Knowledge of Scientific Process Skills and Students' Academic Achievement in Senior Secondary School Biology in Calabar Municipality of Cross River State, Nigeria.

Ayenku, James Ekpe[1], Egbule-Onyenachi[2] & Bruno Ibeabuchi Anwuri[3]
School of Secondary Education (Science)
Biology Education Department
Federal College of Education (Technical), Omoku
jamesekpe10@gmail.com[1], egbulenachi@gmail.com[2], & anwuribruno@gmail.com[3]

Abstract

This study investigated knowledge of scientific process skills and students' academic achievement in senior secondary school Biology in Calabar Municipality of Cross River State, Nigeria. Two (2) research questions and two (2) hypotheses guided the study in which a correlation design was adopted. A sample of 150 senior secondary school two (SS 2) science students was drawn from four intact classes in four secondary schools. Instruments used for data collection were the Knowledge of Science Process Skills Acquisition test (KSPSAT) and the Biology Achievement Test (BAT). SPSAT was made up of 12 items and BAT was made up of 30 items with four options (A-D). One research expert and biology education lecturer from Rivers State University validated instruments. The reliability coefficient of 0.75 and 0.78 respectively was obtained using the test-retest method and Kuder Richardson 20 formula. Data obtained were analyzed using multiple linear regression analysis at.05 level significance. The findings of the study showed that students' knowledge of scientific process skills in observation, measuring, classification, and predicting have no significant influence on their achievement in Senior Secondary School Biology. This is notwithstanding the higher achievement of those with knowledge of scientific process skills. Therefore, It was recommended that the State Ministry of Education should equip schools with biology teaching aids and employ only qualified biology teachers. These teachers can expose their students to knowledge of scientific process skills in observation, measuring, classification, and predicting.

Keywords: Acquisition of Scientific Process Skills, Students' Academic Achievement, Biology

Introduction

All the nations of the world accord priority attention to science and technology in their development efforts. The reason for according to such priority attention to science and technology is that it is a road map to great economic improvement and equally serves as the only means to national development (Ajewole, 2010). In the age of fast-developing technology, it has become necessary for all countries of the world, especially the developing ones, to organize and improve the teaching of science that helps in understanding the fundamental base to develop technology. Technology is the successful application of scientific ideas, principles, laws, and theories to develop services as well as to improve technology itself (Agboola & Oloyede, 2007). Science benefits technology which in turn enhances our understanding of science.

Biology is a branch of natural science that focuses on the origin, evolution, and classification of living organisms, and their contributions to life. As a branch of science and a prerequisite subject for many fields of study, it contributes greatly to the technological growth of all nations. Modern biology is a vast and eclectic field that recognizes the cell as the engine that propels the synthesis and creation of new species (Nwagbo & Chikalu, 2011). Okeke (2007) asserted that biotechnology, medical biochemistry, biochemistry, medicine, forestry, and horticulture, among others, are significant fields of study.

Despite the benefits of biology, there still exist some reports of poor academic achievement in public examination results such as NECO and WAEC in the subject. This suggests the need for more effective teaching methods that can improve students' academic achievement in biology. Evidence abounds that students achieved minimally in Biology over the years, for instance in 2017, 6510 students sat for biology examination and recorded 25.71% failure. In 2019 the matter became a bit better because only 34.07% of the 5138 students who sat for the examinations secured credit passes, the results from 2017 up to 2021 are shown in Table 1.

Table 1: Students' academic performance in SSCE "O" Level Biology in Cross River State Between 2017–2021

Year	Total entry	Total credit	Total fail	% pass	% fail
2017	5138	1321	3817	25.71	74.29
2018	6105	1662	4436	27.34	72.66
2019	6510	2218	4292	34.07	21.48
2020	6850	2382	4468	34.77	65.23
2021	8699	3909	4790	44.94	55.06
Average	**7396**	**3069**	**4326.1**	**39.85**	**60.15**

Source: WAEC Calabar Zonal Office 2017.

Clearly, from Table, 1 there is a downward trend in the percentage of credit passes in biology. This is worrisome because biology is the only basic science subject that every senior secondary school student needs a credit in, and also enhance their scientific processes

Scientific processes are defined as ways by which scientists gather, sort, organize, and make sense of information about the world. Basic processes and application skills include observing, communicating, classifying, measuring, predicting, and inferring. Advanced processes and application skills include controlling variables, defining operationally,

formulating hypotheses, experimenting in a controlled environment, and analyzing data. To reach the goal of scientific literacy for all students the processes and application skills must be embedded throughout the content areas and applied through the use of inquiry. Because inquiry and process skills allow students to participate in and take ownership of science content through investigations, teachers provide students at all levels and in every domain of science with opportunities to safely apply these skills. Basic and advanced scientific processes and application skills are presented in Table 1 which provides a more detailed explanation of each of the skill areas (Keil, Hanney & Zoffel, 2009).

Table 2: Scientific processes and application skills

Observing	Using one or more of the senses to gather information about one's environment.	BASIC
Communication	Conveying oral or written information verbally as well as visually through models, tables, charts, and graphs.	
Classifying	Utilizing simple groups of objects or events based on common properties.	
Measuring	Using appropriate metric units for measuring length, volume, and mass.	
Predicting	Proposing possible results or outcomes of future events based on observations and inferences drawn from previous events.	
Inferring	Constructing an interpretation or explanation based on information gathered.	
Controlling variables	Recognizing the factors that affect the outcome of events and understanding their relationships to each other whereby one factor (variable) can be manipulated while others are controlled.	ADVANCED
Defining operationally	Stating definitions of objects or events based on observable characteristics.	
Formulating hypothesis	Making predictions of future events based on manipulation of variables.	
Experimenting (controlled)	Conducting scientific investigations systematically, including identifying and framing the question carefully.	
Analyzing data	Using collected data to accept or reject hypotheses.	

Source: Rodger (1997) (Adapted).

Scientific literacy enables students to use scientific principles and processes in everyday life to make informed decisions. A solid foundation in science helps develop and strengthen many skills that students use daily. Such skills include; solving problems creatively, thinking critically, working cooperatively in teams, practicing stewardship of natural resources, and using technology effectively. The goal of scientific literacy is best achieved through an inquiry-based science program that incorporates scientific knowledge and skills with opportunities to apply both in practical ways. A scientifically literate person has a sound basis

in scientific knowledge, the ability to use scientific processes and technology to understand science-related decisions and problems, and the ability to apply science to the increasing challenges of an ever-changing world.

Science encourages the development of scientifically literate students. Such individuals are more likely to face with confidence the challenges of an ever-changing world as well as enhance the economic productivity of the nation which is directly linked to the scientific and technological skills of its workforce. Students' achievement of the goal of scientific literacy requires an investment in students' education that is worth the efforts and resources expended (Hurd, 1997).

The American Association for the Advancement of Science (AAAS) (2001) did the pioneering work on the identification of activities that constitute science process skills (Kazeni, 2005), AAAS identified fifteen (15) activities that constitute science process skills. These activities are classified into two (2) categories based on operational difficulties and intellectual demands. These categories with their component skills are the basic science process skills, namely observing, measuring, inferring, classifying, predicting, and communicating, and the advanced science process skills, which include formulating hypotheses, identifying variables, defining variables operationally, designing investigations, experimenting, analyzing data, indicating cause-and-effect relationships, and formulating variables/models. These processes must be taught to the schoolchild because he or she is the future agriculturist, engineer, quantity surveyor, physical surgeon, printer and computer technologist, telecommunication or power engineer, and so on (Nwosu, 1994).

One major aim of Nigerian education is to produce productive citizens (Ango, 1992). To achieve this, it is expected that in teaching school subjects, emphasis should be placed on the active participation of learners in the learning process. They are to have ample opportunity to handle materials and manipulate simple equipment. This participation is likely to enhance reflective thinking, creativity, and entrepreneurship in students. A learner must acquire and internalize more process skills in a learning situation when he is allowed to perform activities ranging from manipulation of apparatus, classification of objects, and hypothesizing to drawing inferences from results. As documented the National Policy on Education (2013), suggested that each secondary school student is expected to study and acquire skills in at least a science subject (out of biology, chemistry, physics, or Health Science).

Biology is one of the most registered science subjects during the Senior Secondary Certificate Examination in Cross River State. However, evidence abounds that students are not performing well enough in Biology at SSCE (Nweke 2015) and consistently students achieve

poorly in secondary school science subjects. Similarly, statistics from the West African Examination Council (WAEC) (2013, 2014, and 2015) and the National Examinations Council (NECO, June/July 2013, 2014, and 2015) on students' performances in the sciences (biology) converge on the fact that students record very poor performance in the Senior Secondary School Certificate Examination.

This trend poses a lot of concern which ought to be addressed if Nigeria and indeed African continent is to grow appreciably in the area of science and technology. According to Nweke (2015) not much has been done to provide specific instructional and assessment programs to facilitate the development of science process skills both at the primary and secondary school levels and by the central examining bodies like WAEC.

Assessment of possession of knowledge of science process skills has so far been intrinsic to other facts contained in science subject domains. Generally, senior secondary school certificate examination (SSCE) candidates show weakness in questions involving the application of acquired science process skills. Observations by several researchers (Okonkwo, 2009; Omiko, 2014 and Nweke, 2015) show similar trends in the primary school basic science and technology and basic science at the junior secondary school (JSS) level. In addition, Nweke (2015) opined that poor performance in practical work is synonymous with poor performance in science process skills. Consequently, it is important to investigate whether the knowledge of scientific process skills acquisition aids students' academic performance in biology; hence, this need inspired the present study.

Statement of the problem

The study of biology is important in all aspects of life. In Nigeria, biology is one of the key science subjects in the senior secondary school curriculum. This underscores the recognition of the vital role it plays in the advancement of science and technology of any nation. Biology by nature supposed to be an interesting subject to students because of its wide application to daily living. Students' achievement in biology is expected to be high or above average, yet, the reverse is the case. Observations and reports have shown that success or high academic achievement in biology has become a Herculean task to accomplish by students in both internal and external exams. This low underachievement of students in biology has been of great concern to educationists, science educators, the government, stakeholders in the education sector, the public, and students themselves.

Knowledge of scientific process skills and the extent of their attainment has been a major challenge facing achievement in biology by senior secondary students. This could be due to low-level acquisition of the knowledge of scientific processes, among other factors. It is

against this background that this study was designed to investigate the extent to which knowledge of scientific process skills acquisition enhances students' achievement in biology in senior secondary school students.

Aim and objectives of the study

This study aimed to investigate the influence of knowledge of scientific process skills acquisition on the academic achievement of senior secondary school students in biology. In specific terms, the study sought to establish whether

1. The extent of knowledge acquisition of scientific process skills of observing and measuring predict the academic achievement of Students in Biology.
2. The extent of knowledge acquisition of scientific process skills of classifying and predicting influences the academic achievement of students in Biology.

Research questions

The following research questions were postulated to guide the study:

1. To what extent does the acquisition of scientific process skills of observing and measuring not predict the academic achievement of students in Biology?
2. To what extent does Knowledge acquisition of scientific process skills of classifying and predicting predict the academic achievement of Students in Biology?

Hypotheses

The following hypotheses guided the study.

1. The extent of Knowledge acquisition of scientific process skills of observing and measuring do not significantly predict academic achievement of students in Biology.
2. The extent of Knowledge acquisition of scientific process skills of classifying and predicting does not significantly predict the academic achievement of students in Biology.

Methodology

The study adopted an ex post facto design. The adoption of this research design was based on the fact that the variables under investigation had already taken place before the researchers undertook the study; hence they could not be manipulated. Furthermore, the research design was deemed appropriate because the inferences about relations among variables are made without direct intervention from concomitant variation of independent and dependent variables.

The population of the study consisted of senior secondary school two (SS2) students in Calabar municipality of Cross River State. A total of 2,191 SS2 students during the 2022/2023 academic year constituted the population. The population was chosen because the

students must have been familiar with the biology concepts and the knowledge of scientific process skills that were used in this study. The students are also considered to be mature enough to comprehend and respond appropriately to the items in the Biology achievement test (BAT) and knowledge of scientific process skills that were given to them. From the population, simple random sampling was used to select a total number of one hundred and fifty (150) Biology students from four out of the 16 secondary schools in the municipal.

Two instruments were validated by one research expert and biology education lecturer from Rivers State University and the instruments were used to gather data for the study. One of them was the Knowledge of Scientific Process Skill Achievements Test (KSPSAT). The scientific process skills Test module was adopted from McComas and Yager in Ochuema (2000) IOWA Assessment package for evaluation in five domains of science.

Three (3) Objective questions each with options ranging from A-D on 4 scientific process skills of observing, measuring, classifying, and predicting were set giving rise to 12 objective items. For scoring purposes, 2 points were awarded to each of the 12 objective test items. The second instrument was the Biology Achievement Test (BAT) which was designed to measure students' achievement in Biology. It consisted of thirty (30) multiple-choice items selected from various aspects of Biology within the scope and coverage of senior secondary two (SS2) students' syllabus.

The validated instruments were personally administered by the researchers with the assistance of four teachers in the study area one from each of the schools with the permission of their principals. This means that each teacher assisted in his/her school to administer the instrument to the students. The acquisition of the Scientific Process Skills Achievement Test was administered to the students for 40 minutes, while the Biology Achievement Test (BAT) was administered to the students for 1 hour. The administration was on two separate days and each instrument was collected at the expiration of the time allotted. There was no additional time. At the end of the data collection exercise, 144 out of 150 students were validly completed and used in the analysis.

Procedure for data analysis

Multiple Linear Regression Analysis was employed in analyzing the data collected

1. Hypothesis 1

The extent of Knowledge acquisition of scientific process skills of observing and measuring do not significantly predict academic achievement of students in Biology.

Independent Variables: Knowledge acquisition of scientific process skills of observing (ASPSO) and measuring (KASPSM).

Dependent variable: Academic achievement in Biology (AAB)

Statistical model: $AAB = \beta 0 + \beta_1 ASPSO + \beta_2 KASPSM + e$

2. Hypothesis 2

The extent of Knowledge acquisition of scientific process skills of classifying and predicting does not significantly predict the academic achievement of students in Biology.

Independent variables: Knowledge acquisition of scientific process skills of classifying (KASPSC) and predicting (KASPSP).

Dependent variable: Academic achievement in Biology (AAB).

Statistical model: $AAB = \beta 0 + \beta_1 KASPSC + \beta_2 KASPSP + e$

Results and Discussion

Descriptive Statistics of Study Variables

The descriptive statistics – mean, standard deviation, standard error, minimum, and maximum – were computed, using SPSS version 23.0 for the five study variables; observation, classifying, measuring, predicting skills, and biology achievement. The results are given in Table 3.

Table 3: Descriptive Statistics of Science Process skills variables and biology achievement

Variable name	Mean	Std dev	Std error	Expected mean	Minimum	Maximum
Observation	1.819	.944	079	2.000	000	6.000
Classifying	1.014	1.228	102	2.000	.000	6.000
Measuring	2.153	1.674	139	2.000	000	6.000
Predicting	1.347	1.355	113	2.000	.000	6.000
Biology achievement	18.521	6.010	501	20.000	6.000	6.000

The results in Table 3 show that knowledge of scientific process skills was highest in measuring ($\bar{x}$ = 2.153), followed by observation ($\bar{x}$ = 1.819), and least was classifying ($\bar{x}$ = 1.014) only the mean knowledge of measuring ($\bar{x}$ = 2.153) was above the expected (μ = 2.000).

Inter-variable relationships

The Pearson Product moment correlation coefficient was computed for all possible pairs of the study variables. The resulting correlation matrix is given in Table 4

Table 4: Inter-variable Pearson Product moment correlation coefficients

Name of variable	Observation Skill	Classifying Skill	Measuring Skill	Predicting Skill	Biology achievement
Observation	1**	.135	.053	.192*	.115
Classifying	.107	1	-.049	-.037	-.004
Measuring	.528	.563	1	.217*	-.018
Predicting	.021	.664	.009	1	.099
Biology achievement	.169	.964	.833	.239	1

* Significant at .05 level. P < .05

** Values above the main diagonal are correlation coefficients and below are corresponding P-values

From Table 4, observation and predicting skills correlate positively (r = .115 & .099) with biology achievement while classifying and measuring skills correlate negatively (r = -.004 & -.018) with biology achievement. The correlations between predicting and observation (r = .192) and measuring (r = .217) were positive and significant (p < .05). All other correlations were not significant. A positive correlation means that as one variable increases, the other also increases while a negative correlation means that increases in one are associated with decreases in the other.

Test of hypotheses:

All decisions were taken at a .05 level of significance such that the null hypothesis was rejected if the p-value associated with the computed test statistic was less than .05 and accepted if otherwise.

Hypothesis one

Knowledge acquisition of scientific process skills of observing and measuring do not significantly predict academic achievement of students in Biology.

Table 5: Regression of students' biology achievement on acquisition of observing and measuring skills

R-value = .118 adj. R-squared =.000			R-squared = .014 std. error = 6.011		
Source of variation	Sum of squares	Df	Mean square	F-value	P-value
Regression Residual Total	71.670 5094.268 5165.938	2 141 143	35.835 36.130	.992	.373
Predictor variable	Unstandardized coefficient		Standardized coefficient	t-value	P-value
	B	Std. error			

Constant	17.354	1.243		13.959*	.000
Observing	.743	.533	.117	1.392	.166
Measuring	-.086	.301	-.024	-.285	.776

*Significant at .05 level P < .05

The results in Table 5 indicate an R-value of .118 and an R-squared value of .014. This means that about 1.4% of the total variation in biology achievement is accounted for by the variation in the two independent variables. The P-value (.373) associated with the computed F-value (.992) was greater than .05, so the null hypothesis was accepted. This means that the acquisition of scientific process skills of observing and measuring do not significantly predict on academic achievement of students in biology, with only the regression constant (17.35) making a significant relative contribution to the model. (t = 13.959, P = .000 < .05).

Hypothesis two

Knowledge acquisition of scientific process skills of classifying and predicting does not significantly predict the academic achievement of students in Biology.

Table 6: Regression of students' biology achievement on the acquisition of scientific process skills of classifying and predicting

R-value = .099			R-squared = .000		
adj. R-squared =.010			std. error = 6.023		
Source of variation	Sum of squares	Df	Mean square	F-value	P-value
Regression	50.318	2	25.159	.693	.502
Residual	5115.619	141	36.281		
Total	5165.938	143			
Predictor variable	Unstandardized coefficient		Standardized coefficient	t-value	P-value
	B	Std. error			
Constant	17.932	.831		21.590*	.000
Classifying	-.001	.410	.000	-.003	.998
Predicting	.438	.372	.099	1.177	.241

*Significant at .05 level P < .05

The results in Table 6 show an R-value of .099 and an R-squared value of .010. This means that about 1.0% of the total variation in students' biology achievement was explained by the collective variation in the acquisition of scientific process skills of classifying and predicting. The P-value (.502) associated with the computed F-value (.693) is greater than .05, so the null hypothesis was accepted. This means that knowledge of scientific process skills of classifying and predicting does not significantly predict students' academic achievement in

biology. Only the regression constant (17.932) made a significant relative contribution to the influence model ($t = 21.570$, $P = .000 < .05$).

Discussion of findings

Knowledge acquisition of observing, and measuring skills on academic achievement of students in Biology

Results of the first hypothesis showed that knowledge of scientific process skills of observing and measuring do not significantly predict on academic achievement of students in biology. The results of the present study finding agree with the findings of a study by Akinyemi and Folashade (2010) when they showed that students performed below expectations despite the knowledge of observing and communicating. The finding of this study is also supported by the finding of Devi and Raj (2014) who reported no significant relationship despite a positive correlation between scientific process skills and students' academic achievement. This means that there is no significant effect of scientific process skills and students' academic achievement in science.

Acquisition of classifying, and predicting skills on students' academic achievement in Biology

Results of the second hypothesis showed that the acquisition of scientific process skills of classifying and predicting does not significantly predict students' academic achievement in biology. This finding is contrary to the findings of Devi and Raj (2013) which showed a significant effect of acquiring classifying skills on students' academic achievement in sciences and biology to be specific. The finding is also contrary to the finding of Malongo (2015) which also reported a significant effect of mastery of scientific process skills on students' academic achievement in practical biology at the external and internal examinations.

Conclusion

Based on the analyses and results obtained from the data used in this study, the researchers concluded that there was no significant prediction of the acquisition of scientific process skills on the academic achievement of students in biology. This means that though the students who showed the acquisition of these scientific process skills achieved higher in biology (sciences) than those who showed no evidence of scientific process skills, the improvement in achievement was insignificant. Consequently, the researchers concluded that students' active engagement in biology learning and handling of biology equipment during

practicals would enhance achievement in biology.

Recommendations

Based on the above findings and conclusions, the following recommendations are made:

1. The state ministry of education should equip the schools with biology teaching aids and employ only experienced teachers who can use the aids to expose students to scientific process skills of observation, measuring, classifying, and predicting.
2. Biology teachers should design and use scientific process competitions to help their students acquire skills in observation, measuring, classifying, and predicting which can aid their academic achievement.

References

AAAS, (2001). American Association for the Advancement of Science, Project 2001: *Science for all Americans.* Washington D.C.

Agboola, S. & Oloyede, E. (2007). Effects of project, inquiry, and lecture-demonstration Teaching methods on senior secondary schools achievement in the separation of mixtures of the fractional test. *Educational Research and Review, 2*(6), 124-132.Available online at http://www.academicjournal.org/ERRISSN1990-3839(C) Acadenuchiyrbaks.

Ajewole, G.A. (2010). Curriculum development in science technology and mathematics education in secondary schools, global challenges, and possible remedies. 49th *Annual conference proceedings of the Science Teachers Association of Nigeria (*STAN), 18-20.

Akinyemi, O.A. & Folashade, A. (2010). Analysis of science process skills in West African senior school physics practical examinations in Nigeria. *American-Eurasian Journal of Scientific Research* 5 (4), 234-240.

Ango, M. L. (2002). Mastery of science process skill of science and their effective use in the teaching of science: An educology of Science Education in Nigeria context. *International Journal of Educology.* 16(1), 86.

Ango, M. I. (1992). Needed science process skills as a foundation for effective technology education for national development. *The Nigeria Association of Teachers Technology.* 1, 92-108.

Hurd, L. (1997). The total science safety system. *Science Education Literacy Bulletin, 28,* 2-9.

Kazeni, M. M. (2005). Development and validation of a test of integrated science process skills for further education and training of learners. Unpublished M.Ed Dissertation. Faculty of Natural and Agricultural Sciences. University of Pretoria, South Africa.

Keil, C., Hanney, J. & Zoffel, J. (2009). Improvements in students' achievement and science process skills using environment health science problem-based learning curricula. Bowhag Green State University. *Electronic Journal of Science Education*. 13(1), 1-7.

Malongo, D.V. (2015). Impact of school-based practical assessment of learner's achievement in biology in secondary schools in Kakamega country, Kenya. Unpublished M.Ed thesis in Measurement and Evaluation and Mathematics.

National Policy on Education (2013)

National Examination Council (NECO, 2013)

National Examination Council (NECO, 2014)

National Examination Council (NECO, 2015)

Nweke, V.O. (2015). Levels of possession of science process skills by final year students of Federal College of Education, Eha-Amufu Enugu. Unpublished N.C.E Project. Ebonyi State University.

Nwosu, A. (1994). Level of acquisition of science process skills among Year one Senior Secondary School Students. *Journal of Science Teachers Association of Nigeria.* 29, 47-53

Nwosu, A. A. (2003) Constructivism as an innovative model for science teaching: Importance and extent of use in secondary schools. *Journal of the Science Teachers Association of Nigeria* (STAN), 38(1&2), 78-87

Okeke, .A. C. (2007). Effects of laboratory and lecture methods on students in Biology. *African Journal of Education,* 5(2), 247-260.

Okonkwo, G. G. (2009). Level of acquisition of science process skills by final year Nigerian Certificate in Education (NCE) Science students in Eastern Nigeria. Unpublished Ph.D thesis, University of Nigerian, Nsukka Department of Science education.

Omiko, A. (2014). Levels of possession of science process skills by final year students of Colleges of Education in the South-Eastern States of Nigeria. *Journal of Education and Practice.* 6(27), 2015

Raj, R.G., & Devi, S. N. (2014). Science process skills and achievement in science among high school students. *Scholarly Research Journal for Interdisciplinary Studies* 2(15), 2435-2443.

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2003)

West African Examination Council (2012) Chief Examiners Report Lagos.

West African Examination Council (2013) Chief Examiners Report Lagos

West African Examination Council (2014). Chief Examiners report Lagos.

West African Examination Council (2015). Chief examiner's report Lagos.