

Effect of Inquiry Instructional Strategy on Students' Academic Achievement in Physics in Senior Secondary Schools in Education District II in Lagos State

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Abstract

This study examined the effect of inquiry based instructional strategy on students' academic achievement in Physics in Senior Secondary Schools in Education District II In Lagos State. Two hypotheses were tested at 0.05 level of significance using gender as moderator variable. The design of this study was pretest and post-test control group quasi experimental design. The sample was 173 students from four Schools' intact classes. The four Schools were purposively selected from 11 Schools in Education District II zone 3 in Lagos State. The instruments for data collection were; Practical Physics Achievement Test (PPAT), Instructional Guide On Inquiry Instructional Teaching Method (IGOIT) and Instructional guide on Conventional Instructional Teaching Method (IGOCT). (IGOITM) and (IGOCT) were given face validity while PPAT was given both content and face validity. The three instruments used for data collection were validated. Reliability coefficient $r = 0.76$ was calculated for PPAT. Data collected was analyzed using statistical package for social science (SPSS Version 20) Mean and standard deviation were used to provide answers to research questions while analysis of co-variance (ANCOVA) was used to test the hypotheses. Results showed that students who were exposed to inquiry instructional strategy performed significantly better than those who were not exposed to it. There was no significant difference between the academic achievement of male and female students. It was recommended that inquiry instructional strategy should be used for teaching physics in Nigeria senior secondary schools for better academic achievement.

Keywords: *Inquiry, Achievement, Physics and Gender*

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Background to the Study

Physics is a physical science subject that studies matter in relation to energy. It is a very important science subject as no student can study courses such as Engineering, Medicine, Pharmacy, Chemistry, Agriculture, Environmental and Biological sciences in tertiary institution without a credit pass in Physics in WASSCE (West African Senior School Certificate examination). Physics is the most fundamental of all sciences, playing critical roles in medicine and surgical researches (Ngurukwem, 2008, cited in Babajide, 2013), and has to date remained a fundamental part of the educational system. Focusing on the nature of the natural world generally through mathematical analysis, Physics has fostered the development of new methodologies to advance the quality of life, including the production of such facilities as automobiles and modern construction. Furthermore, Medical Physics and Information Technology benefited Rwanda by developing a national nutrition program and an epidemic surveillance system. Physics and engineering has also helped rural areas gain safe drinking water through gravimetric techniques, irrigation techniques and rainwater harvesting.

Developing countries including Nigeria and other African Countries have in recent times realized the importance of Physics as a basic requirement for economic, scientific and technological developments, (Adegoke, 2009; Babajide 2013). In Rwanda, realizing its importance, the ministry of education was mandated to develop the country's scientific and technical know-how The role of science (Physics) in sustainable development was also recognized at the United Nations Millennium Summit 2000. Ogunleye, (2006) and Babajide, (2013), further observed that Physics forms the backbone of technology.

As critical as Physics is as highlighted above, countries cannot develop or sustain any form of technology unless a good foundation for effective and efficient Physics education is laid (Adegoke, 2009) Laying a solid foundation in Physics education involves employing appropriate teaching and learning techniques which will translate into good academic achievement in Physics.

Several teaching methods have been observed by previous researchers as improved strategies of teaching. Such strategies include Practical activities (Babajide, 2012), PowerPoint presentation (Babajide, 2013), Field-base teaching (Yakubu, 2016), problem solving, team teaching (Anchor, Imoko & Jimin, 2011), co-operative learning (Lawal, 2016) guided discovery (Ajewole, 2007) and so on. With all these improved teaching strategies, the achievement of students in Physics has not yet gotten to an excellent level. The table below shows the performance of Physics students in WASSCE 2004 – 2015.

Table 1: Students Performance in May/June SSCE (WAEC) Physics 2004 – 2015.

Year	Total Number of Candidates	Total Pass A ₁ – C ₆	%	Total Pass D ₇ – D ₈	%	Total Fail F ₉	Failed %
2004	321499	158837	49.40	90012	27.99	61940	19.26
2005	344111	142943	41.50	102036	29.62	89150	25.88
2006	375824	218199	58.05	87025	23.15	62119	16.52
2007	418593	180797	43.19	140172	33.49	88480	21.14
2008	415113	200345	48.26	91116	21.95	116776	28.13
2009	465636	222722	47.83	141595	30.41	79919	17.16
2010	463755	237756	51.27	122417	26.40	84716	18.27
2011	563161	360096	63.94	115158	20.45	66236	11.76
2012	624658	429415	68.74	120369	19.27	57440	9.20
2013	636857	296910	46.62	175877	27.62	145980	22.92
2014	635739	386270	60.75	157414	24.76	78019	12.27
2015	657266	390447	59.40	160664	24.44	88598	13.47

Source: The West African Examination Council (WAEC) Head Quarters, Yaba, Lagos

A cursory look at table 1 above shows that for five consecutive years, candidates who sat for WASSCE scored below 50% average in May/June external examination from (2004-2009). The above average performance in 2006 was attributed to students' desperation to pass through examination mal- practice. (Babajide, 2013). Then there was above average performance for two year from 2010 to 2012. It fell again below average in 2013. In 2014 and 2015 there was a rise and fall in the performance of the candidates in physics respectively.

A lot of factors have been identified by previous researchers as being responsible for this non excellent and inconsistent in achievement in Physics. According to Adeyemo (2010) “they include: inadequate modern laboratory facilities, inadequate qualified teachers, inadequate classroom and inadequate teaching methods”. This study focuses on verifying the adequacy and effectiveness of inquiry instructional strategies in teaching and learning physics as an alternative method. This may help to improve students' academic achievement in Physics and in turn make students / learners become lifelong learners, thereby achieving the Nigerian National Policy on education (2008) which advocated that education should lay foundation for lifelong learning. Inquiry is a process of learning that is driven by questioning, thoughtful investigating, making sense of information and developing new understanding. (Diggs, 2009).

Joe (2004) defined “inquiry” as “a seeking for the truth, information, or knowledge – seeking information by questioning”. He further observed that individuals do inquiry from the day they are born till they die. This is so even though they may not reflect upon the process. For instance, babies observe faces that come near them, they grasp objects, put things in their mouths, and turn toward voices. An old adage states” “Tell me and I forget, show me and I remember, involve me and I understand. Joe (2004) says the last part of this statement is the essence of inquiry based learning. Inquiry implies involvement that leads to understanding. Also, involvement in learning implies possessing skills and attitudes that permit one to seek resolutions to questions and issues while constructing new knowledge. Lehmann. Inquiring

approach is more focused on using and learning content as a means to develop information processing and problem – solving skills. It is more students centered There is great emphasis on “how one comes to know” and less on “what one knows”. Students are more engaged in construction of knowledge through active involvement. It is an open system classroom where students are encouraged to search and make use of resources beyond the classroom and the school. Warmer and Myers, (2004) defined inquiry based teaching as method that combines the curiosity of students and the scientific method to enhance the development of critical thinking skills while learning science. They also opined that teaching of science through enquiry is the cornerstone of good teaching (Warmer and Myer,2004).“According to National Counsel n.d how one comes to know”, should be one of the most frequently asked questions in the classroom. Students' answers should be by evidence which should be adequately critiqued, (National Research Council n.d). On the other hand, traditional approach to learning is teacher- centered. The teacher focuses on giving out information about “what is known”. Students are receivers of information while the teacher is the dispenser. Also the focus is on mastering of content with less emphasis on the development of skills and nurturing of inquiring attitudes. Traditional classrooms are closed system where information is filtered through layers to students.

There are three types of inquiry as reported by Bandi and Bell (2008) and Bulbal (2010)

1. **Structured inquiry:** This involves giving students an open question and an investigation method, the students use the method to get an evidence backed conclusion
2. **Guided inquiry:** This entails giving student an open question usually in groups. They design investigation methods to arrive at a conclusion.
3. **Open inquiry:** This is characterized by giving students time and support. They pose the original questions they will investigate through their own method. They finally present their results for discussion and expansion/ modification.

Statement of the Problem

The teaching method in most Nigerian secondary schools is teacher-centred rather than learner-centred. This is contrary to Nigerian National Policy on education. The National Policy on education advocates that education activities should be learner centred. The emphasis in most Nigeria secondary schools is on teaching to cover the scheme of work instead of teaching for permanent learning. Little or no attention is paid to the process of learning or how students learn. This has reduced students' creative thinking which is useful in the 21st century workplace. Traditional method of teaching in most Nigerian secondary schools does not teach learners how to think creatively. With this in mind, there is need to expose the learners/students to creative thinking as it develops problem solving skills. This can be achieved by making learners the centre of learning process/activities so as to enable them to take active control of their learning as they become inquiry based learners. This study therefore investigated the effect of inquiry instructional strategies on students' academic achievement in Physics in Senior Secondary Schools in Lagos State.

Purpose and Objective of the Study

The purpose of this study was to determine the effect of inquiry instructional strategies on students' academic achievement in Physics in Senior Secondary Schools, in Lagos State, while the objectives of the study were to determine the:

1. Effect of inquiry instructional strategy on students' academic achievement in physics when compared with their counterpart that were not exposed to inquiry teaching method.
2. Difference in the mean achievement scores of male and female students that were exposed to inquiry based learning

Research Questions

The following research questions guided this study:

1. What is the effect of inquiry instructional strategy on students' academic achievement in Physics?
2. What is the influence of gender on inquiry instructional strategy?

Hypotheses

The following hypotheses were tested at 0.05 level of significant the study.

1. There is no significant main effect of inquiry instructional strategy on mean score of students that will be exposed to it and those that will not be exposed to it.
2. There is no significant main effect of gender on inquiry instructional strategy

Significance of the Study

This study is significant to teacher training institutions, in-service teachers, students, parents and curriculum planners in various ways.

1. This study is significant to teacher training institutions like Faculty of Education in Nigerian Universities and Colleges of Education in that it enables them to see the need to incorporate professional development training program on inquiry for pre-service teachers. If pre-service teachers receive training on inquiry instructional strategies while in school as students, they will be able to apply the skills in the classroom as teachers. This is important because one cannot impart what one doesn't know or have
2. For in-service teachers, this study will enable them to see the need to incorporate activities and discussions that will help learners comprehend how they learn, their strength and their needs and to better understand the learning process.
3. To the curriculum planners and developers, it will enable them to see the need to incorporate inquiry activities in the curriculum.
4. To parents, it will enhance their ability to be able to make their children to become inquiry learners when they are able to help them take ownership of their learning and become life-long learners, thereby helping to realize the goal of education in Nigeria, according to National Policy on education 2008 on life-long learning.

Scope of the Study

This study covered Education District II in Lagos State Nigeria. The study was conducted between February and March 2019. Senior Secondary School Two (SSS2) students were used. Topics drawn from Senior Secondary School II syllabus were used. For instance:

- i. Mechanics (Experiment on simple pendulum)
- ii. Light Waves (Determination of focal length of a converging lens)

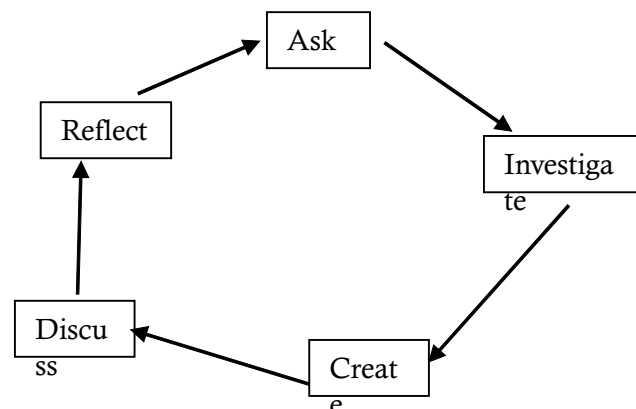
The above topics were chosen because they involve a lot of arithmetic operations. According to chief examiners' report (2015) most candidates find it difficult to perform arithmetic operations. Also, from the researcher's over ten years personal experience as WASSCE examiner and Physics teacher, areas dealing with calculations constitute great challenge to most students, offering Physics.

Theoretical Framework

The theory of inquiry instructional strategy is based on the theory of constructivism. The theory of constructivism propose that knowledge does not exist outside the human minds; truth is not absolute and knowledge is not discovered but constructed by individuals based on experience (Hendry, Frommer & Walker 1999; Crotty 1998; Fosnot 1996) Constructivist post that knowledge is not passively received from the world or from authoritative sources but rather, it is constructed by persons or groups making meaning from their experience (Mackellan & Soder, 2004) Constructivism advances meaning –making and knowledge construction as its foremost principles (Crotty,1998; Fosnot,1996; Philip,1995) The classroom for the constructivist is students centered. Classroom is no more a place where the teacher (expert) pours Knowledge into the passive students, who waits like empty vessels to be filled. The students are encouraged to be actively involved in their own learning process. Students and the teacher think of knowledge as dynamic and ever-changing view of the world we live in. In the constructivist classroom, students use inquiry method to ask questions, investigate a topic and use different resources to get solutions and answers. The role of the student is to be actively involved in his or her own learning .Students frequently think or reflect on their own learning Students are encouraged to use active techniques such as experimentation, real world problem solving to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher does not take the role of the 'sage on the stage' However, the teacher acts as a 'guide on the side' providing students with opportunities to test the correctness of their present understanding.

Model of Inquiry

This study adapted John Dewey's model of inquiry John Dewey's model of inquiry as shown in the figure below (Cochran Smith & Lytle 1999).



Empirical Review

The following empirical studies both international and local were reviewed by the research: Ali-Abdi (2014) carried out a study on the effect of inquiry based learning supported by 5E learning on student's academic achievement in science course in Kermanshah Iran. The study was quasi experimental research design. The sample of the study was 40 girls of fifth grade primary school pupils. The finding revealed that experimental girls performed significantly better than the control girls' group. The study is in line with the findings of (Adams, Benevion & Dengel 1999; Sunger, Tekkaya & Geban 2001; Lord, 1999; Marek, Eubanks & Gallaher; 1990; Seythan & Morgil, 2007; Anderson, 2008).

Maxwell D. O., Lambeth D. T. & Cox, J. T. (2014) carried out a work to determine the effect of inquiry-based learning on science achievement for fifth-grade students. The researcher used a convenient sampling techniques to select participates from two of the 4 fifth-grade classes. A total of 42 pupils participated in the study 22 pupils made up experimental group while 20 pupils the control group. The finding revealed that experimental group performed significantly better than the control group.

In Nigeria, Mohammed A. A. (2019) determined the effect of constructivist and inquiry teaching strategies on senior secondary school students' academic achievement in ecology in Adamawa state, Nigeria. The design of the study was quasi-experimental pre-test, post-test control group design. The sample was 84 male and 91 female students of SS 11 students from three senior secondary schools in Adamawa state. The researcher used multi-stage sampling techniques. The researcher used purposive sampling techniques to select co-educational schools funded by the state government while random sampling was used to assign experimental and control group to the selected schools. The result showed that experimental group performed significantly better than control group. The result of this study is line with that of other science researchers Nwagbo & Obiekwe (2010) revealed that 5Es constructivist instructional strategy was more effective in facilitating student's achievements in econology. Of all the literature reviewed in this study non is on effect of inquiry based learning on students' achievement in physics based on structured inquiry.

According to (Bandi; Bell (2008); Bulbul (2010) there are three types of inquiry; structured inquiry, guided inquiry and open inquiry. Hence, this study focused on effect of inquiry (structured inquiry) on students' academic achievement in physics.

Methodology

Quasi-experimental pre-test, post-test non-equivalent control group design was used for this study. The design is represented symbolically below:

Experimental Group	$O_1 X O_2$
Control Group	$O_3 - O_4$

O_1 and O_3 represent pretest for both groups while O_2 and O_4 represent post-test for the two groups. X is the treatment given to the experimental group. The population of the study comprised all the SSII students offering Physics in senior secondary schools, Lagos state. Purposive sampling technique was used to select four schools from 11 senior secondary schools in zone 3 of education district 2 of Lagos State. Intact classes of the selected schools were used. A total of 173 students comprised the sample. 71 students made up the experimental while 102 students comprised control group. The instruments for data collection were; Practical Physics Achievement Test (PPAT), Instructional guide on Inquiry Instructional Teaching Method (IGOITM) and Instructional guide on Conventional Instructional Teaching Method (IGOCTM). (PPAT) was a 36 short answer practical questions. It was adapted from West Africa Senior School Examination questions and was validated by the researcher's supervisor who made some corrections to the questions and added more.

The study was conducted for four weeks Pre-test was given before the commencement of the treatment to both groups while post-test was given at the end of the study to the two groups. Only the experiment group received treatment on inquiry instructional strategy while the control group did not. Research assistants helped in teaching their students practical physics through inquiry after they had been trained for one week by the researcher on how to use this strategy. The control group was taught practical physics without inquiry but with traditional method. Post-test was administered to both groups at the end of the treatment.

Instructional Procedural Steps Adapted for Teaching Inquiry for Experimental Group

1. The teacher divided the students into groups of four or five members and gave them apparatus and instructional guide.
2. The teacher posed questions to the students
3. The students were allowed to make guess of what the answers should be and wrote it down
4. They carried out an investigation with the apparatus and procedure supplied by the teacher.
5. Students used evidence to accept, modify or reject the answer in no. 2 using scientific knowledge.
6. They compared their answers with their group members
7. Each group shared their findings with their classmates

Instructional procedural Steps Adapted for Teaching Control Group

1. The teacher divided the students into groups of four or five members and gave them apparatus and instructional guide.
2. The teacher explained to the students what to do
3. The students did what the teacher asked them to do
4. The teacher summarized the lesson for the students

The research questions were answered using descriptive statistics of mean and standard deviation. However, the hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA).

Research Questions

1. What is the effect of treatments on students' academic achievement in Physics?

Table 1: Descriptive Statistics of Experimental and Control Group Post-Test Scores of Physics Students

Group Statistics					
	TREATMENT	N	Mean	Std. Deviation	Std. Error Mean
POSTTEST	EXPERIMENTAL	71	52.4930	5.46645	.64875
	CONTROL	102	34.0000	8.97301	.88846

Results

From table 1 above, the mean and standard deviation of experimental and control groups are 52.4930 and 34:000, 5.46645 and 8.97301. The mean difference between the two groups was 18.493. The experiment is responsible for the mean difference. This implies that the group of physics students taught with inquiry instructional strategy performance better than the control group taught through the traditional method.

1. What is the influence of gender on academic achievement of physics students?

Table 2: Descriptive statistics of male and female post-test scores of students in physics

Group Statistics					
	GENDER	N	Mean	Std. Deviation	Std. Error Mean
POSTTEST	MALE	96	37.2188	11.79492	1.20381
	FEMALE	77	47.0390	9.73523	1.10943

From table 2 above, means and standard deviation of male and female students who were exposed to the treatment are: 37;2188 and 47.0390, 11.79492 and 9.73523. There was a difference of 9.8202 this implies that the experimental girls performed better than

experimental boys. This could be because the female students were more curious and eager to learn than their male counterpart. The female students were more actively involved in the hand on activities during the treatment section. Gone are days when female students sit back and allow the male students to do the work for them. Also, the researcher being a female gave great motivation and encouragement to female students that they too can do well.

Research Hypotheses

Ho1: There is no significant main effect of treatment on mean score of students who will be exposed to treatment and those who will be exposed to treatment.

Table 3: Analysis of co-variance of post-test scores of treatment and gender of physics students

Tests of Between-Subjects Effects

Dependent Variable: POSTTEST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15989.703 ^a	4	3997.426	78.544	.000
Intercept	40549.902	1	40549.902	796.755	.000
PRETEST	1414.954	1	1414.954	27.802	.000
TREATMENT	5629.924	1	5629.924	110.621	.000
GENDER	173.304	1	173.304	3.405	.067
TREATMENT * GENDER	.977	1	.977	.019	.890
Error	8550.158	168	50.894		
Total	323777.000	173			
Corrected Total	24539.861	172			

a. R Squared = .652 (Adjusted R Squared = .643)

Table 3 shows that $F_{(1,173)} = 110.621$ which was significant at $p(0.000) < 0.05$ level of significance. This implies that there was significant differences in mean scores of students who were exposed to inquiry instructional strategy. Table 1 showed the mean difference of experimental and control group. Therefore, we reject the null hypothesis.

H02: There is no significant main effect of gender on students' achievement in Physics.

Table 3 also indicated that $F_{(1,173)} = 3.405$ with P-value of 0.067 is not significant at $P(0.000) < 0.05$ level of significance. This implies that there was no significant difference in the means score of male and female physics students. Table 2 showed the mean difference between the male and female students in physics. Therefore, we accept the null hypothesis.

Findings

1. Students who were taught physics using inquiry instructional strategy performed significantly better than their counter part that were not exposed to the treatment.

2. Female students who were exposed to the treatment performed better than their male counterpart though it was not significant.

Discussion of the Results

The findings revealed that there was significant difference between the students that were exposed to inquiry instructional strategy and those that were not exposed to it. There was full participation of students in the inquiry classroom. Students were active in constructing knowledge through a hand on activities. They used evidence and scientific knowledge to accept, reject or modify their initial predictions before investigation started. The use of inquiry teaching method had positive effects on students' academic achievement. The level of students' achievement improved significantly in the experimental group. This is in line with the findings of (Wangeand Wen, 2010; Wazirai, 2014 and Stephen, 2005). This result is also in line with Akinbola and Afolabi (2010) who carried out a research work on comparative study of the effect of guided discovery, demonstration and expository method on cognitive achievement of Nigerian secondary school physics students. They reported that the method had positive effect on the academic achievement of students in Physics.

Furthermore there was no significant difference in the mean scores of Male and Female students who were exposed to inquiry instructional strategy. This result is supported by the finding by (Babajide, 2016 and 2012; Agommuon and Nzewi 2003; Ogunleye and Babajide, 2011). And the findings of this research on gender is contrary to that of (Ezirim 2006; Ogunneye (2002) Olorunkooba, Lawal & Jiya, 2012) who observed that gender had significant effect on achievement of students in physics

Conclusion

This study was designed to determine the effect of inquiry instructional strategy on students' academic achievement in Physics. It was found that it helped to improve students' academic achievement in Physics. This strategy can be used by physics teachers to teach physics since it helps to improve students' academic achievement in physics. Furthermore there was no significant difference in the mean scores of Male and Female students who were exposed to inquiry instructional strategy.

Recommendations

1. Inquiry instructional strategy should be used to teach physics since it enhance students' academic achievement. It's also students centred.
2. Since inquiry instructional strategy helps students to understand what they do, workshops and training should be organized for teachers on how they can incorporate it in their teaching methods.
3. The finding of the research showed that there was no significant difference in the academic achievement of gender; female students should be motivated to study science (Physics).

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