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EFFECT OF INQUIRY BASED LEARNING ON SECONDARY SCHOOLS STUDENTS' MISCONCEPTION OF SCIENCE CONCEPTS AND ACADEMIC ACHIEVEMENT IN SCIENCE

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ABSTRACT

The study examined the effect of inquiry based learning on secondary schools students' misconception of science concepts and academic achievement in science. Two hypotheses guided the study. The design of the study was quasi-experimental; specifically the pre-test, post-test; non randomized control group design. The population of study comprised of 1902 SS11 science' students. The sample consisted of 174 SS11 science students who were purposively drawn from four coeducational secondary schools in the study area. Instruments known as "Science Misconceptions Test (SMT) and Science Achievement Test" (SAT) were used for data collection. The hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). The results revealed that there was a significant difference in the mean achievement scores of students exposed to inquiry based learning than those exposed to conventional lecture method; gender had no significant effect on the mean achievement scores of students in science concepts. Based on the findings of this study, the following recommendations were made; that use of conventional method of teaching should be de-emphasized in secondary schools to enhance better understanding of science concepts vis a vis achievement in science. The developer of instructional materials should reflect teaching techniques in planning science subject curriculum for secondary schools.

Key Words: Inquiry-based learning, Misconception, Achievement and Science concepts

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Introduction

Science is the branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general law. Ada (2014) stated that today's science is tomorrow's solution and tomorrow's problem too. Throughout the history of mankind science has been dominant factor for initiating and accelerating human progress and development. Ada further observed that all the nation of the world are aware of the significant contribution of science as exemplified in the transformation of their economies, improving the living standard of their people both in urban and rural areas, promotion of health over diseases through development of new method and skills production. Science plays an important role in education, health, economic development, energy and environment.

Despite the importance of science and its applications, the performance of science students at West African Examination Council (WAEC) and National Examination Council (NECO) has not been satisfactory. Research has shown that for several years the performance of students in science has been very poor (NERDC, 2004; Eniayeju, 2010; Obi & Ewuzie, 2014). Analysis of results given by West African Examination Council (WAEC) Chief Examiners reports showed the average mean performance score of students who sat for physics for several years in 2014, 2015, 2016 and 2017 to be 24, 20, 23 and 21 respectively (WAEC Chief Examiners Reports). The continual dismal performance rate is a glaring indication that Nigeria's secondary education system just like the tertiary and primary system is troubled and in a state of decay (Obi & Ewuzie, 2014). WAEC Chief Examiners' Reports (2012) revealed that identification of physics concepts which students find difficult is necessary in addressing poor performance in the subject.

Several studies attributed students' achievement or failure in science subject to various reasons. Akor (2013) opined that lack of equipment in science affects teaching and learning which also affects performance in science. Among many reasons proffered by researchers, such as qualification of teachers, students' parental background, facilities, misconception of concepts appears to be significant factors affecting students' achievement in science subject. Chief Examiners' Reports (2012) pointed out that lack of in depth understanding of various concepts and inability to recall units at calculated quantities, as the students' weaknesses in science. WAEC Chief Examiners' Report (2013) attributed students' weaknesses in physics to poor understanding of basic concepts such as boiling point, sound wave, projectiles, polarization and cathode ray tube. Furthermore, West African Examination Chief Examiners Reports of 2014, 2015 and 2016 showed that students were unable to read measurement from ammeter and voltmeter to the required accuracy. In addition Chief Examiners, further commentated students could not connect circuit correctly and did not posses computational skills. The Reports agreed with Ogbole (2015) who opined that students' poor performance was due to misconception of concepts in physics. Almahdi (2011) opined that most of the students held alternative conceptions of heat and temperature, Obasi (2013) outlined a number of ways which confirm students difficulty in understanding the concepts in the following areas; (i) difficulty in interpreting pictorial representations of sound standing wave. (ii) misunderstanding of the phenomena of medium through which light travel (iii) misconceptions about spectrum of light and their range of frequencies. (iv) misconceptions of formulas and their application as well as poor computational skills.

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Almalidi (2011), Ngumah and Agbo (2012), identified some concepts in science which are frequently misunderstood by students and which also pose confusion to students. They are: heat, temperature, force, motion, projectile, momentum, wave, sound, pressure, electricity.

It is believed that for students to perform better in science and understand the invaluable application of science in daily life, they need to be guided properly through appropriate teaching method. Studies such as Njoku (2013), Ada (2014) and Usoh (2015) reveal that Nigerian teachers persistently use traditional/conventional teaching method. Conventional method whereby the teacher is the central focus, who talks to passive students, does not promote meaningful learning neither does it foster critical thinking, students' participation and 21st century competencies (Ada, 2014; Nwosu, 2012; Njoku 2013 & Usoh 2015), whereas understanding of science concepts such as electricity, reproduction, oxidation reaction and waves require critical thinking and hand-on-activities.

Students' non-participation in the learning process does not create an environment that could challenge students to change the disequilibrium in their mindset to tackle the wrong concepts they brought to the classroom. Hence, the need to involve students in a more proactive learning process such as the inquiry based learning.

Marcus (2017) defined inquiry based learning as a form of active learning that starts by posing questions, problems or scenarios rather than simply presenting established facts or portraying a smooth path to knowledge. It is important to define inquiry based learning from both learner and teacher perspectives. From the students' point of view, inquiry based learning focuses on investigating an open question or problem. They must use evidence - based reasoning and creative problem- solving to reach a conclusion, which they must defend or present. From teachers' point of view, inquiry based teaching focuses on moving students' beyond general curiosity into the realms of critical thinking and understanding. Science educators (Aminu, 2010 and Owadara, 2012) encouraged teachers to replace traditional teacher-centered instructional practices, such as emphasis on textbooks, lectures, and scientific facts, with inquiry-oriented approaches that (i) engage students' interest in science, (ii) provide opportunities for students to use appropriate laboratory technique (iii) require students to solve problems using logic and evidence, (iv) encourage students to conduct further study to develop more elaborate explanations, and (v) emphasize the importance of writing scientific explanations on the basis of evidence (Nnadi, 2011). Sandoval & Reiser (2004) pointed out that in order to build the inquiry-based classroom, the lesson must be project based with activities that will encourage students' participation. They must experience the process of knowing and be able to give their own justification knowledge and interpretation of physics concepts especially concepts on wave.

Misconception is a conclusion that is wrong because it is based on faulty thinking or facts that are wrong. In the view of Ogbole (2015) misconception might also be referred to as preconceived notions, non-scientific beliefs, naive theories, mixed conception or conceptual misunderstanding. Owadara (2012) observed that misconception in physics is quite prevalent among secondary school students. Cookey (2015) opined that students have developed common-sense theories of the physical world that have proven satisfactory for their day-to-day experience, but many of the students' common-sense theories turn out to be wrong or incorrect. The wrong ideas, belief, notions which students (both male and female) bring to physics classroom impact heavily on their conceptual understanding of physics' concepts and consequently contribute to their failure in both internal and external examinations.

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Fatokum & Odagboyi (2010) noted that some subjects such as physics, chemistry and mathematics are branded masculine while others like home economic, secretarial studies are branded feminine. The issue of gender and gender stereotyping permeate every aspect of human endeavor. Nnorom, Alachi and Anozie (2014) observed that the consequences of gender stereotyping cut across social, economic, political and educational development especially in the areas of science and technology. Some studies (Ada, 2014) have shown that the conventional teaching method of physics is not gender friendly. Thus, Gender has been identified as one of the factors influencing students' achievement in physics at senior secondary school level. Inedu (2011) opined that male students have fewer misconceptions than the female students in mechanics. However, Nwoke (2013) reported that female performed better than male students when taught mathematics using cooperative learning. Contrarily, Adeyemi (2008) and Ajaja & Eravwoke (2010) reported that gender had no effect on academic achievement of students in cooperative learning. These contradictory findings have caused for inclusion of gender as the moderating variable for this study. Furthermore, this study was also carried out using students' achievement in the areas of waves. This area is considered very important in physics teaching and learning and feature prominently in WAEC and NECO examination questions.

Statement of the Problem

Various researchers noted that among reasons which affect students' achievement in science, misconception of key science concepts, is a fundamental issue. WAEC Chief Examiners' Reports over several years indicated that students' weaknesses in science are as a result of misconception of science concepts, which play a role in students' achievement. Studies so far done, showed that conventional method of teaching science did not help students gain conceptual understanding nor helped them to correct the misconceptions which they brought to classroom. Therefore, this study investigated the extent to which inquiry based learning could correct students' misconceptions in science concepts and thus promote achievement in science. Put in question form, therefore the statement of problem of this study is "To what extent will inquiry based learning promote students' understanding of science concepts, thereby enabling them correct misconceptions in science concepts and by extension enhance their achievement in the science subject?"

Purpose of the study

The main purpose of the study was to investigate the effect of inquiry based learning on secondary school students' misconception of science concepts and academic achievement in science.

Specifically, the study investigated:

i. To determine the significant difference of the students exposed to inquiry based learning and those exposed to conventional lecture method
ii. To determine the effect of inquiry based learning on male and female students.

Research Hypotheses

The following hypotheses were formulated and tested at level of 0.05 significance.

1. There is no significant difference in the mean achievement scores of students taught using inquiry based learning and those taught using conventional lecture method.

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2. There is no significant difference in the mean achievement scores of male and female students taught using inquiry based learning approach.

Materials and Method

The study is a quasi experimental, pretest, post test, non-equivalent, non-randomized control group design. It seeks the impact evaluation that assigns members to the experimental group and control group by a method other than random assignment.

Study area: The study was carried out in Zone C Educational Zone in Benue State of Nigeria. Benue State falls in the middle belt of the country (Nigeria). Geographically it is located in the north-central zone of Nigeria.

Population of the study: The population of the study comprised of 1902 SS11 Physics students in 53 Government Secondary Schools in Zone C of Benue State.

Sample and Sampling Technique: Sample for the study was made up of 174 SS11 science students. Stratified random sampling was used to select Zone C out of the 3 education zones. Purposive sampling was used to select two coeducation schools that have standard equipped science laboratory out of the 42 coeducation schools in the zone. The experimental groups were drawn from these two schools, which comprised 88 students (49 male and 39 female). An intact class is made up of 23 male, 19 female and 26 male, 20 male in the experimental group. Purposive sampling was also used to draw two coeducation schools with highest number of students offering science but with science laboratory that were not properly equipped. These formed the control group. The control group comprised 22 male, 20 female and 23 male, 21 female given a total of 86 students. Therefore, the total number of students in four intact classes used for the study was 174 (94 male and 80 female).

Instrument for Data Collection: Science Misconception Test (SMT) and Science Achievement Test (SAT) were used in the collection of data which were used in addressing research hypotheses of the study. The SMT and SAT comprised 30 multiple choice test items. The test was constructed by the researcher, covering the topics in wave. The multiple–choice test items were chosen to ensure that all the areas taught to students were covered in the test items and for easy scoring too.

Instructional Procedures: *Pre-testing***:** The treatment procedure lasted for four weeks. On the first day of the week, the pre-test (SMT) was administered to the students by the regular class teachers in the control groups and the research assistants in the experimental groups. The pre-test was given to the students before the commencement of the treatment to ascertain their misconception in waves prior to treatment with IBL. The students' pre-test scripts were marked and results collated.

Teacher Activity: The teacher asks provocative questions on wave.

Students Activity: The students investigate the questions, create ideas and discuss the ideas.

Post-testing: On the last day of the fourth week, the post-test was administered to the students in the experimental and control groups to ascertain the level of achievement in wave. The students' post-test scripts were marked and results collated.

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Data Analysis: ANCOVA was used to test the hypotheses at 0.05 level of significance.

RESULTS AND DISCUSSION

Hypothesis 1: There is no significant difference in the mean achievement score on misconception of students taught using inquiry based learning and those taught using conventional lecture method.

Table 1: ANCOVA for the mean achievement scores for wave

Dependent Variable: posttest

Source	Type 111 sum of Square	df	Mean Square	F	Sig	Partial Eta Square
Corrected Model	15864.879*	4	3966.220	19.372	.000	.314
Intercept	23049.556	1	23049.556	112.580	.000	.400
Pretest	11863.015	1	11863.015	57.942	.000	.255
Group	3515.978	1	3515.978	17.173	.000	.092
Sex	416.934	1	416.934	2.036	.155	.012
Group*sex	60.673	1	60.673	.296	.587	.002
Error	34600.869	169	204.729			
Total	668899.240	174				
Corrected Total	50465.748	173				

Table 1 showed a statistical main effect for method $p < 0.05$ (Fcal 17.173 > Fcrit 3.92). The null hypothesis was rejected, indicating that there was significant difference in the mean achievement scores on misconception of students exposed to inquiry based leaning and those exposed to conventional lecture method. The difference was in favour of experimental group.

Hypothesis 2: There is no significant difference in the mean achievement scores on misconception of male and female students taught wave using inquiry based learning approach.

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Table 2: ANCOVA for the mean achievement scores for male and female students

Dependent Variable: posttest

Source	Type 111 sum of Square	df	Mean Square	F	Sig	Partial Eta Square
Corrected Model	15864.879*	4	3966.220	19.372	.000	.314
Intercept	23049.556	1	23049.556	112.580	.000	.400
Pretest	11863.015	1	11863.015	57.942	.000	.255
Group	3515.978	1	3515.978	17.173	.000	.092
Sex	416.934	1	416.934	2.036	.155	.012
Group*sex	60.673	1	60.673	.296	.587	.002
Error	34600.869	169	204.729			
Total	668899.240	174				
Corrected Total	50465.748	173				

Data in table 2 showed a statistical main effect for method $p > 0.05$ (Fcal $2.036 < Fcrt 3.93$). The table revealed non-significant effect of gender. The null hypothesis was not rejected, indicating that there was no significant difference in the mean achievement scores on misconception of male and female students in science.

Summary of the major findings

The results revealed that

1. There was a significant difference in the mean achievement scores on misconception of students exposed to inquiry based learning than those exposed to conventional lecture method.
2. Gender has no significant effect on the mean achievement scores on misconception of students exposed to inquiry based learning.

Conclusion

Based on the finding of this study, there was a significant difference between the experimental and control groups which indicate that inquiry based learning has positive effect on students in science concepts and there was no effect in gender.

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Recommendations

Based on the research findings, the following recommendations are made:

1. Use of conventional method of teaching should be de-emphasized in secondary schools as that does not contribute much in students' achievement in science subject.
2. The developer of instructional materials should reflect teaching techniques in planning science subject curriculum for secondary schools.

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