EFFECT OF PROJECT-BASED LEARNING ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN ELECTROCHEMICAL CELLS IN AGBANI EDUCATION ZONE

Dr. Cynthia O. Omeje
Department of Science Education, Enugu State University
of Science and Technology

ABSTRACT

The study centred on the effect of project-based learning on secondary school students' academic achievement in electrochemical cells in Agbani education zone. Two research questions guided the study while two null hypotheses were tested at .05 level of significance. The design for this study was quasi-experimental design of the pre-test post-test non-equivalent research design. The population for the study consisted of 4,109 Senior Secondary two (SS II) students in Agbani Education Zone of Enugu State. The sample size was 365 students. Purposive sampling was adopted to identify four out of the 45 senior public secondary schools in Agbani Education Zone of Enugu State. The instrument for data collection was Electrochemical Cells Achievement Test (ECAT). The instrument was validated in two phases which included: face validation and content validation. The reliability coefficient of the ECAT was determined using Kuder Richardson KR_{20}. Reliability coefficient of 0.81 was gotten showing that ECAT was stable. The research questions were answered using mean and standard deviation. Analysis of covariance was used in testing the hypotheses at .05 level of significance. The findings of the study revealed that students that were taught electrochemical cells with project-based learning recorded higher academic achievement than those taught with expository method. The findings showed that male students that were taught electrochemical cells with project-based learning recorded higher academic achievement than their female counterparts. Based on the findings of the study, the researcher revealed among others that the use of project-based learning should be encouraged by teachers to students during teaching and learning of Chemistry (Electrochemical cells in Senior Secondary School since it enhanced better performance of students irrespective of the scoring level.

Keywords and Phrases: Project-based learning, electrochemical cells and Chemistry achievement.

INTRODUCTION

Chemistry is the science of molecules and their transformations. Chemistry as defined by Okeke and Ezekamgha (2010) as a branch of science that deals with composition and changes of matter. According to Jegede (2013), chemistry is a core subject for the medical sciences, textile technology, agricultural science, synthetic industry, printing technology, pharmacy, chemical engineering, to mention just a few. Chemistry is one of the science subjects that occupy a unique position in schools curriculum. It is an integral part of science

and its importance in the field of science cannot be overemphasized. The study of chemistry is essential for the nation's scientific and technological development. According to Ukeh, et al. (2020), whatever the teacher does in the classroom is significant to students' learning ability, hence, the method of teaching is critical in any teaching-learning situation.

The current mode of learning in Nigerian education has been found to be mostly based on conventional chalk-and-talk approaches. A method of teaching comprises the principles and methods used by teachers to enable a positive student learning outcome (Daluba, 2013). According to Aladejana in Bamidele and Yoade (2017), teaching still follows the old conservative model with teachers serving as repositories of information and students as latent receivers. Research findings of Nwanekezi and Kalu (2012), Oshinaike and Adekunmisi (2012), and Robert (2011) have established that traditional teaching methods have contributed to poor levels of academic achievement in some subjects. For the purpose of this study, electrochemical cell which is a topic in chemistry will be comparatively taught with expository method as well as the use of project-based learning.

Electrochemical cell is a device that can generate electrical energy from the chemical reactions occurring in it, or use the electrical energy supplied to it to facilitate chemical reactions in it. These devices are capable of converting chemical energy into electrical energy or vice versa. The dismal performance of students in electrochemical cells over the years necessitated the search for alternative instructional methods and strategies that could ensure better students' achievement in electrochemical cells. One possible way to achieve the knowledge of electrochemical cell might be through the use of project-based learning (Tamimi, 2020).

Project-based learning (PBL) or project-based instruction is an instructional approach designed to give students the opportunity to develop knowledge and skills through engaging projects set around challenges and problems they may face in the real world. Project Based Learning is a complex concept which means much more than the simple inclusion of projects into the curriculum (Stoller in Tamimi, 2020). PBL can be considered as a method that would assist students to obtain critical skills such as communication skills and thinking skills in addition to using technology (Larmer, 2018). Project-based learning (PBL) enables students to learn deeply and develop core employability skills through participating in real work projects and experiences. Project based learning activities allow students to develop deep content knowledge. It is a hands-on experience which starts with driving questions or problems that create activities and lead to the meaningful products at the end (Simpson, 2011). It is a student-centered instructional approach used to promote active and deep learning by involving students in investigating real-world issues in a collaborative environment (Yam and Rossini, 2010). Importantly, PBL also supports development of 21st century skills such as critical thinking, collaboration, creativity and communication.

Project-based learning cultivates students' curiosity and builds an understanding of core ideas in science, enabling students to solve problems and become responsible citizens with scientific literacy (Krajcik & Czerniak, 2018). The benefits of project based learning include: deeper engagement and interaction with learning content, encouragement of

higher order thinking and problem-solving skills, development of peer and professional networks, engagement with potential employers and career mentors among others. Yanan and Lei (2022), in their study revealed that project-based learning showed a promising effect on student achievement in chemistry. Researchers suggested that a longer duration of experience in PBL helps foster students' cognitive competencies (such as knowledge and skill) and non-cognitive competencies (such as motivation and interest of learning science) (Bhuyan et al., 2020; Jenkins, 2017). These studies were carried out in foreign countries; hence this study intends to find out the situation in Nigerian schools taking cognizance of secondary school students' achievement.

Academic achievement is an accomplishment or an act of achieving or performing desired task. Academic achievement is a result-oriented construct that encapsulates the extent of performance of a desired task (Rix in Nneji, 2013). Academic achievement, according to Ademola (2013) is an indicator of a student's progress in completing particular activities in a subject or field of study after a learning experience. Students' poor achievement can be attributed to their perceived difficult nature of chemistry; involvement of multitude of facts; and its disconnection from reality (Dori, 2015). According to Ewansiba, (2013), students' achievement in chemistry at senior secondary school level in Nigeria has been abysmally poor, with no appreciable improvement over the years. The WAEC results from 2017-2020 revealed that secondary school students' academic achievement in core subjects (chemistry inclusive) is on the decline. The reports of West African Examination Council (WAEC, 2013) chief examiner and chemistry education researchers revealed that most students including those who passed chemistry at credit level and those who failed, haphazardly attempted electrochemical cells questions or avoided them completely. Therefore, in this study, the researcher established whether the students' achievement will be improved by the use of project-based learning notwithstanding students' gender.

One important factor that has been pointed out by researchers is students' gender. Gender is defined differently by various authorities and schools. The World Health Organization (WHO, 2015) defined the word gender as it is used to describe the characteristics, roles and responsibilities of women and men, boys and girls which are socially constructed. United Nations Educational, Scientific and Cultural Organization (UNESCO, 2016) defined gender as the roles and responsibilities of men and women that are created in families, societies and cultures. Several studies like Onuora (2012) and Smith (2015) have looked into the effect of gender on academic achievement and interest, especially in science courses. Olatoye, Aderogba and Aanu (2012) reported that students' gender influences their academic achievement, interest and retention in some subject areas. It can be deduced from the foregoing that the issue of influence of gender on electrochemical cells achievement has not yet been resolved hence, the need for the present study to investigate the gender effect on students' achievement in electrochemical cells when project-based learning is employed by the teachers. One wonders whether project-based learning can equally be effective in teaching other science subjects and their influence on gender. This necessitated the present study which investigated the effect of project-based learning on students' academic achievement in electrochemical cells in secondary schools in Agbani Education Zone of Enugu State.

The poor performance of students in electrochemical cells in Enugu State especially in Agbani Education zone has posed a challenge to educational efficiency. Strategic stakeholders in secondary education have attributed such failure to the manner in which electrochemical cells is taught. The expository teaching method using textbook as the main teaching tool has been the most widely practiced among the teachers. After realizing the need for a more efficient teaching approach, a paradigm change in the style of lesson presentation is needed. Project-based learning is one of the approaches that have been proposed. Gender has been found to be an indicator of academic success in the majority of research. In this analysis, the implication of gender was taken into account.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the effect of project-based learning on students' academic achievement in electrochemical cells. Specifically, the study sought to determine the:

1. mean academic achievement scores and standard deviations of students taught electrochemical cells with project-based learning (Experimental group) and those taught using expository teaching method (Control group) in both pre-test and post-test;
2. mean academic achievement scores and standard deviations of male and female students taught electrochemical cells with project-based learning (Experimental group.

RESEARCH QUESTIONS

The following research questions guided the study:

1. What are the mean academic achievement scores and standard deviations of students taught electrochemical cells with project-based learning and those taught using expository teaching method in both pre-test and post-test?
2. What are the mean academic achievement scores and standard deviations of male and female students taught electrochemical cells with project-based learning?

HYPOTHESES

The following null hypotheses guided the study at probability, $p \leq .05$:

Ho_1: There is no significant difference in the mean achievement and standard deviation scores of SS2 students taught electrochemical cells with project-based learning and those taught using expository teaching method.

Ho_2: There is no significant difference between the mean academic achievement scores of male and female students taught electrochemical cells with project-based learning.

Ho_3: There is no interaction effect of gender and methods (project-based learning and expository teaching method) on students' achievement in electrochemical cells.

METHOD

The design for this study was quasi-experimental design of the pre-test Post-test non-equivalent research design. Quasi-experimental research design is defined as one which random assignment of subjects to experiment and control groups is not possible (Nworgu, 2015). The area of the study was Agbani Education Zone of Enugu State. It is one of the six education zones in Enugu State. The population for the study consisted of 4,109 Senior Secondary two (SS II) students in Agbani Education Zone of Enugu State. The number of male in the study was 2,204 while the number of female was 1,905 (Source: - Planning, Research and Statistics Unit, Post Primary School Management Board (PPSMB), Enugu State, 2021). The choice of SS II students was that they were not part of examination classes in secondary education. The sample size was 365 students. Purposive sampling was adopted to identify four out of the 45 senior public secondary schools in Agbani Education Zone of Enugu State.

The four schools drawn operate co-education and were considered to be better equipped for the study. This study also considered gender as a variable so as to have a basis for comparison in co-education schools. Therefore, this study comprised 198 students in the experimental group (102 males and 96 females) and 167 students in the control group (92 males and 75 females). The instrument for data collection was Electrochemical Cells Achievement Test (ECAT). The instrument was validated in two phases which included: face validation and content validation. A trial test of the instrument was carried out for the purpose of determining the coefficient of temporal stability of the Electrochemical Cells Achievement Test (ECAT) using test retest reliability technique. The instrument was administered on 30 SS II Students in Enugu Education Zone of Enugu State. The reliability coefficient of the ECAT was determined using Kuder Richardson KR_{20}. Reliability coefficient of 0.81 was gotten showing that ECAT was stable.

A one week intensive briefing for the teachers was conducted by the researcher. Four teachers were briefed before the treatment. The teachers were given detailed explanation on the use of project-based learning and other research expectation. The briefing was based on the purpose of the study, the topics to be taught, the use of the lesson plans, the use of ECAT and general conduct of the study. The research questions were answered using mean and standard deviation. Analysis of covariance (ANCOVA) was used in testing the hypotheses at .05 level of significance.

RESULTS

Research Question One: What are the mean academic achievement scores and standard deviations of students taught electrochemical cells with project-based learning (Experimental group) and those taught using expository teaching method (Control group) in both pre-test and post-test?

Table 1: Mean academic achievement scores and standard deviations of students taught electrochemical cells with project-based learning (Experimental group) and those taught using expository teaching method (Control group) in both pre-test and post-test

Groups	Number	Pre-test		Post-test		Mean Gain
		Mean ($\underline{x}$)	Standard Deviation (s)	Mean ($\underline{x}$)	Standard Deviation (s)	
Experimental	198	29.59	11.11	38.41	13.30	8.82
Control	167	25.61	10.41	33.31	12.22	7.70
Mean Diff.						**1.12**

Table 1, showed that students taught electrochemical cells with project-based learning had pre-ECAT and post-ECAT scores of 29.59 and 38.41 with standard deviations of 11.11 and 13.30 respectively. Students taught using expository teaching method had pre-ECAT and post-ECAT of 25.61 and 33.31 with standard deviation of 10.41 and 12.22 respectively. The mean gain for the experimental group was 8.82, while the mean gain in the control group was 7.70 with the mean difference of 1.12, which showed the difference in mean achievement scores between experimental and control groups. From the analyses, it showed that learning took place. This is because the two groups achieved higher mean scores in their posttests than their pretests. This indicated that students that were taught electrochemical cells with project-based learning recorded higher academic achievement than those taught with expository method.

Research Question Two: What are the mean academic achievement scores and standard deviations of male and female students taught electrochemical cells with project-based learning (Experimental group?

Table 2: Mean academic achievement scores and standard deviations of male and female students taught electrochemical cells with project-based learning

Gender	Number	Pre-test		Post-test		Mean Gain
		Mean ($\underline{x}$)	Standard Deviation (s)	Mean ($\underline{x}$)	Standard Deviation (s)	
Male	102	21.29	12.21	37.89	14.19	16.60
Female	96	21.16	10.18	35.42	12.91	14.26
Mean Diff.						**2.34**

Table 2, showed that male students taught electrochemical cells with project-based learning had pre-ECAT and post-ECAT scores of 21.29 and 37.89 with standard deviations of 12.21 and 14.19 respectively. The female students taught with electrochemical cells with project-based learning had pre-ECAT and post-ECAT scores of 21.16 and 35.42 with standard deviation of 10.18 and 12.91 respectively. The mean gain for the male students in the experimental group was 16.60, while the mean gain for the female students in the experimental group was 14.26 with the mean difference of 2.34, which showed the difference in mean academic achievement scores between male and female students in the experimental group. The findings showed that male students that were taught electrochemical cells with project-based learning recorded higher academic achievement than their female counterparts.

Hypotheses

Ho_1: There is no significant difference in the mean achievement and standard deviation scores of SS2 students taught electrochemical cells with project-based learning and those taught using expository teaching method.

Table 3: ANCOVA on the Mean Academic Achievement Scores of Students in Experimental and Control Groups

Source	Type II Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	1372.124	2	686.062	1304.376	.023	Rejected
Intercept	4804.802	1	4804.802	352.017	.213	
Pretest	502.411	1	502.411			
Method	432.678	1	432.678	21.932	.003	
Error	250.640	362	.520	156.402	.050	
Total	36405.000	365				
Corrected Total	78065.129	364				

a. R Squared = .992 (Adjusted R Squared = .991)

Table 3 revealed that $F(1, 362) = 21.932$; $p = 0.003<0.05$. The null hypothesis is rejected meaning that there is significant difference between the mean achievement scores of students in experimental and control groups in favour of experimental group.

Ho_2: There is no significant difference between the mean academic achievement scores of male and female students taught electrochemical cells with project-based learning (Experimental group).

Table 4: Mean Academic Achievement Scores and Standard Deviations of Male and Female Students in Experimental group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	9464.494	2	4732.247	23.642	.000	Rejected
Intercept	5820.730	1	5820.730	29.080	.000	
Pretest	9438.592	1	9438.592			
GENDER	178.022	1	178.022	47.155	.000	
Error	31425.006	195	200.159	0.889	.147	
Total	434912.000	198				
Corrected Total	40889.500	197				

a. R Squared = .231 (Adjusted R Squared = .222)

Table 4 revealed that F(1, 195) = 47.155; p = 0.000<0.05. The null hypothesis is rejected meaning that there is significant difference between the mean achievement scores of male and female students in experimental group in favour of male students.

Ho_3: There is no interaction effect of gender and methods (project-based learning and expository teaching method) on students' achievement in electrochemical cells.

Table 5: ANCOVA on the interaction between method and gender on student' academic achievement scores

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Decision**
Corrected Model	289.802	2	144.901	19.89	.00	Rejected
Intercept	2091.89	1	2091.89	1011.32	.00	
METHODS *GENDER	167.98	1	167.98	19.89	.02	
Error	5019.77	362	24.20	81.99	.03	
Total	14311.45	365				
Corrected Total	8901.89	364				

Table 5 revealed that F(1,362) = 81.99; p = 0.02<0.05. The null hypothesis is rejected meaning that there is an interaction effect between methods and gender in the academic achievement scores of students.

DISCUSSION OF FINDINGS

The finding of the study revealed that students that were taught electrochemical cells with project-based learning recorded higher academic achievement than those taught with expository method. The finding of the study is in accordance with Yanan and Lei (2022), who posited that project-based learning is significant for students' academic achievement

in chemistry. The null hypothesis tested indicated that the null hypothesis is rejected meaning that there is significant difference between the mean achievement scores of male and female students in experimental group in favour of male students.

The finding of the study revealed that male students that were taught electrochemical cells with project-based learning recorded higher academic achievement than their female counterparts. The finding of the study is in line with Olatoye, Aderogba and Aanu (2012) reported that students' gender influences their academic achievement in some subject areas. The null hypothesis tested showed that the null hypothesis is rejected meaning that there is an interaction effect between methods and gender in the academic achievement scores of students.

CONCLUSION

The findings of this study served as a basis for making the following conclusions: project-based learning enhanced better academic achievement of students exposed to electrochemical cells. The strategy also enhanced better achievement among male students. Therefore, it could be concluded that project-based learning is a good instructional method for teaching electrochemical cells. Adoption of project-based learning by the chemistry teachers would go a long way in improving students' achievement in electrochemical cells.

RECOMMENDATIONS

Based on the findings, the following recommendations were proffered:

1. The use of project-based learning should be encouraged by teachers to students during teaching and learning of Chemistry (Electrochemical cells in Senior Secondary School since it enhanced better performance of students irrespective of the scoring level.
2. Text-Book authors should endeavour to incorporate the project-based learning of teaching while writing new editions. This would encourage the use of the models by both teachers and students.

REFERENCES

Bamidele, E.F. & Yoade, F.B. (2017). Effects of modes of computer animation instructional packages on students' achievement in OSUN state secondary schools' biology. *International Journal of Innovation and Research in Educational Sciences*, *4*(4), 496-501.

Bhuyan, J., Wu, F., Thomas, C., Koong, K., Hur, J. W., & Wang, C. (2020). Aerial drone: An effective tool to teach information technology and cybersecurity through project based learning to minority high school students in the U.S. TechTrends: *Linking Research & Practice to Improve Learning*, 64(6), 899–910.

Daluba, N.E. (2013). Effect of demonstration method of teaching on students' achievement in agricultural science. *World Journal of Education, 3*(6), 1-7.

Jegede, S.A. (2013). Students' anxiety towards the learning of Chemistry in some Nigerian secondary schools. *Educational Research Review, 2*(7), 193-197.

Jenkins, J. (2017). The effectiveness of project-based learning on mathematics proficiency with African American students. Proquest Llc.

Krajcik, J.S., & Czerniak, C.M. (2018). *Teaching science in elementary and middle school: A project-based learning approach.* Fifth Edition. Taylor and Francis: London.

Larmer, J. (2018). Project-based learning in social studies. *Social Education, 82*(1), 20-23.

Nneji, S.O. (2013). Effect of Polya George's problem solving model on students' achievement and retention in algebra. *Journal of Educational and Social Research, 3*(6), 41- 48.

Nwanekezi, A.U. & Kalu, N.E. (2012). Effect of multimedia on primary school pupils' retention and interest in basic science concepts. *An International Multidisciplinary Journal, Ethiopia, 6*(2), 206-214.

Nworgu, B.G. (2015). *Educational research: Basic issues and methodology (Third Edition)*. Nsukka, Enugu: University Trust Publishers.

Okeke, C. & Ezekamgha, M. (2010). Influence of gender, school location and the use of play- simulation on school achievement in chemistry. *Journal of Research in National Development*, 9(1b), 381-387.

Olatoye, R.A., Aderogba, A.A. & Aanu, E.M. (2011). Effect of co-operative and individualized teaching methods on senior secondary school students' achievement in organic chemistry. *Pacific Journal of Science and Technology. 12*(2), 310-319.

Oshinaike, A.B. & Adekunmisi, S.R. (2012). Use of multimedia for teaching in Nigerian university system: a case study of university of Ibadan. *Library Philosophy and Practice*. Retrieved from: http:// unllib.unl.edu/LPP/

Robert, O.O. (2011). Information and communication technology awareness among technical college teachers in Benue State, Nigeria. *International Journal of Vocational and Technical Education, 3(6),* 75-8.

Simpson, J. (2011). *Integrating project-based learning in an English Language Tourism Classroom in a Thai University* (Unpublished doctoral dissertation). Australian Catholic University, Australia.

Tamimi, R.I.S. (2020). Effectiveness of project-based learning on students' achievement and motivation towards English in an EFL Environment. *Hebron University Research Journal (B), 15*(2), 237-268.

Ukeh, B.O., Okeke, H.K., Okechukwu, O., Eziokwu, P.N., Onovo, N.E. & Orie, M.J. (2020). Effect of Prezi presentation software on the achievement of students in computer studies. *International Journal of Research in Education*, 2(3): 47-52.

UNESCO, (2016). UNESCO's Gender Mainstreaming Implementation Framework

World Health Organization, (2015). *Gender and Health.* WHO report, 2015.

Yam, L.H.S., & Rossini, P. (2010). *Implementing a project-based learning approach in an introductory property course.* Paper presented at the 16th Pacific Rim Real Estate Society Conference, Wellington, New Zealand. Retrieved from http://www.prres.net/Proceedings/..%5CPapers%5CYam_Implementing_a_Project-Based_Learning_Approach_in_an_Introductory_Property_Course.pdf

Yanan, Z. & Lei, W. (2022). A case study of student development across project-based learning units in middle school chemistry. *Disciplinary and Interdisciplinary Science Education Research*, *4*(5), 1-20.