

EFFECTS OF PROJECT-BASED LEARNING STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' PRACTICAL ABILITY IN BIOLOGY IN OYO STATE NIGERIA

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Abstract

The research concerns itself with the effects of Project based strategy on senior secondary school students' practical skills in Biology in Oyo state Nigeria. The moderating effects of mental ability and learning style were also examined. The study adopted a pretest, posttest, control group, quasi-experimental research design. Seven instruments were constructed and it includes: The following research instruments were used for the study Biology Practical Skills Rating Scale (BPSRS), Student Mental Ability Test (SMAT), Student Learning Styles Questionnaire (SLSQ), Teachers' Instructional Guide on Project based Strategy (TIGSRS), Teachers' Instructional Guide on the Conventional Strategy (TIGCS), Evaluation Sheet for Assessing Teachers' Performance on Self-regulatory Strategy on pollination and reproduction in plants (ESATPSRS), and Conventional Strategy on pollination and reproduction in plants (ESATPCS). Three null hypotheses were tested at 0.05 alpha level. Data was analysed using ANCOVA. There was a significant main effect of treatment Project based strategy on students' practical skills in biology ($F_{(1,278)} = 7.95$; $P < 0.05$, Partial $N^2 = 0.05$). It was recommended that Curriculum planners and developers in science courses for secondary school should emphasize on the need to continuously use innovative strategy such as Project based Strategy to enhance science based instruction.

Keywords: Project based Strategy, Conventional strategy, Student Mental Ability, learning style and students' practical skills in biology

Introduction

Biology incorporates physical and social sciences. Through it, students can be helped to understand the natural communities of plants and animals which, during the centuries, have shaped his own region for its present human utility. Students can moreover be made aware of the impact of man upon these natural communities, and the resultant change. They will come to realize how the changes produced by man have affected other aspects of life such as his social and economic life. It helps to understand that man faces the task of building a new type of living community if he is to survive. In this community, while man remains the dominant organism, he must be able to make a place for many kinds of plants and animals to function in their proper relationships

The learning of Biology provides an individual with useful information in solving everyday life challenges. Studies have shown that the knowledge of Biology contributes towards the socio-economic development of a country (Ogundiwin, 2013). The goals of teaching Biology as documented by the National Policy on Education (NERDC, 2013) are highlighted as follows:

- (i) Acquisition of manipulative skills to enable students carry out experiments and projects in Biology.
- (ii) Acquisition of scientific skills and processes such as observation, classification, and interpretation among others.
- (iii) Acquisition of scientific attitudes for problem solving such as curiosity, scepticism, open mindedness, and objectivity among others.
- (iv) Ability to apply biological principles in everyday life.
- (v) Provision of foundation for future professions such as Medicine, Nursing, Botany, Zoology, and Agriculture among others Awareness of nature of things around them (NERDC, 2013).

The national policy on Education in the National curriculum for Senior Secondary Schools volume 3 science stated specific objectives to be achieved by each subject curriculum. The cardinal objectives for Biology include:

- (i) Adequate laboratory and field skills in Biology
- (ii) Meaningful and relevant knowledge in Biology
- (iii) Ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture; and
- (iv) Reasonable and functional scientific attitudes.

However, practical skills are an essential part of Biology education. It gives students the necessary skills for higher education and employment, deepens their knowledge of scientific ideas and enables them to engage in the processes of biology. Practical skills are formative as it helps the students to understand science and how the scientific ideas are developed (Watts, 2013). To achieve the goals of biology education, it is imperative that an attempt is made to balance emphasis on both theory and experiments. Experiments in biology illustrate the fact that biology is not a theoretical abstraction as it describes the real world around us. Authors and researchers have identified some factors that are responsible for poor performance in Biology and other related sciences. These factors may cut across all levels of education where Biology is offered. The identified factors include; textbook and laboratory based reasons (Ivowi, 2000), misconceptions of concepts identified (Olagunju & Abiona, 2004; D'Avanzo, 2008), large class size (Olagunju, 2005), and insufficient practical skills (Danmole, 2012).

Project-based Learning Strategy is a student-centered approach to teaching and learning process (Condliffe *et al.*, 2016). Project-Based Learning Strategy is a method in which students gain knowledge and skills by working to investigate and respond to an engaging question, or problem (Buck Institute, 2015). Project-based learning Strategy is an authentic learning strategy in which students plan, implement, and evaluate projects that have real-world applications beyond the classroom (Westwood et al., 2008). Students drive their own learning through inquiry, as well as work collaboratively to research and create projects that reflect their knowledge. Project-based learning strategy advocates believe that it can motivate students who might otherwise find school boring or meaningless, Project-Based learning promises a shift in the culture of learning in a school (Buck Institute for Education, 2011). Other defining features of Project-Based learning found in the literature include authentic content, authentic assessment, teacher facilitation, explicit educational goals, cooperative learning, reflection, and incorporation of skills (Bullard & Bullock, 2006).

Mental ability is defined as students' ability to handle quantitative information (Ogunwuyi, 2009). Onabanjo (2007) found a very high relationship with students' mental ability and performance in science related courses. Aina (2006) reported a causal linkage between mental ability and achievement in senior secondary physics. Mental ability has also been found to influence learning of students in science (Olagunju & Chukwuka, 2008; Raimi, 2003). Olatoye and Aderogba (2011) determined the role of students' verbal and numerical abilities on performance of senior secondary school science students in aptitude tests. Two hundred senior secondary school science students participated in the study using three validated research instruments to collect data and regression analysis tool for data analysis. Findings revealed an existence of strong correlation between students' mental ability and overall students' performance.

Learning style is another variable that may affect students' learning outcomes in school subjects. It is known that learning process varies among learners due to the presence of biological and psychological differences (Locke, 2008). Learning styles refers to the concept that individuals differ in regard to what mode of instruction or study is most effective for them (Pashler, McDaniel, and Rohrer, 2009). Connerr (2008) stated that we each have a unique and individual style of learning, thinking and communicating, it's desirable that we interact differently with information. Society needs all kinds of thinkers, with each expressing different mental strengths. Proponents of learning-style assessment contend that optimal instruction requires diagnosing students' learning style and tailoring instruction accordingly. Learner's experience of learning is not the same. One learner might describe the learning experience in biology as the retention of knowledge by dint of memorisation and repetition, while another might describe it as interpreting meanings and trying to understand reality. The style of learning and the motive for learning rests within the learner and in most cases relates to past experiences. Students learn best by seeing the value and importance of the information presented in the classroom. If the students are not interested in the material presented, they will not learn it. In order to achieve the ultimate goal of student learning it is important to use a combination of teaching methods and to make the classroom environment as stimulating and interactive as possible.

Given the conflicting result on the influence of learning style on learning outcomes, there is therefore need to carry out more research to affirm the conflicting claims. Again, most of previous studies made use of learning style as independent variable but in this study it was used as moderator variable. In an attempt to enhance Biology students' learning outcomes and their mental ability and learning style, this study therefore determined the effects of Collaborative Project-Based learning and Self-regulatory Strategies on of senior secondary school students' Practical skills in Biology in Oyo State Nigeria.

Statement of the Problem

Empirical literature has documented a strong link between these variables and students' students' Practical skills in mathematics, English language, economics, and agricultural science to mention a few, but none in biology. Thus, there is need for further studies to establish the appropriate instructional strategies for both high and low mental ability levels of students with different Learning styles in Biology. The past studies on the use of Project-Based learning and Self-regulatory strategy did not focus on the moderating effects of mental ability and learning styles on senior secondary schools students. The two strategies have been used separately and in different subjects. None of the researchers investigated the combined effects of the two

strategies on biology. Here are the gaps which this study filled. The presents study therefore adopted Project-Based learning strategy taking into consideration the students' mental ability and learning style and their effects on students' Practical skills in Biology in Oyo state.

Hypotheses

This study tested the following hypotheses at $p < .05$ level of significance:

Ho₁: There is no significant main effect of treatment on students' Practical skills in Biology

Ho₂: There is no significant main effect of mental ability on student Practical skills in Biology

Ho₃: There is no significant main effect of learning style on students Practical skills in Biology

Methodology

The study adopted the pretest-posttest control group quasi experimental design

Sample Selection and Sampling Techniques

Two Local Government Areas were randomly selected from the eleven local government areas within Ibadan, Oyo state. Two schools were purposively selected from each local government Area understudy, two schools each for the experimental group and two schools for the control group. Intact classes were used for this study in which all students were purposively selected because this study adopts a pretest-posttest control group quasi-experimental design. A total of four purposively selected schools in which three hundred and two students and four teachers were used for the study. The criteria for the selection of the schools are as follows:-

- (i) Evidence of the school having good and standardized Biology laboratory
- (ii) Presence of qualified Biology teachers
- (iii) Evidence of having Biology textbooks
- (iv) Readiness of teaching staff of the school and students to participate in the study
- (v) The school being a co-educational school

Research Instruments

The following research instruments were used for the study

- (i) Biology Practical Skills Rating Scale (BPSRS)
- (ii) Student Mental Ability Test (SMAT)
- (iii) Student Learning Styles Questionnaire (SLSQ)
- (iv) Teachers' Instructional Guide
- (v) Teachers' Instructional Guide on Project-Based learning Strategy (TIGPBLS).
- (vi) Teachers' Instructional Guide on the Conventional Strategy (TIGCS).
- (vii) Evaluation Sheet for Assessing Teachers' Performance on
- (viii) Project-Based learning Strategy on pollination and reproduction in plants (ESATPPBLS).
- (ix) Conventional Strategy on pollination and reproduction in plants (ESATPCS)

Biology Practical Skills Rating Scale (BPSRS)

The instrument was adopted from Awolere (2015) by the researcher to investigate students' practical task based on direct observation during their laboratory activities. The biology practical skills rating scale (BPSRS) was used to determine students' ability to manipulate, observe, record, label, classify and draw in practical class.

Section A- consists of the personal data of the respondents in terms of gender, location of the school and name of respondent.

Section B- was a six - point continuum that ranged from zero (0) for total inability to exhibit the skills (Very Poor), to five (5) at the extreme for full exhibition of the skills (Excellent).

Scoring of Biology Practical Skills Rating Scale

The maximum score a student can obtain is 30%. Students who score:

0 -5% = **0** (Very Poor)

6% -10% = **1** (Poor)

11% - 15% = **2** (Average)

16% - 20% = **3** (Good)

21% - 25% = **4** (Very Good)

26% - 30% = **5** (Excellent)

The face validity of SBPRS was done by showing the items to three science educators with bias in Biology to determine its suitability in term of clarity of ideas, language of presentation, class levels, coverage, relevance, and adaptation to the study. Out of the 6 items with sub-sections, only 4 items survive scrutiny, the instrument had been trial tested on 45 students in separate school and the scores were analysed for their reliability. A reliability coefficient of 0.812 was obtained using Cronbach alpha measure. Therefore the instrument was considered suitable to be used for the study.

Students Mental Ability Test (SMAT)

The instrument was adopted from OTIS-LENON (1967) mental ability test used by Aina (2006). The instrument was a 40-item multiple choice with 4 options. This instrument will measure the mental ability of the learners.

Scoring of SMAT

The maximum score a student can obtain is 100%. Students who score 50% and above will be grouped into high mental group; while students who obtain less than 49% and below will be placed in low mental ability group.

The face validity of student mental ability test (SMAT) was done by showing the items to three science educators with bias in Biology to determine its suitability in term of clarity of ideas, language of presentation, class levels, coverage, relevance, and adaptation to the study. Out of the 50 items, only 40 survive scrutiny, the instrument had been trial tested on 45 students in separate school and the scores were analysed using Kuder-Richardson formula 20 (KR 20) for their reliability. A reliability coefficient of 0.821 was obtained.

Student Learning Style Questionnaire (SLSQ)

The Student Learning Style Questionnaire was the 40 items students scale adopted from O'Brien (1985) to measure the learning styles of selected students. All choices correspond to the four sensory modalities which are measured by VARK (visual, aural/auditory, read/write, and kinesthetic).

Ten out of the 50 items that were not relevant to biology were discarded, hence the student Learning Style Questionnaire contained 40 items. There were two sections; section A sought for demographic data of students, while section B consisted of 40 items which students responded to by expressing their level of agreement.

Scoring of SLSI

The maximum score a student can obtain is 30%. The modality type with the highest score indicates your preferred learning style. The higher the score, the stronger the preference. If

you have relatively high scores in two or more sections, you probably have more than one strength. If the scores in the sections are roughly equal, you probably do not have a preferred learning style; you are a multi-sensory learner.

The Questionnaire was presented to experts in science and mathematics unit and finally the researcher's supervisor to determine the suitability for the target population in terms of clarity of ideas, breadth, language, relevance and application to the study. Out of 50 items, only 40 items survived scrutiny and was trial tested by administering it to thirty students from intact class of co-educational senior secondary school II different from the selected school of the main study. The reliability of the instrument was determined by using Cronbach coefficient which was found to be 0.89

Teachers' Instructional Guides

Teachers' Instructional Guide on the use of Project-Based Learning Strategy (TIGPBL)

This is an instructional guide for the teacher participating in the experimental group. It contains the steps involved in presenting the course to the students in Project-based learning strategy (TIGPBL). It was used in the training of teachers to allow uniformity in the teaching strategy, will last for the period of eight weeks.

Teacher instructional guide on Project-Based Learning Strategy

STEP 1:

The teacher arranges the students in groups at the beginning to facilitate learning.

The teacher determine the necessary approaches to learning for student success.

STEP 2:

The teacher points out the essential and non-essential parts of plants.

The teacher provides clear and concise instructions on the concept.

STEP 3:

Pace material according to students' ability.

Recognized and value diversity and encouraged all points on pollination in plants.

STEP 4: The students' curiosity and passion in learning are enhanced by asking questions. Promote discussion by using open ended questions.

STEP 5: The students engage in practical activities that will generate ideas, such as observation, recording drawing, labelling and classification.

STEP 6: The students unfold the content of pollination in flowering plants.

The students give insights, feedback and comments gained during the teaching.

The students evaluate the solution and make modification.

The students carry out a task to consolidate learning

TIGCPBLS was given to experienced Biology teachers in senior secondary school and University lecturers in Department of Science and Technology to examine its content and face validity. The recommendations given were used to reconstruct the guide and the inter-rater reliability was then estimated using Scott'. The inter-rater reliability index was determined as 0.83.

Teachers' Instructional Guide on Conventional Strategy (TIGCS)

This is an instructional guide for the research assistant participating in the classroom using modified conventional strategy. This was used in training of research assistant to allow

uniformity in the teaching strategy. Here, students sit individually throughout the lesson and the research assistant presents the lesson in the form of lecture.

STEP I: The research assistant introduces the lesson by asking questions based on prior knowledge

STEP II: The research assistant discusses the content of the lesson

STEP III: The students write down the board summaries in their notebooks

STEP IV: The research assistant solicits questions from the class and gives class work

STEP V: The research assistant marks students' work.

STEP VI: The research assistant evaluates by asking questions and giving home assignment.

The instrument was validated using the Scott's κ statistical measure. The reliability coefficient of 0.802 was obtained.

Evaluation Sheet for Assessing Teachers' Performance (ESATP)

This is the guidelines for evaluating performance of the trained research assistant on the effective use of these strategies: the instrument revealed their presentation of concepts, mastery of the topics, use of materials and directed activities, and how effective their presentation was for the mastery of the concepts by the students.

Project-Based learning Strategy (PBLs)

Conventional strategy (CS).

The instrument was trial tested to ensure its reliability. For the purpose of validation, expert's attention was drawn to ascertain the appropriateness of the concepts and methods. The observations and comments of these experts was taken into consideration.

Research Procedure

Data collection was conducted over a period of twelve (12) weeks as follows:

Training of Research Assistants

Two weeks was used to train the research assistants. The researcher explained the purpose and procedure for the study to them. The research assistant in the experimental groups were exposed to the use of the instructional strategy by the researcher after which they were allowed to use it in order to assess their competence. The objectives and content of each topic was given to each of them.

Administration of Pretest

After the training of the research assistants, the participants in each group were asked to allow students to fill the mental ability questionnaire and the learning style questionnaire in order to categorise them according to their mental ability and Learning style group. This was followed by the administration of: Biology Practical Skills Rating Scale (BPSRS)

Treatment Procedure

The participating teacher administered the treatments in both groups for a period of eight weeks. Steps followed in the Experimental Group as it is written in the Project-Based Learning Strategy Guides

Administration of Posttest

It was administered on the twelfth week. Senior Secondary II Biology students' in the six (6) selected schools for the Experimental and Conventional group was given posttest on all the

Evaluative Instruments. The posttest administered was the Biology Practical Skills Rating Scale (BPSRS)

Methods of Data Analysis

The quantitative data collected were analysed using inferential statistics of Analysis of Covariance (ANCOVA) to determine the significant main and interaction effects with the pretest scores as the covariates to test the hypotheses. ANCOVA was used to single out the initial group differences. The estimated marginal mean (EMM) of different groups was used to detect the magnitude and direction of differences. Bonferroni post hoc test was used where significant main effects were obtained.

Results

Ho₁: There is no significant main effect of treatment on students' practical skills in Biology

Table 2: Analysis of Covariance (ANCOVA) of Post-Practical skills by Treatment, Learning style and Mental ability

Source	Type III Sum of Squares	df	Mean square	F	Sig.	Partial Eta Squared
Corrected Model	2036.859	24	84.869	8.175	0.000	0.414
Intercept	3404.280	1	3404.280	327.922	0.000	0.541
Pre practical skills	908.337	1	908.337	87.497	0.000	0.239
Treatment	164.986	1	164.986	7.946	0.000*	0.054
Learning style	8.436	2	4.218	0.271	0.846	0.003
Mental ability	1.949	1	1.949	0.188	0.665	0.001
Error	2886.019	278	10.381			
Total	121292.000	303				
Corrected Total	4922.878	302				

R Squared = 0.41 (Adjusted R Squared = 0.36) *denotes significant $p < 0.05$

Table 2 shows that there is a significant main effect of treatment on students' practical skills in biology ($F_{(1,278)} = 7.95$; $P < 0.05$, Partial $\eta^2 = 0.05$). The effect is 5.0%. This implies that 5.0% variation in students, practical skills in biology was due to the significant main effect of treatment. Hence, hypothesis 1 was rejected. To determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups were carried out and the result is presented in Table 3.

Table 3: Estimated Marginal Means for Post-Practical Skills by Treatment and Control group

Treatment	Mean	Std. Error
Project based Strategy (PBS)	20.80	0.42
Conventional Strategy (CS)	17.88	0.59

Table 3 indicates the senior secondary school students taught with project based strategy (PBS) treatment group had higher adjusted post-practical skills mean score in biology (20.80) while the Conventional Strategy (CS) Control group (17.88) had the lower adjusted post-practical skills mean score in Biology. This order is represented as $PBS > CS$.

Ho₂: There is no significant main effect of learning style on students' practical skills in Biology
Table 2 indicates that there is no significant main effect of learning style on students' practical skills in Biology ($F_{(2,278)} = 0.27$, $P > 0.05$; Partial $\eta^2 = 0.00$). Thus, hypothesis 2 was not rejected. This means that learning style had no effect on senior secondary school students' practical skills in Biology.

Ho₃: There is no significant main effect of mental ability on students' practical skills in Biology
Table 2 shows that there is no significant main effect of mental ability on students' practical skills in Biology ($F_{(1,278)} = 0.19$, $P > 0.05$; Partial $\eta^2 = 0.00$). Thus, hypothesis 3 was not rejected. This means that mental ability had no effect on senior secondary school students' practical skills in Biology.

Discussion of Findings

The findings of the study revealed that there is a significant main effect of treatment on students' practical skills in Biology: students in Project based treatment group had the higher adjusted post-practical skills mean score in Biology while students in the control group had the lower adjusted post mean scores in Biology Practical Skill Rating Scale (BPSRS). Possible reason for this may be because of the active involvement of students in their learning process, which the basic assumption of constructivist is learning theory on Project based Strategy is based. Jegede *et al* (2013) advocated for practical focused approaches in the instruction of Biology.

Project based learning strategy as used in this study had the highest positive effect on students' practical skill. Students in the Project based learning group improved in their practical skills more than other groups most likely because they were more engaged in learning process by taking charge of their own learning. Biology practical is centred more on the psychomotor domain than cognitive domain of Bloom's taxonomy, therefore strategy that involves learners participation would help to improve mastery of such skills. It is not surprising therefore to see that Project based learning group had the highest adjusted post-test mean score. The result also lends credence to the claims of Sams (2010), Nguyen *et. al.* (2012), Jason (2012), Brame (2013) and Miles (2015). These researchers have established that whenever there is peer collaboration, students always enjoy support from each other which is not always available whenever the lesson is teacher dominated. So, when there is peer assistance and support in a practical lesson, mastery of skills are likely to be more than when it is teacher mediated. From the findings of this study, it may therefore be reasonable to conclude that Project based learning strategy particularly has the tendency to improve students mastery of practical skills.

Contribution to Knowledge

The study has contributed to knowledge in the following ways:

- (i) Project based Learning Strategy increase students' acquisition of critical knowledge, problem solving proficiency and participation skills during practical activities.
- (ii) The study has also established that the mental ability and learning style of students can't hinder their acquisition of practical skills.
- (iii) The study has brought about a paradigm shift in how biology is taught and assessed at the secondary school level in Nigeria.
- (iv) The study has revealed that teachers are positively disposed to using project based learning strategy and their views about practical activities indicates that practical activities fosters promotion of classroom interaction and skills development; encourages

active engagement of student; makes learning becomes fun and promotion of future interest in Biology.

Conclusion

The results of the study have shown the both Project-based learning Strategy are more effective in enhancing students' level of practical skill in Biology than the Conventional Strategy. When secondary school students are exposed to strategy where experience/explorations are hands on, mind on, structured and are guided by the teacher, it fosters the scientific knowledge and skills of students better than conventional strategy.

The Project-based learning Strategy produced better practical skill in Biology concepts than the conventional method. This means that the usual inability to cover the voluminous Biology topic/ contents in the stipulated time and the usual poor Biology practical skill resulting from insufficient practical resources which often lead to poor performance in Biology could be effectively tackled through the application of Project-based learning Strategy. The study also showed that learning carried out with students largely in charge of their learning can lead to greater practical skill of students in Biology.

Educational Implications of Findings

Project based Learning Strategy has been found positively affect the enhancement of student's practical skill in Biology. The finding in this study has therefore revealed the importance of using instructional strategy that are learner centered to increase the participation of learners during teaching and learning processes; resulting into a long-lasting effect on cognitive outcomes. The students who were taught Biology with Project based Learning Strategy experienced a more activity based teaching and learning where learner were active, as a result of the thinking tasks involved in the strategy. The study also revealed the need for Project based Learning Strategy to be incorporated into our educational system, as they are potent tools in enhancing practical skill of students in Biology.

Recommendations

Based on the findings of this study the following recommendation are made

- (i) The Government and other Stakeholders in Education should collaborate with bodies such as science teachers' association of Nigeria (STAN), Nigeria Union of Teachers (NUT) and so on to organize in –service training for biology and other subject teachers to acquire necessary and adequate knowledge need in the practice of instructional strategies such as project-based learning strategy.
- (ii) Curriculum planners and developers in science courses for secondary school should emphasize on the need to continuously use innovative strategy such as Project based Learning Strategy to enhance science based instruction.

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