-solving which does not involve the students in scaffolding processes. For the experimental class, the same set of activities for the control group was carried out for both double periods; but in addition to discussing and writing down their observations, students were engaged in such scaffolding activities as:

a) ***Concept Maps***

Concept maps are defined as the schematic drawings which are used for showing the meaningful relations among the concepts in a proposition form. The concept map is a practical technique of scaffolding teaching approach as it helps students relate their previous knowledge with the new knowledge.

b) ***Word Association Test***

It is the most common and the oldest methods in the investigation of cognitive structure and has been used by

several researchers. In this technique, mnemonic are used to memorize concepts.

c) ***Diagnostic tree testing***

It is a simple tree design that shows the strength and weakness of the students. It consists of seven statements to which a true/false response is required. The route a student follows on the test gives an indication of where s/he has wrong linkages, wrong strategies, or incorrect knowledge.

d) ***Clinical interview***

This has been used by researchers to determine the interest of the students. It is a conversation of an expert with a student, focused by initial questions about the situations represented in series of line diagrams to check the student's interpretation of natural phenomena or social occurrence. It enables the students to interact closely with experts (the researcher).

The instrument used for data collection were the Physics Achievement Test (PAT) adopted from WAEC past Questions between 2015-2020 comprised 25 multiple-choice items with four options (prep-50). The instruments were face and content validated by three experts and tested for reliability using Kuder Richardson 20 (KR-20) which yielded a coefficient of 0.87. The instrument was firstly administered as pre-test, scored and kept without any feedback to the students. After the treatment, the same test with the same contents was reshuffled and given as post-test. Both tests were scored by the researcher to avoid bias. The results obtained were used for analysis. Research questions were answered using mean and standard deviation (SD) while the hypothesis were tested using ANCOVA.

RESULTS

Research Question 1: What is the difference in the pretest and posttest mean achievement scores of physics students taught Quantum Physics using scaffolding approach and those taught using Conventional instructional approach?

Answer to Research question 1 is presented in Table 1

Table 1: Mean and Standard deviation of achievement scores of students taught Quantum Physics using scaffolding teaching approach and those taught using conventional approach

Teaching Method	Pre-test			Post-test			
	N	Mean($\widetilde{x}$)	SD	N	Mean($\widetilde{x}$)	SD	Mean Gain($\widetilde{x}$)
Scaffolding teaching Approach	40	26.10	12.81	40	61.70	14.18	35.60
Conventional method	45	24.71	9.73	45	36.98	10.48	12.27

Table 1, shows that the pretest and posttests mean achievement scores of students taught Quantum Physics using scaffolding teaching approach were *26.10* and *61.70* while the gain in mean score was 35.60. Their counterpart taught using conventional approach, on the other hand, had 24.71, 36.98 and 12.27 as pretest, posttest and gain in mean scores respectively. This shows a 23.33 difference in gain in mean scores between the two groups in favor of the students taught with the scaffolding teaching approach. The result also shows a remarkable difference in mean gain scores between students taught quantum physics using scaffolding teaching approach. These students had higher post-test mean achievement score and greater gain in mean score in achievement than students taught using conventional method.

Research Question 2: What is the difference in the mean achievement scores of male and female students taught quantum physics using scaffolding teaching approach?

Answer to Research question 2 is presented in Table 2

Table 2: Mean and Standard deviation of achievement scores of male and female students taught quantum physics using scaffolding teaching approach

Gender	Pre-test			Post-test			
	N	Mean($\widetilde{x}$)	SD	N	Mean($\widetilde{x}$)	SD	Mean Gain($\widetilde{x}$)
Male	22	25.64	9.37	22	60.91	11.04	35.27
Female	18	26.67	16.35	18	62.67	17.57	36.00

Table 2 shows the pre- and post-tests mean achievement scores of male students (25.64 and 60.91) and their female counterpart (26.67 and 62.67) taught quantum physics using scaffolding teaching approach. The gain in mean score for male students was 35.27 while that of the female counterpart was 36.00. This indicates a mean difference of 0.73 in favor of the female students. The mean difference is not significant amongst the gender. Therefore, there is no gender difference.

Hypothesis 1: There is no significant difference in the pretest and posttest mean achievement scores of Physics students taught quantum physics using scaffolding teaching approach and those taught using conventional approach.

Table 3: Summary of Analysis of Covariance of effect of scaffolding teaching approach on students' achievement in quantum physics by Treatment and Gender

Dependent Variable: posttest						
Source	Type II Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13651.929[a]	4	3412.982	22.821	.000	.533
Intercept	25322.571	1	25322.571	169.321	.000	.679
Pretest	659.868	1	659.868	4.412	.039	.052
Approach	12522.662	1	12522.662	83.734	.000	.511
Gender	.253	1	.253	.002	.967	.000
Interaction	40.684	1	40.684	.272	.603	.003
Error	11964.259	80	149.553			
Total	226480.000	85				
Corrected Total	25616.188	84				
a. R Squared = .533 (Adjusted R Squared = .510)						

Table 3 shows that the probability associated with the calculated value of *F (1,80) = 83.734* for the effect of scaffolding teaching approach on students' achievement in quantum physics is *.000*. Since the probability value of *.000* is less than the *.05* level of significance *(p < .05),* the null hypothesis was rejected. Thus, there is a significant difference between the mean achievement scores of the students taught quantum physics in secondary schools with scaffolding teaching approach and those taught with conventional method in favor of those in experimental group (scaffolding teaching approach).

Hypothesis 2: There is no significant difference in the mean achievement score of male and female students taught quantum physics using scaffolding teaching approach.

Table 3 shows that the probability associated with the calculated value of *F (1,80) =.002* for the influence of gender on students' achievement in quantum physics is .967. Since the probability value of .967 is greater than .05 level of significance *(p> .05),* the null hypothesis was accepted. Thus, gender has no significant influence on the academic achievement of students in quantum physics.

Hypothesis 3: There is no significant interaction effect of gender and teaching methods on students mean achievement scores in quantum physics.

Table 3 reveals that the calculated value of *F (1, 80) = .272* for the interaction effect of treatment and gender on students' academic achievement in quantum physics had a probability value of *.603*. Hence, there is no significant interaction effect of treatment and gender on students' achievement in quantum physics since the

probability value is greater than the *.05* level of significance *(p > .05).*

DISCUSSIONS

The result of this study as shown in Table 1 revealed that students taught Quantum Physics using scaffolding teaching approach and those of the control group taught with conventional teaching approach were similar in terms of their achievement scores in the pretest. However, after the experiment, the experimental group performed better in achievement score test than those taught using conventional teaching approach. From Table 3, significant difference existed between the academic achievement scores of the experimental and control groups in favor of the experimental group. This result is consistent with the findings of Omoniyi (2017). In that study, Omoniyi observed that scaffolding teaching approach had a significant positive effect in promoting students' conceptual understanding when compared with the effect of lecture method of instruction.

In the present study, scaffolding teaching approach was used to highlight the intelligibility and the usefulness of the selected Physics concepts Quantum Physics and so promoted achievement scores in students by getting them actively involved in constructing their own knowledge through active involvement in metacognitive processes. The result also agreed with the findings of Awodun (2019), Ogunseemi (2013), Chukwuagu (2016), Bansal (2017) and Nwali (2014). More so, the scaffolding teaching processes used in the present study gave the students in the experimental group opportunity to interact among themselves and with the more knowledgeable others especially during clinical interview, creating cognitive conflict in students which led to dissatisfaction alternative conceptions. Resolving these dissatisfactions result in conceptual understanding as well, which in turn promoted their academic achievement. This type of interaction also helped the students to share their ideas with each other and ponder those ideas in depth. Engagement in word association test and diagnostic tree testing created enthusiasm in students which encouraged conceptual understanding in them which is evident in students as they restructure their initial concepts having found the new ones more meaningful. On the other hand, conventional approach which was used on the students in the control group comprised lecture, use of textbooks and only explanation of important concepts where, according to Ceylan & Geban (2010), teachers' major task was to transfer knowledge to students. The conventional teaching approach does not engage students in metacognitive processes like concept maps, mind mapping and so, did not have enough quality to eliminate students' alternative conceptions and bring about conceptual understanding in students.

Table 2 showed that gender has no influence on students' achievement on Physics concepts (Quantum Physics) using scaffolding teaching approach. This is because, no significant difference existed between the achievement scores of male and female students in the experimental group. The result agrees with Awodun (2019), Piraksa, Srisawasdi and Koul (2013), Orefor (2016); and Nnorom (2015). On the other hand, the study disagrees with Nworgu, Ugwuanyi and Nworgu (2013) and Nwankwo and Madu (2014) who noted a gender difference with a teaching method.

From the Data displayed in Table 3 there is no significant interaction between instructional approach and gender on students' academic achievement scores in Physics was observed. This result agreed with the findings of Nwankwo and Madu (2014), who discovered no significant interaction between gender and instructional approach on students' conceptual change in physics, agreed with the present finding. On the other hand, Baser and Durmus (2010) who noted a significant interaction between gender and instructional treatment on students' academic achievement in Quantum Physics. It is obvious that there is no agreement in the research community concerning the interaction effect of gender and instructional strategies have on students' conceptual understanding of science especially physics concepts. The differences in observation by different researchers could be attributed to the influence of location and some other extraneous threats to the experiment. There is therefore a great need to embark in more studies in order to shed further light on this issue.

CONCLUSION/ RECOMMENDATIONS

Use of Scaffolding teaching approach in science instruction is effective in increasing Physics students' academic achievement. This is because, the students performed significantly better in posttest scores, when taught quantum physics using scaffolding teaching approach than when taught same concepts using conventional teaching approach. The study however, showed there is no significant gender difference in students' academic achievement scores.

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

1) Teacher educators in Universities and Colleges of Educations should be focused on preparing Physics teachers to acquire appropriate skills and competence needed for scaffolding instructional approach.

2) Federal Ministry of Education should incorporate scaffolding teaching approach based on the information collected here as a basis for taking decision on the best instructional approaches to be adopted in Nigerian secondary school physics curriculum as opposed to using lecture teaching approach. This is so, as activity-based approaches are aimed at making science (especially Physics) learning interesting and exciting which in turn improves academic achievement.

3) Teacher-training programme designers should include in its curriculum a course on scaffolding teaching approach, while practicing teachers should be re-trained in the approach through seminars, workshops, conferences, in-service trainings, annual teacher vacation courses and refresher courses.

4) Curriculum should be reviewed by curriculum planners to reflect the approach while textbook authors should be encouraged to incorporate the approach in Physics textbooks.

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Cite this Article: Onah, KT (2022). Effect of Scaffolding Teaching Approach on Students' Academic Achievement in Quantum Physics in Enugu Education Zone. Greener Journal of Educational Research, 12(1): 13-21.