Effects of Project-Based Learning on Students' Achievement in Secondary School Physics in Bokkos Local Government Area, Plateau State

Macmillan Mafulul Josiah, Isa Shehu Usman, Yohanna Iliya Mallo, Mohammed Umaru Gwamna and Uwem Sunday Inyang

Abstract

This study investigated the effects of project-based learning on students' achievement in secondary school physics in Bokkos Local Government Area, Plateau state. It employed the non-equivalent, control group, pre-test, post-test quasi-experimental design. Fifty (50) SS II students from two co-educational secondary schools were used as sample and were tested on the concepts of propagation and production of waves using a developed 25-item Waves Achievement Test (WAT) whose reliability coefficient was 0.85 using Kuder-Richardson (KR-20) method. Two research questions were raised and answered using mean and standard deviation scores while three hypotheses were formulated and tested using One-way Analysis of Variance (ANOVA). The analyses revealed, amongst others, that students taught using project-based learning (PBL) achieved significantly higher than those instructed under the conventional lecture method. Based on the findings, recommendations were made which include suggesting that physics teachers should adopt PBL as one of the methods of instruction in secondary schools.

Key Words: *Project-Based Learning, Students' Achievement, Physics, Students' Gender*

Introduction

The application of science through technology is crucial for providing the infrastructure needed for use in the society. In regards to that, Murenzi (2005) mentioned that educators, physicists and politicians worldwide met in South Africa in 2005 to deliberate on the role of physics in creating a sustainable future for countries considered as developing. This implies that physics is important and its importance for the development of a nation must not be taken for granted. Nelkon (2013) defined physics as a subject which studies the properties of matter and its behaviour in relation to energy. Physics is a basic science subject and its concepts and techniques underpin the understanding of all other branches of science. For instance, a thorough understanding of quantum mechanics is necessary to chemists and material scientists since the structure of every atom in the universe is determined by quantum mechanics. In the health sector, the understanding of basic physics is quite necessary for developing new instrumentation and techniques – with the help of medical physics, the right equipment for the diagnosis of diseases and the efficient communication of medical data are acquired.

Physics education plays a vital role for technological development of any nation. This is

because the level of technological growth of such a nation depends on the quality of physics education, which in turn relies on the quality of its physics teachers. This signifies that the physics teacher plays a key role in shaping the destiny of a nation. This role can be observed in the relationship that exists between the teacher's usage of instructional methods, outcome of teachers' instruction and the development or under-development of the nation. In Nigeria, despite the enormous importance of physics to the development of a nation and the efforts of the government and other stakeholders in improving science education, physics results in most externally organized examinations such as Senior School Certificate Examination (SSCE) have not been satisfactory (WAEC, 2015). These unsatisfactory results have been attributed to many factors which include utilization of inappropriate methods of instruction in schools and the dearth of qualified and experienced physics teachers in secondary schools (Boyo, 2010; Mankilik & Josiah, 2013). The lecture method of instruction is still the most frequently employed by physics teachers in teaching physics in Nigeria. This method has been reported to be ineffective in the teaching of physics in schools (Boyo, 2010).Little or no wonder the unsatisfactory results in the above-mentioned examinations over the years. The lecture method has been defined by Slavin (2011) as one in which the teacher stands before a class of students and presents information for the students to learn. Although, the method of instruction is advantageous such that it covers a wide range of syllabus within a limited time frame, amongst others, its disadvantages are so many. These disadvantages include truth that the method is teacher-centred instead of student-centred methods of instruction advocated for by the Nigerian Educational Research and Development Council, NERDC (2008); students are just passive listeners, not actively engaging themselves in the process of abstraction and generalization; and students can find lessons boring causing them to lose interest in the lesson/subject. In the 21st century teaching physics should be done in such a way that knowledge and skills are acquired by students instead of learning by rote. This is because physics is a science subject and science and technology drive the social and economic wheels of any thriving nation. Project-based learning (PBL) is a method of teaching physics which promotes skills acquisition in students for the necessary scientific and technological development of a nation.

Project-based learning (PBL) is a method of instruction which involves knowledge and skills learnt by students through practical handling of problems in natural setting. According to Ugwu, cited in Sunday, Owadara and Iwu (2016), PBL is a teaching approach that actively engages students in sustained, collaborative real-world investigation. Akpan (2018) added that PBL enhances students' knowledge of the content of a subject and the skills therein. During project-based learning, projects are organized around a driving question and students participate in a variety of tasks that seek to meaningfully address this question. Jones, Rasmussen and Moffih, cited in Sunday, Owadara and Iwu (2016) opined that the projects are complete tasks, based on challenging questions or problems that involve students in design, problem-solving, decision making or investigative activities or an opportunity to work relatively autonomously over extended period of time. In a project-based learning, the central activities of the project must involve the transformation and construction of knowledge on the part of students. According to Muriithi, Odundo, Origa and Gatumu (2013), PBL

involves the construction or making of actual projects by the students. Such projects are student-centered, following standards, parameters, and milestones clearly identified by the teacher. Students have control over the planning, refining, presenting, and reflecting of the project. Through projects, students are engaged in innovation and creativity. Project-based learning involves assignments that call for students to produce something, such as a process or product design, a computer code or simulation, or the design of an experiment and the analysis and interpretation of the data (Muriithi, Odundo, Origa & Gatumu, 2013). Projects are usually done by student groups but they may also be assigned to individuals to avoid many logistical and interpersonal problems, although doing so may cut down on the range of skills that can be developed through the project.

Researches show diverse achievement outcomes when PBL is used to teach students. Muriithi, Odundo, Origa and Gatumu (2013) studied project method and learner achievement in physics and the findings showed that students exposed to learning physics through PBL achieved higher than those who did not learn the subject through PBL. Furthermore, both male and female students achieved higher in physics when PBL was used. In their study on effect of project-based method on students' achievement in physics, Sunday, Owadara and Iwu (2016) found that students who are taught physics using project-based method achieve higher than their counterparts who are taught using the conventional lecture method. In a study investigating the effects of project-based learning on students' performance of higher cognitive skills in secondary school agriculture, Kibett and Kathuri (2005) found out that those taught using project-based learning achieved higher than their counterparts taught using conventional lecture method. Olatoye and Adekoya (2010) studied effect of project-based, demonstration and lecture teaching strategies on secondary school students' achievement in an aspect of Agricultural science. The study found out that students exposed to pasture and forage crops through project-based teaching strategy achieved higher than those exposed to pasture and forage crops through demonstration and lecture teaching strategies. They also found out that gender had no effect on the students' achievement after being exposed to the three instructional methods. On the contrary, there are also studies that claimed that despite the positive effects of project-based learning on students' achievement it does not exhibit a superior effect on students' achievements when compared to other methods of instruction (Araz & Sungur, 2007; Filippatou & Kaldi, 2010; Ozyurt & Ozyurt, 2017). Mills and Treagust as cited in Muriithi, Odundo, Origa and Gatumu (2013) particularly noted that students taught with PBL sometimes gain less mastery of scientific concepts than those taught using the conventional methods. The study further noted that some of the students turn out not to be happy as a result of the conflicts experienced by individual students with other members in group work and the duration and effort needed to complete a project.

Project-based learning has been found to be advantageous to students. The purpose of project-based learning in physics, according to Sunday, Owadara and Iwu (2016), is to provide a structure where students can demonstrate mastery of physics by creating and presenting research-based projects, driven by their own interest in topics and permits them to work within the same parameters as real researchers. In undertaking these

projects, the students may be exposed to improvising or constructing materials or equipment not available in the physics laboratory. Constructing or improvising such materials and equipment can be easily achieved through the use of local materials found in the immediate environment, when the original equipment is not readily available. One of the general objectives of the physics curriculum is the acquisition of essential scientific skills and attitudes by students so as to prepare them for technological application of physics (NERDC, 2008). Therefore, when students are taught physics concepts using project-based learning the required scientific skills and attitudes will be learnt for technological application and subsequent development of the nation.

Students' gender researches with respect to achievement have been carried out in physics education. In a study undertaken by Inyang and Josiah (2016) on perceived difficulty of physics concepts in secondary schools, it was found out that male students achieve significantly higher than their female counterparts. However, it was discovered that female students outperformed their male counterparts in difficult concrete concepts of physics. The researchers attributed this difference to the female students' lack of confidence (who usually perceive physics as a difficult mathematically-inclined subject) and their general lack of interest in the sciences. Apata (2011) had earlier embarked upon a similar research and also found out that male students achieve higher in physics than female students. Agommuoh and Nzewi(2015), in their study on the effect of videotaped instruction and the learning cycle constructivist model on secondary school students' interest and achievement in physics, found out that male students achieved higher in physics than their female counterparts. Other studies, such as that of Ojediran, Oludipe and Ehindero (2014), showed that female students achieve higher than their male counterparts in physics. In view of the afore-mentioned, this study sought to investigate the effects of project-based learning on students' achievement in secondary school physics.

Research Questions

The following questions were raised for the study:

1. What are the mean achievement scores of secondary school two (SS II) students in physics before and after exposure to project-based learning (PBL) and conventional lecture method?
2. What are the mean achievement scores of SS II male and female students in physics after exposure to PBL?

Hypotheses

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

1. There is no significant difference in physics achievement between SS II students in the experimental and control groups prior to treatment.
2. There is no significant difference in physics achievement between SS II students in the experimental and control groups after treatment.
3. There is no significant difference in physics achievement between SS II male and female students who were exposed to the PBL method.

Methodology

This study employed the quasi experimental research design of the non-equivalent, control group, pre-test, post-test type. This implies that intact classes were used from two sampled co-educational secondary schools for the study. The sampling technique used to obtain the two schools was the simple random sampling technique using the table of random numbers (two-digit column). One of the two schools was randomly assigned as experimental group while the second was assigned as the control group. The experimental group was taught production and propagation of waves using PBL, while the control group was taught the same concepts using the conventional lecture method. The instrument used for the study was a twenty five-item multiple-choice 'Waves Achievement Test (WAT)' in conjunction with notes on production and propagation of waves prepared for the experimental group by the researchers, and apparatus and materials for practical exercise. WAT was developed from secondary school physics curriculum and past senior secondary certificate examination (SSCE) organized by the West African Examination Council (WAEC) and National Examination Council (NECO), using table of specification. WAT was given to three experts in the University of Josto peruse for face and content validity. Thereafter, the reliability coefficient of WAT was obtained as 0.85 using Kuder-Richardson (K-R 20) method on the SPSS software version 25. This coefficient implies that the instrument was reliable, since Taber (2018) reported that some authors describe the coefficient range of 0.84-0.90 for an instrument as reliable.

A total of fifty SSII students offering physics from the two sampled co-educational secondary schools in Bokkos Local Government Area of Plateau state comprised the sample for the study. Pre-test was administered on both the experimental and control groups, a week before treatment commenced. Thereafter, treatment was carried out on the experimental group for a period of twelve weeks on the topic production and propagation of waves. All the practical sessions were held in the school laboratory with the materials provided by the school. The control group was merely engaged on the same topic of production and propagation of waves by being taught using conventional lecture method during the same period of twelve weeks that the experimental group was treated. The researchers taught the theory and the students in the control group performed the practical exercise with the researchers as guides. After the twelve weeks treatment, a post-test was administered to all the students in both the experimental and control groups. The mean and standard deviation scores, as descriptive statistics, were used to answer the research questions; while One-way Analysis of Variance (ANOVA) was employed to test the hypotheses.

Results

Research Question One

What are the mean achievement scores of secondary school two (SS II) students in physics before and after exposure to project-based learning (PBL) and conventional lecture method?

Table 1 shows the mean achievement scores of SS II students in physics before exposure

to PBL and conventional lecture method.

Table 1: Mean Achievement Scores of SS II Students in Physics before Treatment

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Experimental	26	36.0000	13.04761	2.55885	30.7300	41.2700	12.00	56.00
Control	24	36.5000	13.46493	2.74852	30.8143	42.1857	12.00	56.00
Total	**50**	**36.2400**	**13.11575**	**1.85485**	**32.5125**	**39.9675**	**12.00**	**56.00**

From Table 1, the physics mean achievement score of students in the experimental group (36.00) did not differ much from that of students in the control group (36.50) before treatment was introduced. This implies that the achievement entry levels of students in the two groups did not differ much.

Table 2 shows the mean achievement scores of SS II students in physics after exposure to PBL and conventional lecture method.

Table 2: Mean Achievement Scores of SS II Students in Physics after Treatment

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Experimental	26	56.6154	10.03624	1.96827	52.5617	60.6691	36.00	72.00
Control	24	38.5000	12.41668	2.53454	33.2569	43.7431	16.00	56.00
Total	**50**	**47.9200**	**14.39932**	**2.03637**	**43.8278**	**52.0122**	**16.00**	**72.00**

From Table 2, the physics mean achievement score of students in the experimental group (56.62) was higher than that of students in the control group (38.50). This means that students who were taught the concept of production and propagation of waves using PBL achieved higher than their counterparts who were taught same concept but with conventional lecture method.

Research Question Two

What are the mean achievement scores of SS II male and female students in physics after exposure to PBL?

Table 3 shows the mean achievement scores of SS II male and female students in physics after exposure to PBL.

Table 3: Mean Achievement Scores of SS II Students in Physics after Treatment by Gender

Gender	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Male	13	58.4615	9.02418	2.50286	53.0083	63.9148	44.00	72.00
Female	13	54.7692	11.00117	3.05117	48.1213	61.4172	36.00	68.00
Total	**26**	**56.6154**	**10.03624**	**1.96827**	**52.5617**	**60.6691**	**36.00**	**72.00**

From Table 3, the physics mean achievement score of female students in the experimental group was 54.77 while that of their male counterparts was 58.46. These mean scores signify that both male and female students who were exposed to PBL achieved high in physics concepts – production and propagation of waves.

Hypothesis One

There is no significant difference in physics achievement between SS II students in the experimental and control groups prior to treatment.

Table 4 shows the One-way Analysis of Variance (ANOVA) on Physics achievement mean scores of SSII students in the experimental and control groups prior to treatment.

Table 4: ANOVA Result of Difference in the P hysics Achievement Mean Scores of SSII Students in the Experimental and Control Groups Prior to Treatment

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.120	1	3.120	.018	.894
Within Groups	8426.000	48	175.542		
Total	**8429.120**	**49**			

p>0.05

The finding from Table 4 revealed that ($F_{(1,48)}$ = 0.018, p = .894), which means p>0.05.Based on this,$H_0$is not rejected and the study concludes that there is no significant difference in physics achievement between SS II students in the experimental and control groups prior to treatment.

Hypothesis Two

There is no significant difference in physics achievement between SS II students in the experimental and control groups after treatment.

Table 5 presents the One-way Analysis of Variance (ANOVA) on Physics achievement mean scores of SSII students who were taught Physics using PBL and those taught using conventional lecture method.

Table 5: ANOVA Result of Difference in the Physics Achievement Mean Scores of SSII Students Taught using PBL and Conventional Lecture Method

Source of Variation	Sum of Squares	df	Mean Square	F	p
Between Groups	4095.526	1	4095.526	32.418	.000
Within Groups	6064.154	48	126.337		
Total	**10159.680**	**49**			

p<0.05

The finding from Table 5 revealed that ($F_{(1,48)}$ =32.418,p =.000),which means p<0.05.Based on this,$H_0$is rejected and the study concludes that there is significant difference in physics achievement between SS II students who were taught physics using PBL and those taught using conventional lecture method.

Hypothesis Three

There is no significant difference in physics achievement between SS II male and female students who were exposed to physics using PBL.

Table 6 shows the One-way Analysis of Variance (ANOVA) on Physics achievement mean scores of SSII male and female students in the experimental group after treatment.

Table 6: ANOVA Result of Difference in the Physics Achievement Mean Scores of SSII Students Taught using PBL, by Gender

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	88.615	1	88.615	.875	.359
Within Groups	2429.538	24	101.231		
Total	**2518.154**	**25**			

p>0.05

The finding from Table 6 revealed that ($F_{(1,48)}$ = 0.875, p =.359), which means p>0.05.Based on this,$H_0$is retained and the study concludes that there is no significant difference in physics achievement between SS II male and female students who were exposed to physics using PBL.

Discussion

The project-based learning (PBL) was found to be more effective in learning physics concepts than the conventional lecture method of instruction. This can be attributed to the learner-centred nature of PBL and its advantage of hands-on and cooperation in groups to undertake given projects (tasks). In addition, Webb as cited in Olatoye and Adekoya (2010) was of the view that the constant interactions resulting from the collaborations that exist between the students that are taught concepts using PBL enhances their performance; hence their achievement. This finding was in agreement to those of Muriithi, Odundo, Origam, Gatumu (2013), Sunday, Owadara and Iwu (2016) who found out that conventional lecture method of instructing students in physics is less superior, in terms of their achievement, to the PBL. Prior to treatment in this study, the physics mean achievement score of students taught using conventional lecture method did not differ significantly from that of students taught using PBL. However, after treatment the physics mean achievement score of students taught using conventional lecture method differed significantly from that of students taught using PBL. Students who were taught concepts of physics using the PBL achieved higher than their counterparts who were taught same concepts using the conventional lecture method.

This corroborates the report by Khan, Muhammad, Ahmed, Saeed and Khan (2012), that students generally remember 90% of what they do (designing or performing a presentation such as in PBL) which enables them to analyze, design, create and evaluate.

Project-based learning was found to be gender-insensitive. Findings revealed that the achievement in physics of male students who were subjected to PBL did not differ significantly from that of their female counterparts. This corroborates the results of Muriithi, Odundo, Origa and Gatumu (2013) which showed that both male and female students achieve higher in physics when PBL is used. Furthermore, result from this study showed that both male and female students improved significantly in their achievement when PBL was employed in instructing students. This suggests that both male and female students are capable of achieving high scores when effectively taught with PBL.

Conclusion

When PBL is used as an instructional method in teaching physics, it enhances students' achievement in the subject. Moreover, the achievement of students who learn under the method of instruction does not depend on gender.

Recommendations

Based on the findings from the study, the following recommendations were proffered:

1. Physics teachers should adopt PBL as one of the methods of instruction in secondary school since it is found to be effective in learning physics concepts.
2. Physics teachers should undertake in-service training in other to be able to effectively use PBL to facilitate students' achievement in physics.
3. PBL is gender-insensitive. Therefore, it should be employed in instructing students in physics as it rids female students of negative attitude towards the study of the subject thereby improving their achievement.

References

Agommuoh, P.C. &Nzewi, U.M. (2015). Effect of videotaped instruction and the learning cycle constructivist model on secondary school physics students' interest and achievement. *IORS Journal of Research and Method in Education, 5*(1), 56-62.

Akpan, B. (2018). *Science, Technology, Engineering and Mathematics (STEM) and Economic Growth.* Abuja: The STAN Place Ltd.

Apata, F.S. (2011). Students' gender and numerical proficiency in secondary school physics in Kwara State, Nigeria. *Journal of Research in Education and Society, 2*(1), 195-198.

Araz, G. & Sungur, S. (2007). Effectiveness of problem-based learning on academic

performance in genetics. *Biochemistry and Molecular Biology Education, 35*(6), 448-451.

Baran, M. & Maskan, A. (2013). Examining the influence of technology and project-supported thinking journey on achievement. *TOJET: The Turkish Online Journal of Educational Technology, 12*(2), 122-130.

Boyo, A. (2010). *Identifying problems associated with studying Physics in Lagos state, Nigeria*. Retrieved on 15th January 2019 from http://www.wepsd.org/posters/education/boyo-adenike-1.pdf

Filippatou, D. & Kaldi, S. (2010). The effectiveness of project-based learning on pupils with learning difficulties regarding academic performance, group work and motivation. *International Journal of Special Education, 25*(1), 17-26.

Inyang, U.S. & Josiah, M.M. (2016). Students' gender and perceived difficulty of concepts in secondary school physics in Jos metropolis, Nigeria. *IOSR Journal of Research and Method in Education, 6*(5), 1-5.

Khan, M., Muhammad, N., Ahmed, M., Saeed, F. & Khan, S.A. (2012). Impact of activity-based teaching on students' academic achievements in physics at secondary level. *Academic Research International, 3*(1), 146-156.

Kibet, J.K. & Kathuri, N.K. (2005). Effects of project-based learning on students' performance in secondary school Agriculture. *Zimbabwe Journal of Educational Research, 29(1), 63- 80.*

Mankilik, M. & Josiah, M.M.(2013). Effects of computer-assisted instruction (CAI) on students' achievement in secondary school physics in Pankshin Local Government Area of Plateau State. *International Journal of Research in Science, Technology and Mathematics Education,* 1(1), 23-31.

Murenzi, R. (2005). *Physics has a key role in development.* A paper presented at the World Conference on physics and sustainable development held in Durban, South Africa from 31st October-2nd November.

Murithi, E.M., Odundo, P.A., Origa, J.O. & Gatumu, J.C. (2013). Project method and learner achievement in physics in Kenyan secondary schools. *International Journal of Education and Research,* 1(7), 1-12.

Nelkon, M. (2013). *Principles of physics for senior secondary schools.* Ikeja: Learn Africa Plc.

Nigerian Educational Research and Development Council, NERDC. (2008). *Senior Secondary School Physics Curriculum for SS1-3.* Abuja: NERDC.

Ojediran, I.A., Oludipe, D.I. & Ehindero, O.J. (2014). Impact of laboratory-based instructional intervention on the learning outcomes of low performing senior secondary school students in physics. *Creative Education, 5*,197-206.

Olatoye, R.A. & Adekoya,Y.M. (2010). Effect of project-based, demonstration and lecture teaching strategies on senior secondary students' achievement in an aspect of Agricultural Science. *International Journal of Educational Research and Technology,* 1(1), 19-29.

Ozyurt, H. & Ozyurt, Ö. (2017). Analysis of student views on project-based learning experience in visual programming course. *Turkish Journal of Computer and Mathematics Education, 8*(2), 244-260.

Slavin, R.E. (2011). Instruction based on cooperative learning. In R.E Mayer and P.A Alexander (Eds). *Handbook of Research in Learning and Instruction (344- 360).* New York: Taylor and Francis.

Sunday, A., Owadara, A.B. & Iwu, A.O. (2016). Effect of project-based method on students' achievement in physics-Implication for global competitiveness. *JORIND, 14*(1), 1-12.

Taber, K.S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*, 1273-1296. Doi: 10.1007/s11165-016-9602-2

WAEC(2015). *WAEC's e-learning tool kit.* Retrieved on 15th January 2019 from www.waeconline.org.ng