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An investigation into the use of inquiry based learning (IBL) strategy to teach physics in some selected secondary schools in Birnin-Kebbi Town of Kebbi State

Aliyu Bako *

Department of Physics, Adamu Augie College of Education Argungu, Kebbi State, Nigeria.

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Abstract

Introduction; The roles of the 21st century teacher has become a subject of concern by all stake holders of Education. It is on this note that this paper was written to address one of the fundamental and primary assignment of the teacher to device an innovative method that will lessen the classroom challenges of the 21st century. An IBL teaching strategy is assumed to skyrocket scientific skills however researchers noticed its unused by teachers.

Objective; this paper tried to investigate the physics teachers' use of IBL to teach Physics in secondary school of Birnin Kebbi Town.

Method; all the physics teachers were called by the state ministry of education and serve with a Promoting Inquiry-based learning in Mathematics and Science Education (PRIMAS) questionnaire. Successful teachers were chanced to attend an IBL training workshop after the training the teachers were given the questionnaire. The results of their performances were analyzed.

Result and discussion, the outcome of the study indicated a momentous performance in the physics teachers that attained the IBL training workshop over the Physics teachers that did not attend the training workshop. The findings equally showed that there was no difference in the gender usage of IBL in the physics classroom.

Research implication; the study result has a lot of implications for educational planners and physics teachers. Physics teachers should be mandated to use the method to teach physics using IBL and the educational planners should consider making IBL method compulsory for all subjects at secondary school level.

Originality value; it is imperative to note that study of this kind is necessary to improve critical thinking skills, problem solving skills and scientific thinking to prepare students address the challenges of the 21st century and beyond

Keywords: Inquiry base learning; Strategy; Physics; Secondary schools

1. Introduction

In recent years, there has been an increasing interest in student-cantered instructions where classroom activities depend highly on the students, and the teacher monitors the students. However, this type of method has limited popularity in Nigeria due to background training by the teachers in Nigeria [Traditional chalkboard method] (Olagoke et al., 2014). Student-cantered learning has been found to be more effective by literature and embraced by many developed countries (Herrington et al., 2016) such as the Twelve (12) European member countries, which organized a project to investigate the teacher's implementation and conceptions of IBL in these countries using a developed

* Corresponding author name: Aliyu Bako

questionnaire named Promoting Inquiry-based learning in Mathematics and Science Education (PRIMAS). It is against this bbackground that the researchers set to investigate the level of the usage of inquiry based learning strategy to teach physics in Birnin Kebbi town secondary schools, to serve as a ground towards large scale investigation of the method in other cities of the country. This is because the method was found to be an effective teaching method that increases scientific and critical thinking in students as reported by the 12 European member countries project. Some other related studies indicated that group activities with classmates encourage sstudents to learn better by constructing solutions to open-ended, complex, and problematic activities instead of listening passively to lectures. Although the aactivities take time but can be extremely rewarding when students achieve their learning goals

1.1. Problem statement/Justification

The dependence of the use of the traditional chalk board method of teaching has not yield scientific curiosity, scientific skills, scientific culture and critical thinking in the minds of our teaming Nigerian students youth especially in physics and other related science subjects. Our secondary school students failed physics in their o level examinations hence depriving them from pursuing careers in engineering, technology and medicine. Enrolments in physics is very low in our tertiary institutions. It is paramount to note that Success and understanding of any subject depends strongly on the strategy employed by the teacher to impart on students (Bako and Fatin, 2020). In other words, poor method of teaching discourages, demoralize, and depressed the potentiality of students. Hitherto, the teacher's role in an inquiry class is to guide, lead and direct to avoid misconception and ambiguity (Bako and Fatin, 2020). The entire learning activities rest on the students. The study is choosen to be conducted at Birnin Kebbi town on the basis that it is the state capital many males and females' senior secondary schools are located there. As a state capital conducive learning environment may be available.

1.2. Objectives of the study

- To investigate the extent senior secondary school physics teachers in Birnin Kebbi use IBL in t teaching physics.
- To organize a one day workshop to brain storm the effective ways the IBL method can be effectively imparted on the students
- To follow up in the various physics teachers domicile school to observe the proper implementation of the method in the physics classrooms.
- To compare between IBL and the traditional chalk board method of teaching physics in birnin Kebbi town

1.3. Hypothesis of the Study

- **H01**: There is no significant difference between experimental (physics teachers that attended Inquiry based Learning workshop) and control (physics teachers that did not attend Inquiry based Learning workshop but form part of the research) groups.
- **H02**: There is no gender difference amongst the Physics teachers' use of IBL in teaching physics across groups

1.4. Theoretical framework

This research is guided by the constructivist theory. The theory which Piaget, said "*To understand is to discover, or reconstruct by rediscovery, and such conditions must be compiled with if in future individuals are to be formed who are capable of production and creativity and not simply repetition*"(Piaget,1973, pg.20). To decrease the frustrations of the cankerworm teaching methods associated with behaviorism a new theory emerged known as constructivism. In contrast to the didactic teaching methods, in which learners personalize and control their learning rather than being passive receivers of knowledge. Learners construct their knowledge through a collaborative investigation, criticizing, debating, sharing and reflecting. The process which evidently increases abysmal understanding of the content, ,since the learners connect their prior knowledge to the learning experience. Inquiry learning base learning is argued to be imbedded into the paradigm of the constructivist Balo and Fatin (2020).

2. Literature Review

Inquiry-based Learning (IBL) is denoted as scientific inquiry, which equates to an expression of the nature of science or doing scientist work (Healey, 2005; Crawford, 2012; Minner et al., 2010). It could also be what learners do and is not done for them; it depends on prior knowledge (National Science Education Standards. NSES, 1996). Anderson (2007), Trumbull et al. (2011), Crawford (2012) asserts that among the various ways of testing if inquiry teaching is going on is to find whether learners are engaged in inquiry learning. In furtherance, the National Science Education Standards (NSES, 1996) described five essential features of inquiry in understanding the natural world, which is equally mentioned in Nigeria research and development council (NERDC) document (NERDC, 2005). The five features are scientifically

oriented questions must be involved, prioritising evidence provided by the learners especially when questions were asked, learners are to provide explanations form the provided evidence, the explanations provided by the learners must be connected to scientific knowledge and lastly, students are to communicate and justify their proposed explanations. Furthermore, Models are designed to guide its practices amongst which is the 5E's model.

Sources; UTM Thesis (2020)

Figure 1 The five E's model of inquiry based learning

According to Anderson (2007), Lederman, (2009), Lederman et al. (2014), Mudau (2013), Taconis and Jochems (2011) IBL is a teaching approach that combines the scientific method and curiosity of students in the development of critical thinking skills of learners. The inquiry approach is student-centered learning that emerged from the constructivist paradigm (Demir and Abell, 2010; Gormally et al., 2011). The teacher's role in the constructivist view is to facilitate student efforts, to developed and consolidate their inferences on the subject (Fosnot, 2005; Francis and Mabel, 2016; Gormally et al., 2011; Capps and Crawford, 2013). Despite all the benefits of the inquiry approach, few pieces of literature reported its practices in the Nigerian high colleges due to nature of the curriculum and teachers' insufficient knowledge of inquiry practices (Akben, 2015; Ojediran et al., 2014). However, the teacher's exposure to diverse methods of teaching become necessary because of the dynamic nature of education and the challenges of scientific and technological developments. Knowledge update for teachers will help to curtail misconceptions and increase critical thinking (Ramnarain,2016). Moreover, the physics teachers' scientific skills such as analysis, synthesis and communicative needs to be updated due changes in the world of science and technology.

The instructions of IBL are fundamentally based on the paradigm of the constructivist views of learning in which learners develop their ideas and concept, under the supervision and guidance of the teacher. The following steps.guides its implementation. The steps begin with the activity, the activity leads to the concepts; the concepts do not necessarily lead to the activity (Taber, 2011). The learner's prior knowledge and experience constitute the main goal of IBL teaching in constructivistt paradigm, therefore, formulated questions and answers posed to them amongst themselves established the process of learning. Minner et al. (2010) described IBL as the use of questions and formulating problems as a catalyst for learning, usually includes student-centered activities which engage students and encourage them to become active participants in their own learning process. Moreover, when teachers use IBL methods, the learners are provided with opportunity to participate actively in the lifelong learning processts through observations, gathering data, drawing conclusions, and practice the knowledge gained (Minner et al., 2010). It wort noting that Lederman et al., (2014) viewed that understandings of teachers' inquiry methods are consequential in view of the social context in the classroom. Unfortunately, bundle of the research studies carried out to have a clear picture of science teachers understanding of IBL and its practices in the classrooms remained vague, especially in the underdeveloped countries.

This study focuses on the Kebbi state physics teacher's use of IBL in teaching and learning of physics in Birnin Kebbi high colleges. It is widely believed that the success of any curriculum depends on the quality of the teachers, and IBL aimed at preparing quality teachers due to its demand in preparation and execution (Ramnarain and Hlatswayo, 2018). Teachers should note that IBL learning: is a knowledge building (Taber, 2011), not knowledge consumption and

regurgitation. Some physics teachers are afraid of facing challenges in practicing inquiry because they believe that their content knowledge or pedagogical skills to implement IBL is shallow (Kanli, 2014; Foisy, 2015; Kaltake-Gurel et al., 2016; Bak and Schousboe, 2017). Physics teachers' must be critical in their thought to address challenging questions that may likely be raised by the students (Bak and Schousboe, 2017).

3. Methodology

This research work was conducted in stages; in the first stage a questionnaire was administered to male and female physics teachers in Birnin Kebbi town. The questionnaire aimed at finding the extent to which the teachers knew about IBL and its pedagogies. The second stage invited participating teachers to a 2- day's workshop which purpose was to brainstorm and develop some more ways to strengthen the IBL usage. the third stage visited the participants in their domicile schools to ascertain the level of their comprehension in a practicum.

3.1. First stage

A self-developed questionnaire designed to evaluate teachers technical know-how of IBL was distributed to the total number of Physics teachers (76) in Birnin Kebbi town senior secondary schools. The responses of the questionnaire was used to guide the researchers' on the selection of the teachers and the in-depth or otherwise of the content of the workshop course material,. Twenty five (25) successful physics teachers were selected to participate in the workshop based on their responses to the questionnaire .This class of teachers are the experimental group while the control group consist of the other participating physics teachers that were served with the questionnaire.

3.2. Stage two

The researchers conducted a two-day' discussion to brainstorm with the participants the way and manner IBL is expected to be done. The participants are expected to put to practice the modulus operando of IBL in form of hands on desk activities during the workshop. At the end of the workshop the questionnaire was passed to the twenty five physics teachers. The result of their responses were analysed.

3.3. Stage three

A follow-up activity was organize to visit the physics teachers in the various schools to assess and ensure proper implementation of the learnt strategy as well as interact with the students for their feedback on how well they prefer the new method introduced to them when compared to the traditional chalkboard method through a designed assessment questionnaire. The students' responses were analysed

- **Research Design;** All the state physics teachers were assembled at the ministry of education conference hall. The teachers were made to pick a yes or no pieces of papers. Those that picked 'yes' were allowed to attend the workshop after another screening while those that picked the 'no' were part of the research but not in the workshop. Homogeneity of data was strictly observed.

3.4. Screening and selection of participants Result

Questionnaire was served to all the physics teachers in Birnin Kebbi town. The returned questionnaire was screened and found that 8 (11%) of the teachers did not attempt a single question 56(73%) of the teachers attempted all the questions of the questionnaire while 12(16%) attempted few questions of the questionnaire. Although 73%of the teachers attempted the questions but when ranked according to the quality of the responses only 40(72%) of the teachers were successfully selected for the workshop.

3.5. Validity and reliability of the questionnaire

PRIMAS is a questionnaire developed by the European Union validated by a number of specialist in measurement and evaluation and deem it worthy of implementation. The same questionnaire was adopted and used for the study. The reliability of the questionnaire was determined using Cronbach alpha after administering it to a number of teachers that were not part of the training.

4. Data collection

The figure below represent the normality curve for the PRIMAS questionnaire, the data followed the bell shape except for the poor responses from few respondents perhaps the question was misunderstood.

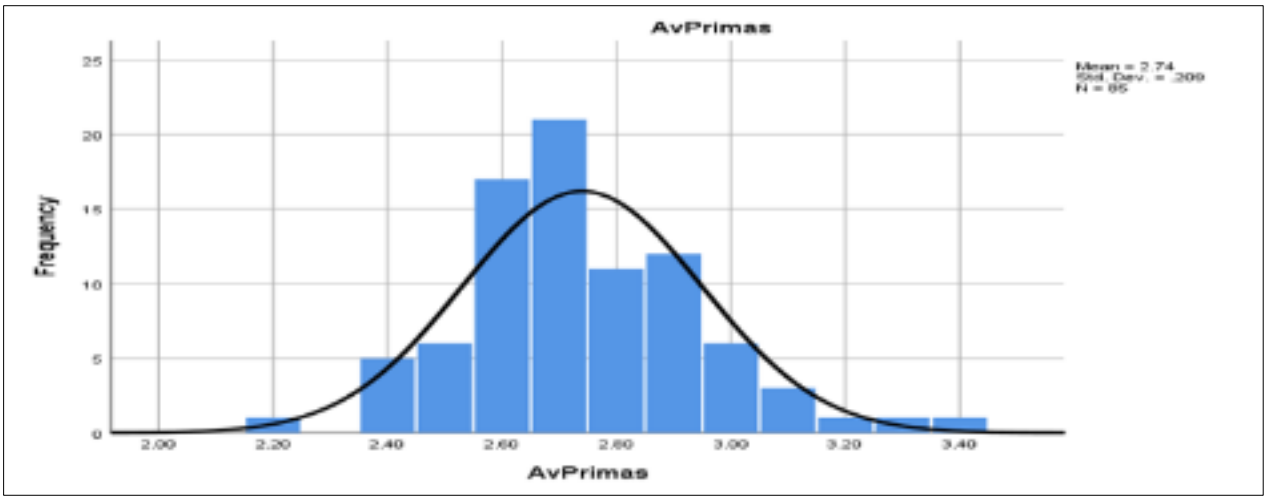

Figure 2 Normally Curve for PRIMAS

Table 1 Participants of the Study

Groups	No of Physics Teachers			Total
	Male	Female	Subtotal	
Experimental	20	6	26	76
Control	32	18	50	

- **Research Question 1**: Can there be any significant difference between the physics teachers taught by inquiry or lecture method?

The research question was answered using, the pre-test and post-test /experimental and control groups.mean and standard deviation. The summary of the analysis is presented in Table 2:

Table 2 Summary of pre workshop and post workshop scores

Groups N=76	N	Pre workshop		Post workshop		Mean Achievement Gain	p-value
		mean	SD	Mean	SD		
Experimental	26	5.400	1.609	12.813	1.460	4.205	<0.001*
Control	50	5.440	1.568	7.454	1.850	1.007	
Mean difference		0.04		5.359			

N: Total number of physics teachers. n sample of physics teachers SD standard deviation. p < 0.005 is statistically significant. *t-test comparing post-test mean scores between the experimental and control groups

Table 1 displayed the mean score of the pre-test and post-test of the experimental and control groups. 5.400 and 5.440 are the corresponding mean scores for experimental and control group respectively, a mean difference of 0.04 is obtained. Nevertheless, 12.813 and 7.454 were the mean score of the experimental and control groups respectively a mean difference of 5,359was obtained. While the mean achievement gain for the experimental and control groups were calculated to be 4.205 and 1.007 respectively. The p-value of the post-test result of the experimental and control group was abysmal at <0.001. Since p-value obtained is less than 0.05 significant level set for the hypothesis to be rejected. Which mean there is significant difference in the means performance score of physics teachers that participated in the inquiry-based method workshop with the Physics teachers that did not took part in the workshop.

- **Research Question 2:** What is the difference between the academic performance mean scores of male and female Physics teachers that participated in the inquiry-based method workshop and the Physics teachers did not took part of the training?

The research question is answered by administering the questionnaire (pre-test) and post-test (questionnaire) on the male and female physics teachers of the experimental and control group Mean and standard deviation of their responses to the questionnaire are presented on the table as in table 3 below

Table 3 Summary of Physics teachers

Groups N= 76	**Gender**	**n**	**Pre workshop Quest.**		**Post workshop Quest.**		**Mean achievement Gain**	**P-Value**
			Mean	**SD**	**Mean**	**SD**		
Experimental	Male	20	5.230	1.722	12.231	3.332	7.001	0.452*
	female	6	3.241	1.121	6.115	1.921	2.874	
Mean difference			1.989		6.116			
Control	Male	32	8.437	6	9.334	2.134		<0.001*
	female	18	5.023	2.976	6.325	1.997		
Mean difference			3.464		3.009			

N total number of Physics teachers; n sample of physics teachers; SD standard deviation P < 0.005 is statistically significant. *t- test comparing mean marks scored between males and females for post-test.

Table 2 the mean scores of males and females of the experimental and control groups in both pre-test and post-test is shown in the table. The result indicates that the mean score of males and females of the experimental group in the pretest were 5.230 and 3.241, but that of the control group counterpart were 8.437 and 5.023 respectively. On the other hand, the mean score of males and females of the experimental groups in the posttest were 12. 231 and 6.115 while that of the control group were 9.334 and 6.325 respectively.

The males and females scores of the experimental was not significant at a males and females' scores of the experimental was not significant at P-value of 0.652. Since 0.452 is greater than 0.05 significant level set for the hypothesis, the hypothesis, is therefore accepted. This means, there is no significant difference in mean performance scores of males and females' Physics teachers that attained the workshop on the inquiry-based method.

Even though a significant difference between male and female physics teachers trained with lecture method has been indicated at <0.001 level of significance. The hypothesis is rejected because 0.001 is less than 0.05 significant level.

The results analysis of this study revealed that the physics teachers that attended the workshop by inquiry-based method (experimental group) performed significantly better than physics teachers that did not attend the workshop but formed part of the research (control group) in physics teaching. The experimental group significant performance could be not be unconnected to the active participation of physics teachers in the training workshop and hands on desk a situation whereby the physics teachers had an opportunity to interact and share, collaborate their learnt experiences in the absence of the facilitator, and arrive at new knowledge by themselves.

5. Result and Discussion

This findings of the experimental group is in conformity with the findings of Bako and Fatin (2020), Jerrim et al, (2020), Ogumah *et al*. (2019), it was reported by Ghumdia (2016) that inquiry strategy simplify the teachers work and improves students' attitudes towards physics and related sciences. It equally boost interest, curiosity and scientific skills. The teachers and students pre-existing knowledge is vehemently utilized to construct new concepts, findings and conceptions. The method is not limited to the mentioned parameters but also enhances kinaesthetic and visual auditory since it involves hands on desk activities. In contrast with the control group whose findings revealed a low performance, this may perhaps be due to the dormancy of the traditional approach and the teachers conceptions, the findings agreed with that of Teig et al, (2018) he opined that the traditional approach to learning is teacher cantered he added that such a method made the teacher to feel proud and boastful since he owns the learning. The student are made to be passive listeners which renders classroom activates to be dull and cumbersome.

The study revealed that the male students have a higher mean score than their female counterpart. This difference can be attributed to the social reasons. The IBL class encourages collaboration and some of the female teachers are married; they therefore feared mingling with their colleagues. The result contradict the findings of Jerrim et al. (2020) that found no Significant difference between male and female in an IBL classroom . This is due to the fact that the students used for the study were of secondary school students that are not married .the mean difference in the control group indicated the performance of male over their female counterpart to be very small. This indicated that the method that the teachers where exposed to do not encourage collaboration, so the female learned almost at the same level with the male this result was equally obtained by Ramnarain and Hlatswayo. (2018).

6. Conclusion

The study reveals a significant difference in the teachers that attained an inquiry based learning training workshop over the teachers that were not in the training. This indicated IBL is a very good method of teaching that should be embrace by all physics teachers in Birnin Kebbi town. IBL encourages hands on desk activities and it is void of gender as the study indicated even though the teachers were trained in the traditional didactic method

This study has a lot of implications especially in educational settings for instance; the teacher's knowledge of IBL assist in covering a very wide spectrum of topics within the shortest time possible. The role of the teacher in IBL is to guide the learners, ensure discipline and concentrating on the topic of discussion, making sure of limited misconception of facts. The teacher is bound to gain a lot of information from the learners about the subject due to the fact that the learners have full control of what they learn instead of forcing the learners to study very little about a topic.

In an inquiry based classroom the students are having full control on what to learn, competition is set amongst the learners, every learner wants to share the new knowledge found amongst colleagues, thereby creating an enabling environment that encourages active learning. To such an extent of not weary of time.

The education policy designers should use the result this study to incorporate IBL teaching approach to teach physics and other science related courses at senior secondary schools and teacher training institute. Doing so can improve students learning of physics. It is observed by the research to deepen the investigation into primary and tertiary level of education in the Nigerian states and beyond.

Compliance with ethical standards

Statement of informed consent

Indeed all are happy to see the result published'

References

[1] Akben, N. (2015). Improving science process skills in science and technology course activities, using the inquiry method*. Education and Science*, 4 (179), 11-132.

[2] Anderson, R. D. (2007). Inquiry as an organizing theme for science curricula. In S. Abell and N. Lederman (Eds.), *Handbook of science education* 807-830. New Jersey: Lawrence Erlbaum Associates, 11,122-134.

[3] Bako. A and Fatin. P. A (2020) Teaching Conceptions of Inquiry-based Learning among Nigerian Secondary School Physics Teachers. *International Journal of Psychosocial* Rehabilitation volume 24, Issue; 5 2020.

[4] Bak, L. K and Schousboe, A (2017). Misconceptions Regarding Basic thermodynamics and Enzyme Kinetics Have Led to Erroneous Conclusions Regarding the Metabolic importance of Lactate dehydrogenase Iso-enzyme Expression. *Journal of Neuroscience Research,* 95(11), 2098-2102.

[5] Capps, D., K., and Crawford, B., A. (2013). Inquiry-based professional development: what does it take to support teachers in learning about the nature of science? *International Journal of Science Education.35*(12), 1947-1978.

[6] Crawford, B. A (2014). From inquiry to scientific practices in the science classroom. In NG Lederman and S.K Abell (eds). Handbook of research on science education (Vol. 2). London, England: Routledge Creighton, P. and Scott, N. (2006). An introduction to situational judgement inventories. Selection and Development. Review, 22, 3-6.

[7] Fosnot, C.T. (2005). Constructivism: Theory, Perspectives, and Practice Second Edition Catherine Twomey. Teachers College, Columbia University New York and London, 10-12.

[8] Foisy, B. M., Potvin, P., Riopel, M., and Masson, S. (2015). Is inhibition involved in overcoming a common physics misconception in mechanics? Trends in Neuroscience and Education, 4(1-2), 26-36.

[9] Francis, A. A. and Mabel, I. I. (2015). Effects of 7E Learning Cycle Model and Case-Based Learning Strategy on Secondary School Students' Learning Outcomes in Chemistry. *Journal of integrated science and technology education* (JISTE) 19(1),7-18.

[10] Gormally, C., Brickman, P., Hallar, B., and Armstrong, N. (2011). Lessons learned about implementing an inquiry-based curriculum in a college biology laboratory classroom. *Journal of College Science Teaching*, 40(3), 45–51.

[11] Healey, M. (2005). Linking research and teaching to benefit student learning, *Journal of Geography in Higher Education, 29(1), 211-224*

[12] Jerrim, J., Oliver, M., and Sims, S. (2020). The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. *Learning and Instruction*, 101310.

[13] Kanli, U. (2014). A Study on Identifying the Misconceptions of Pre-service and In-service Teachers about Basic Astronomy. EURASIA *Journal of Mathematics, Science Technology Education,* 10 (5), 471–479.

[14] Kaltakci-Gurel, D., Eryilmaz, A and McDermott, L. C. (2016). Identifying Pre-service Physics Teachers' Misconceptions and Conceptual Difficulties about Geometrical Optics. *European Journal of Physics* 37(4).64-76.

[15] Lederman, J. S., Lederman, N. G, Bartos, S. A., Barles, S. L., Meyer, A. A.and Schwartz, R. S. (2014). Meaningful assessment of learners' understanding about scientific inquiry: The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching,* 51(1), 65-83.

[16] Minner, D. D., Levy, A. A. and Century, J. (2010). Inquiry-based science instruction- what is and does it matter: Results from research synthesis 1984-2002. *Journal of Research in Science Teaching,* 47 (4), 474-496.

[17] Mudau, A. V. (2013). Teaching Difficulties from Interactions and Discourse in a Science Classroom. *Journal of Educational and Social Research,* 3(3), 113-120.

[18] National Science Education Standards. (1996). Washington, DC: National Academy Press

[19] NERDC, (2005). Workshop on difficult concepts physics group report. Nigerian Educational Research and Development Council, Lagos.

[20] Ojediran, I. A., Oludipe, D. I. and Ehindero, O. J. (2014). Impact of Laboratory-Based Instructional Intervention on the Learning Outcomes of Low Performing Senior Secondary Students in Physics. *Creative Educ. 5,97-206.*

[21] Olagoke, A. M., Mobolaji, O. S. and Mercy, A. D.(2014). Inquiry-Based Learning Approaches: The Best Practice for Basic Science Teachers. *International journal Curriculum Research and Review, 6(15) 15-19.*

[22] Ogumah, B. A. O., Babaji, H. U., Alome, S. A., and Taiye, A. (2020). Effect of Guided Inquiry Teaching Method on Students Academic Performance in Electrical Installation and Maintenance Work in Technical Colleges in Gombe State. *ATBU Journal of Science, Technology and Education*, *7*(4), 343-3"

[23] Piaget, J. (1972). *The Psychology of the Child*. New York: Basic Books. 137-141.

[24] Ramnarain, U. and Hlatswayo, M. (2018). Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa. *South African Journal of Education, 38(1),52-62.*

[25] Ramnarain, U. (2016). Understanding the influence of intrinsic and extrinsic factors on inquiry-based science education at township schools in South Africa. *Journal of Research in Science teaching*, 53 (4), 598-619.

[26] Taber, K. S. (2011). Constructivism as Educational Theory: Contingency in Learning, and Optimally. Guided Instruction in educational theory, editor Jaleh Hassaskhah, Nova science publishers' Inc.118-121.

[27] Taconis, R. and Jochems, W. M. G. (2011). Exploring the Underlying Components of Primary School Teachers' Pedagogical Content Knowledge for Technology Education. *Eurasia Journal of Mathematics, Science and Technology Education*, 7(4), 263-274.

[28] Teig, N., Scherer, R., and Nilsen, T. (2018). More isn't always better: The curvilinear relationship between inquiry-based teaching and student achievement in science. Learning and Instruction, 56, 20–29.

[29] Trumbull, D. J., Bonny, R. and Grudens-Schck, N. (2011). Developing materials to promote inquiry: lesson learned. *Science Education*, 89, 819-900.