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The Effect of Inquiry-Based Learning Approach Using the 5E Instructional Model on Academic Achievement in Teaching Physics to SS2 Students in Kano State, Nigeria.

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Abstract

The aim of this study was to investigate the effect of Inquiry-Based Learning Approach using the 5E Instructional Model on the academic achievement of Physics Students in Science Secondary Schools in Kano State. The pre-test post-test quasi-experimental design was employed. The population of the research was made up of 2250 SSII students of Science Colleges, Kano state, from where a sample of 80 was purposively selected using intact class. The study was guided by two research questions based on the specific objective and two null hypotheses tested at $\propto = 0.05$ level of significance. A 20 item multiple-choice Physics Achievement Test (PAT) and 20 items 5-Likert scale Physics Motivation Questionnaires (PMQ) as instruments were administered before and after treatment. The scores obtained were analyzed using SPSS for both independent and dependent t-test statistics. The findings revealed that the Inquiry-Based Learning Approach using the 5E Instructional Model had a significant effect on students' academic achievement in Physics than conventional teaching method. The result showed that the treatment groups were highly motivated. It was therefore recommended that the Inquiry-Based Learning Approach using the 5E Instructional Model should be adopted in teaching Physics in Kano state Science Colleges to enhance students' academic achievement

Keywords: ***Inquiry-based learning, 5E instructional model, Physics, school system and academic achievement***

1.0 Introduction

One of the important goals of 21st-century education is to prepare students for the challenges of today's world. Quick and diverse progress in Science and Technology which has resulted in a rise in community living standards has raised people's expectations from the today education system. The teacher's method of teaching may go a long way in enhancing learning by the student. The traditional method of teaching sciences (physics inclusive) in the schools involve ''Chalk and Talk'' activities which is fully teacher-centered. In this case the student may become passive 'robot' in the classroom who regards the teacher as a

repertoire of knowledge. There is agitation to inculcate the 21st century approaches to science teaching in Nigeria. These include problem-solving techniques, inquiry method, collaboration method etc. They are purely student-centered approaches. Here, students are guided to discover facts and construct their own ideas and understanding of the concepts of study. This demands the replacement of traditional methods of teaching (which is entirely teacher-centered such as lecture method) with student-centered teaching method such as Problem-Based Learning, Project-Based Learning and Inquiry-Based Learning among others. However, within the traditional teaching method, science classroom, material and contents are taught through lectures, worksheets and reading out of some textbooks. These methods have led students to be disengaged and have a lack of interest in what they are learning. These contributed a lot to students' poor academic achievement in science subjects for example physics. Traditional approaches to science education are lackluster. Students can sit through a lecture and not absorb any of the information.

Inquiry-based learning allows students to construct their knowledge which leads to better retention of science concepts and greater involvement in the learning process. Within inquiry-based learning, students are analyzing the result and come up with their conclusion to a research question (Yuliati & Cyan 2018). During the process, students are using problem-solving skills and critical thinking to conclude. Inquiry-based learning is a way of asking questions, seeking information and finding new ideas related to an event i.e. in inquiry-based learning students learn by using cause and effect, rational and critical thinking and combining both scientific knowledge and operation (Husni,2020). Inquiry-based learning also requires students to conduct scientific reasoning and use critical thinking when combining scientific knowledge and process to generate a perception of sciences (Duran, 2016). In Inquiry-Based Learning, students should learn the scientific concepts and improve critical thinking skills while conducting activities (Laksana, 2020).

In Inquiry-based science education, students become engaged in many of the activities and thinking processes that scientists use to produce new knowledge. Science educators encourage teachers to replace traditional teacher-centered instructional practices such as emphasis on textbooks, lecture and scientific facts with an inquiry-oriented approach that;

a) Engages students to be interested in science
b) Provides opportunities for the student to use appropriate laboratory techniques to collect evidence.
c) Requires students to solve problems using logic and evidence
d) Encourages students to conduct further study to develop a more elaborate explanation
e) Emphasize the importance of writing Scientific explanations based on evidence (Turan & Matteson,2021)

Abdi, (2014) pointed out that to build an Inquiry-Based classroom environment, construct a community of practices like the scientist work. In authentic Inquiry-based activities, students experience the process of knowing and justification of knowledge as a scientist might. Traditional classrooms, on the other hand frequently resemble a one-person show with a largely uninvolved learner. Traditional classes can usually be dominated by direct and unilateral instruction. Traditional approach followers assume that there is a fixed body of knowledge that the students must come to know. Students are expected to blindly accept the information they are given without questioning the instructor (Abdi, 2014). The teacher

seeks to transfer thought and meaning to the passive student leaving little room for student-initiated question independent thought or interaction between students. The teacher- center method of teaching also assumes that all students have the same level of background knowledge in the subject matter and can absorb the material at the same phase (Lohr, 2021).

There are different forms of inquiry-based learning (Bulbul, 2010). In structured inquiry, the teacher gives the students problem to research as well as the processes and material to investigate. This type of inquiry learning is used to teach a specific concept, facts or skills and lead the way to open inquiry where the students formulate their problem to investigate. An example of a structured inquiry learning approach is the Learning Inquiry Cycle Model based on Piaget Theory of Cognitive Learning (Lopez-Banet & Aguilera, 2021).

Many version of the learning cycle appears in Science Curricular with the phases ranging in number from 4E to 5E to 7E. Regardless of the number of phases, every learning cycle has its core the same purpose (Settlage,2000). In this study, 5E Learning Cycle Instructional Model by Bybee et al (Turan & Matteson, 2021).

1.1 The 5E Instructional Model

1.1.1 Engaging Learners

The goal of this phase is to capture the students' attention and interest. Get the students focused on a situation, event, demonstration or problem that involve the content and abilities that are the aim of instruction. From a teaching point of view, asking a question, posing a problem, or presenting a discrepant event are all examples of strategies to engage learners. If the student look puzzle, expressing. "How did that happen? Or "I have wondered about that" and "I want to know more about that" etc. they are likely engaged in learning situations.

1.1.2 Exploring Phenomena

In the exploration phase, students have activities with time and opportunities to resolve the disequilibrium of the engagement experience. The exploration lesson or lesson provides a concrete hands-on experience where students express their current conception and demonstrate their abilities as they try to clarify the pushing element of the engagement phase.

Exploration experienced should be designed for later introduction and description of the concept, practical and skills of the instructional sequence. Students should have experience and the occasion to formulate explanations, investigate phenomena, observe the pattern and develop their cognitive and physical abilities.

The teacher's role in the exploration phase is to initiate activities, describe the appropriate background, provide adequate material and equipment and clear any misconception. After this, the teacher steps back and become a coach with the task of listening, observing and guiding students as they clarify their understanding and begin reconstructing scientific concept and developing their abilities.

1.1.3 Explaining Phenomena

The scientific explanation for phenomena is prominent in this phase. The

concept, practices and abilities with which students were originally engaged and use of video, the web or software also provides an excellent explanation.

Subsequently explored, now are made clear and comprehensive. The teacher direct students to the aspect of the prior phase and first task students for their explanation.

Using students' explanations and experiences, the teacher introduces scientific or technological concepts briefly and explicitly. Verbal explanations are common in this phase.

1.1.4 Elaborating Scientific Concept and Abilities

The students are involved in a learning experience that extends, expand and

enriches the concept and abilities developed in the prior phases. The

intention is to facilitate the transfer of concepts and abilities to the related, but

the new situation. A key point for this phase use activities that are a challenge but

achievable by the students.

In this phase, the teacher challenges the students with a new situation and encourages interaction among the students and with other sources such as writing material, databases, simulation and web-based searches.

1.1.5 Evaluating Learners

In the evaluation phase, the teacher should involve students in experiences that are understandable and consistent with those of prior phases and congruent with the explanation. The teacher should determine the evidence for students learning and means of obtaining that evidence as part of evaluating phase. Informal evaluation can occur at the beginning and through the 5E sequence. The teacher can complete a formal evaluation after the elaborate phase. this is the phase in which the teacher

administers the assessment to determine each student's level of understanding (Turan & Matteson, 2021).

5E Instructional Model by San Diego County Office of Education

Source: https://www.sdcoe,net >ngss

The 5E instructional model is based on students' logical and critical thinking. It is used for instructional activities that help students to be properly involved and actively engaged in the learning of Science and Mathematics. The 5E is such an aid or organizer for the teacher to structure and sequence potential learning experience in a systematic and synergistic way consistent with a constructivist view of teaching and learning.

1.2 **Statement of Problem**

Traditional learning produces active and non-active learners as a result of its conceptualization of the learning process. Traditional behavioral classes do not favor active engagement of learners in the learning process, but rather focus on the behavioral impacts of immediate context and the teacher's role on learners. Here, the inquiry-based learning approach using 5E model challenged the concept of traditional learning, because it combines both learning and practices. The purpose of this study is to examine the effect of the Inquiry-Based Learning Approach using the 5E Instructional Model on Academic Achievement in Teaching Physics to SS2 Students in Kano State.

1.3 **The objective of the Study**

The study determined the effect of Inquiry-

Based Learning Approach Using the 5E Instructional Model on Academic Achievement in Teaching Physics to SS2 Students in Kano State. Specifically, the study was concerned with:

1.3.1 Find out if there is any difference in students' achievement in Physics using Inquiry-Based Learning Approach Using the 5E Instructional Model and traditional method of teaching in science secondary schools in Kano state.

1.3.2 The level of motivation of students to study Physics after exposures to Inquiry-Based Learning Approach using the 5E Instructional Model.

1.4.0 Research Questions

The following research questions were posed to guide the study:

1.4.1 Is there any significant difference in students' academic achievement in Physics using Inquiry-Based Learning Approach using the 5E Instructional Model and traditional method of teaching in science secondary schools in Kano state?

1.4.2 Is there any significant difference in the level of students' motivation in Physics after their exposure to Inquiry-Based Learning Approach using the 5E Instructional Model and traditional method of teaching in Science Secondary Schools in Kano state?

1.5.0 Research Hypotheses

The following null hypotheses were tested at $\propto = 0.05$ level of significance to guide the study.

1.5.1 **Ho_1**: There is no significant difference between the mean achievement scores of experimental and control groups with respect to Inquiry-Based Learning Approach using the 5E Instructional Model.

1.5.2 **H_{O2}**: There is no significant difference in students' motivation before and after their exposure to Inquiry-Based Learning Approach using the 5E Instructional Model.

2.0 Methodology

2.1.0 Research Design

The design of the study was Quasi-Experimental which intended to compared the outcome for individuals receiving program activities with outcomes for a similar group of individuals not receiving program activities (Campbell and Stanley, 2015). The following are the variables:

2.1.1 Independent variable

i) Traditional teaching method

ii) Inquiry-Based Learning Approach using the 5E Instructional Model method

2.1.2 Dependent variable

i) Physics Achievement Test (PAT)

ii) Motivation of students to study physics

2.2 Population, Sample Size and Sampling Technique

All SS2 boys Physics students in Science Colleges under Science and Technical Schools Board (STSB) Kano state with a total population of 2250. A sample size of 80 was selected from two schools using intact class and random sampling. The two schools were randomly selected and assigned control and experimental groups using balloting. Since all the schools in the

population are at different locations, it was assumed that interaction did not occur between the groups during the period of treatment which could affect the result of the study.

2.3.0 Instruments of Data Collection

Data were collected using two instruments namely; Physics Achievement Test (PAT) and Physics Motivation Questionnaire (PMQ).

2.3.1 Physics Achievement Test (PAT)

The PAT comprises of two sections i.e. section A consist of instruction and guidelines and section B contained question items. The PAT consists of 20 multiple choice items used by the researcher from selected content for the study on Machine, Electricity and Magnetism. All the 20 items contained in PAT were drawn from West African Examination Certificate (WAEC) past question papers and answer from five years range (2017-2022) and administered to determine the students' achievement.

2.3.2 Physics Motivation Questionnaire (PMQ)

The Physics Motivation Questionnaire (PMQ) was adapted from the science motivation questionnaire developed and used by (Glyan and Koballa, 2006) to suit the present study. It consists of 20 questions constructed based on five Likert Scale (V. Good 5, Good 4, Fair 3, and Poor 2, V. Poor 1), (Ha Shin, 2016). It measured students' motivation toward learning Physics after being exposed to Inquiry-Based Learning Approach using the 5E Instructional Model.

2.4 Validity and Reliability of the Instrument(s)

2.4.1 Validity's of the Instrument

The Physics Achievement Test PAT was selected from (WAEC) past question papers contains 20 items within the range of years (2017-2022) were validated by 4 experts. Two PhD holders from Mathematical Sciences Education Programme, National Mathematical Centre, Abuja and the last one was a Secondary School Physics teacher with 22 years working experience. They assessed both the face and content validity. After revalidation, only twenty out of thirty-five items were elected for the test. While Physics Motivation Questionnaire (PMQ) was validated by one science educator, one psychologist and one language expert all with PhD. Their suggestion led to the reframing of the Physics Motivation Questionnaire, for example, a statement such as Science is a difficult subject; Science is a boy's subject; were reframed to Physics is a difficult subject and Physics is a boy's subject**.**

2.4.2 Reliability of the Instruments

In testing the reliability of the instruments (PAT & PMQ), a pilot study was conducted with a sample school not involved in the study. Pilot study sample 30 SSII were selected and a test re-test was used for both instruments after an interval of 2 weeks for each instrument. The reliability coefficient was computed using Cronbach's alpha and found to be 0.75 for Physics Achievement Test (PAT) and 0.70 for Physics Motivation Questionnaire (PMQ).

The instruments are therefore reliable and were used for data collection in this study.

Procedure

The Physics Achievement Test (PAT) was administered to both groups as a pre-test to ensure their homogeneity. Then, the experimental group was taught the selected Physics concepts i.e. (Machine, Electricity and Magnetism) through Inquiry-Based Learning Approach Using the 5E Instructional Model method (with modules prepared by the researcher) for a period of two weeks at the rate of 60 minutes per day. On the other hand, the control group was taught the same concepts using the traditional method for the same period at the same rate by one of their Physics teachers as a research assistant. After completion of the treatment, both groups were administered Physics Achievement Test (PAT) as a posttest. The Physics Motivation Questionnaire was administered to both the control and experimental groups before and after treatment.

3.0 Results

The data collected were presented and analyzed using Statistical Package for Social Sciences (SPSS) version 20.0 which include: (Mean, Standard deviation (SD), Degree of freedom (df).

3.1 Research Question:

Is there any significant difference in students' academic achievement in Physics using Inquiry-Based Learning Approach Using the 5E Instructional Model and traditional method of teaching in science secondary schools in Kano state?

Table 1: Post-test scores of Physics Achievement Test for Control and Experimental Groups

Group	N	Mean	St. Deviation	St. Error	Mean Difference
Score CG	40	34.75	15.48	2.45	
					19
EG	40	53.75	13.76	2.18	

Table 1: Indicates that the Inquiry-Based Learning Approach using the 5E Instructional Model method has the higher post-test mean scores of (53.75) with standard deviation of (13.76) above the Conventional teaching method which had the mean score of (34.75) with the standard deviation of (15.48). The difference between the two mean was 19. The result shows that Inquiry-Based Learning Approach using the 5E Instructional Model method had high effect on students' academic achievement in the experimental group. Thus, the research question one is answered.

To find out whether the effect of Inquiry-Based Learning Approach using the 5E Instructional Model method is significant or not on students' academic achievement among Science Colleges in Kano state, the null hypothesis was formulated and tested in table 2.

Ho_1: There is no significant difference between the mean achievement scores of experimental and control groups with respect to Inquiry-Based Learning Approach using the 5E Instructional Model method.

Table 2: Post-test scores of Physics Achievement Test for Control and Experimental Groups

Group	N	Mean	S.D	Standard E. Mean	T	Df	p- value
CG	40	34.75	15.48	2.45			
					5.8	78	0.00
EG	40	53.75	13.76	2.18			

Table 2, shows that, the Inquiry-Based Learning Approach using the 5E Instructional Model method had the higher post-test mean score of (53.75) with standard deviation of (13.76) above the Conventional teaching method which had the means score of (34.75) with the standard deviation of (15.48).

The P-value obtained was 0.00 at $\propto = 0.05$ level of significance with degree of freedom 78 .Therefore, since $p - value$ is less than $\propto - value$, the null hypothesis was not6 accepted, meaning that there is a significant difference between the experimental group taught with Inquiry-Based Learning Approach using the 5E Instructional Model method control group taught with conventional teaching method.

3.2 Research Question:

Is there any significant difference in the level of students' motivation in Physics after their exposure to Inquiry-Based Learning Approach Using the 5E Instructional Model and traditional method of teaching in Science Secondary Schools in Kano state?

Table 3: Comparisons Scores of Students on Motivation Questionnaire before and after treatment

Group	N	Mean	St. Deviation	St. Error	Mean Difference
Before	40	67.85	6.61	1.01	
					9.88
After	40	77.73	7.07	1.11	

Table 3, it could be seen that, the mean score was found to be 67.85 with standard deviation of 6.61 before treatment and 77.73 and 7.07 both as mean score and standard deviation after treatment. The difference of the two mean scores was 9.88. This implied that the Inquiry-Based Learning Approach using the 5E Instructional Model has motivated the student in a positive way toward achieving high scores in Physics Achievement Test. Hence, the research question is answered.

To find out, whether the effect is significant or not, the null hypothesis was formulated and tested.

H_{O2}: There is no significant difference in students' motivation before and after their exposure to Inquiry-Based Learning Approach using the 5E Instructional Model.

Table 4: Comparison of Scores of Students on Physics Motivation Questionnaire before and after treatment

Group	N	Mean	S.D	Standard E. Mean	Z	Df	P- value
Before Treatment	40	67.85	6.61	1.04			
					9.22	82	0.00
After Treatment	40	77.73	7.07	1.11			

Table 4: It could be seen that, the P-Value = 0.00 was found to be less than 0.05 from paired sample T-test, then we concluded that there is a significant difference between the two mean scores implying that Inquiry-Based Learning Approach using the 5E Instructional Model had positively motivated learners.

4.0 Discussion

This study investigated the effect of Inquiry-Based Learning Approach using the 5E Instructional Model on academic achievement of Physics in Science Secondary Schools, in Kano state. The research questions were answered and the Hypotheses were tested at $\alpha = 0.05$ level of significance.

4.1 Research Question:

Effect of Inquiry-Based Learning Approach using the 5E Instructional Model on SSII Academic Achievement.

Table 1: Indicates that the Inquiry-Based Learning Approach using the 5E Instructional Model has the higher post-test mean score of (53.75) with standard deviation of (13.76) above the Conventional teaching method which had the mean score of (34.75) with the standard deviation of (15.48). The difference between the two means was 19. The result showed that Inquiry-Based Learning Approach using the 5E Instructional Model had high effect on students' academic achievement in the experimental group. Thus, the research question one was answered.

In table 2: The result of testing hypothesis one (HO_1) which corresponds to Research Question one (RQ_1) shows that there is significant difference in the means academic achievement scores of experimental group exposed to Inquiry-Based Learning Approach using the 5E Instructional Model and control groups taught with conventional teaching method. The significant difference found between the two groups is likely to be due to the use of Inquiry-Based Learning Approach using the 5E Instructional Model on the experimental group. If the treatments have no effect, the two groups are expected to perform almost the same. Since the experimental group performed significantly better, it implies that using Inquiry-Based Learning Approach using the 5E Instructional Model in teaching physics improved their performance.

The result confirms earlier findings of Stearns (2017) shows that by allowing students to take over, students feel more independent and self-directed guiding their own learning, Inquiry-Based Learning Approach allows students to use their curiosity, their question and learning. This is in support of the research work of Duran and Dukme (2016) who reported that Inquiry-Based Learning Approach increase in critical thinking skills, active engagement with lesson, through discussions among students.

Looking at the scope of Inquiry-Based

Learning Approach there are many aspect that are positives, but there are also remain aspect that are negatives. Some negatives aspect are teachers' preparation time, funding for materials and misunderstanding on how to implement Inquiry-Based Learning Approach.

4.2 Research Question:

Effect of Inquiry-Based Learning Approach using the 5E Instructional Model on Motivation Level of Student

In Table 3, the mean score was found to be 67.85 with standard deviation of 6.61 before treatment and 77.73 and 7.07 both as mean score and standard deviation after treatment. The difference of the two mean scores was 9.88. This implied that Inquiry-Based Learning Approach using the 5E Instructional Model had motivated the experimental group in a positive way toward achieving high scores in Physics Achievement Test. Hence, the research question is answered.

In table 4, the result of testing hypothesis two (HO_2) which corresponds to research question two (RQ_2) shows that Inquiry-Based Learning Approach using the 5E Instructional Model motivated learners, hence contributed to higher academic achievement of Physics students in the study area.

The finding of the study is in agreement with those of Freedman (2012), Mattern and Love (2013) that looked for relationship between the learning – teaching strategies and attitudes. Inquiry-Based Learning Approach increases motivation because students find it fun. Nichols & Miller (1994) report a surprising finding when they used Inquiry-Based Learning Approach for one semester with a high school Algebra II class. When the study ended and students were switched back to the traditional lecture format the student became quite, unhappy and most wished to stay with Inquiry-Based Learning Approach. Motivation and achievement were both affected by displeasure. Munawaroh, (2013) reported that high motivation, self-confidence relating to self-thinking ability and inquiry ability gives positive influence in enhancing students' learning achievement.

5.0 Conclusion

This study investigated the effect of Inquiry-Based Learning Approach using the 5E Instructional Model on academic achievement in Physics Students in Science Secondary Schools, in Kano state. From the finding of the study, it is concluded that:

1) There is significant difference in the academic achievement of students taught with Inquiry-Based Learning Approach using the 5E Instructional Model and those students taught with conventional method. The difference was in favor of the students taught with Inquiry-Based Learning

Approach using the 5E Instructional Model i.e. experimental group.

2) There is difference in the level of students' motivation after being exposed to Inquiry-Based Learning Approach using the 5E Instructional Model.

3) Inquiry-Based Learning Approach using the 5E Instructional Model improved students' academic achievement in Physics in the study area.

5.1 Recommendations

1) Based on the research findings of the study, it is hereby recommended that Inquiry-Based Learning Approach using the 5E Instructional Model be adopted as one of the effective learning strategies in order to improve students' academic achievement in Physics.

2) Physics teachers need to undergo further training to update their skills in different teaching methods effectively especially in the use of Inquiry-Based Learning Approach using the 5E Instructional Model.

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