Impact of Modified Laboratory Learning Environment on transformative Biology Process Skills among Secondary School Students in Osun State, Nigeria

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Abstract

This study examined the impact a modified laboratory learning environment (MLLE) has on the Biology process skills of secondary school students. It compared the process skills of high and low achievers when taught in a modified laboratory learning environment and also determined how MLLE can improve achievement of students and their retention ability in Biology. 274 senior secondary class one (SSI) students were randomly selected from six intact classes for the study. A pre-test post-test quasi experimental design was adopted for the study. The students were taught plant and animal nutrition for six weeks. An Observation Checklist/Rating Scale containing 22-item exercises was used to assess the students' process skills in an on-going manner during practical exercises. The instrument was adapted from the one used in the Faculty of Education, Obafemi Awolowo University, Ile-Ife, Nigeria for assessing student-teachers' teaching skills during teaching practice. It was found that the process skills of the students improved when they were taught under a modified laboratory learning environment. It was also found that the biology process skills of low achievers improved significantly and the students' retention was also significant. The study concluded that a modified biology laboratory environment is an effective way of improving students' biology process skills, achievement and retention.

1. Introduction

Biology is one of the core science subjects offered in Nigerian secondary schools and it is the most highly subscribed among the science subjects of the Nigerian senior secondary school curriculum by both schools and students. Majority of the students offer it at the Senior School Certificate Examinations (SSCE) because the knowledge of Biology is needed in the fields of medicine, nursing, pharmacy, agriculture, engineering and other related disciplines. It is a subject that requires the processes and skills of science, through laboratory experiences, to understand its theoretical concepts and application of such concepts in practical and similar situations in everyday life. Such practical experiences encourage critical thinking which can enhance innovation and productivity (manufacturing) that are highly needed in Africa as a developing continent.

Laboratory work is seen as an integral part of most science courses, including Biology. However, a significant proportion of laboratory activities remain highly prescriptive and fail to challenge secondary school students (Fisher, Harrison, Handerson, and Hofstein, 1998). The laboratory has been given a central and distinctive role in science education. Science educators have suggested that rich benefits in learning accrue from using laboratory activities (Hofstein and Lunetta, 2003). According to Hofstein, et al, (2003), science laboratory activities are learning experiences in which students interact with materials and/ or with models to observe and understand the natural world. This leads to metacognition which Gunstone and Champagne (1990) suggested is an elaboration and application of one's learning which can result in enhanced understanding. The challenge therefore is to help learners take control of their own learning in the search for understanding. In the process, it is vital to provide opportunities that encourage learners to ask questions, suggest hypotheses and design investigations. There is the need to provide students with frequent opportunities for feedback, reflection, and modification of ideas (Barron, et al., 1998). Research has not provided evidence that such opportunities exist in most schools in Nigeria.

The teaching and learning of Biology demands laboratory activities in an environment that is inspiring, encouraging and challenging to learners to enable them acquire and utilize the necessary science process skills in the subject. Such process skills which are either generic or integrated include observing, classifying, measuring, reporting, analyzing, communicating, using numbers and recognizing spatial relations. Others are inferring, predicting, defining operationally, hypothesizing, identifying and controlling variables, experimenting, interpreting data and using models. Science process skills are fundamental to science, allowing every category of learner to conduct investigations and reach conclusions. A good laboratory environment, according to Aladejana and Aderibigbe (2007), promotes curiosity in students, reward creativity, encourages the spirit of healthy questioning, avoids dogmatism and also promotes meaningful understanding. In line with the above, Metzenberg (2005) suggested that students need to develop necessary social and learning skills so that they can collaborate effectively, share, debate, defend their ideas and be able to work in groups. In this way they can interact and help one another to acquire process skills needed in learning especially the sciences like Biology.

Science process skills are learnt and acquired among learners in environments that encourage thinking and eagerness to work and find out new things. In schools where Biology is compulsory for students to offer as a core science subject, the class is made of different categories of learners like males and females, science-oriented and non-science-oriented and high and low achievers. Such a class demands that lessons should be conducted in an environment that can elicit from the learners the desire to work with materials, manipulate equipment and carry out experiments. However, all children who come to school can learn but some are slower at learning than others. In a normal heterogeneous class, students grouped as lowest in achievement in any subject constitute the slow learners and those highest in achievement constitute the fast learners in that subject (Ekpo, 1991). Inyang and Ekpeyong (2000) noted that one of the issues often debated in educational circles is that of grouping secondary school students by ability. Sometimes some teachers group their students according to their scores in a given test or examination by fixing a certain mark as the grading point above which are the high achievers and below which are the low achievers.

Low achievers in one subject may be high achievers in another. It is the duty of the teacher therefore, to make a lesson as interesting and as involving to the students as possible by creating a science learning environment. In Biology lessons, the teacher is expected to provide working materials and equipment for the students to work with. The students should be given adequate opportunity to work with the materials and equipment under the teacher's guidance. In this way some low achievers may become high achievers in subsequent tests or tasks from retained knowledge gained from active participation in the lessons. An encouraging learning environment can also build in the learners a free, critical, innovative and productive thinking which is vital to a developing continent like Africa.

2. Statement of the Problem

Researchers like Akubuilo, (2004) for example, have shown that when learners are actively involved in the process of learning, they are able to retain what they have learnt. Vygotsky's theory of scaffolding and its zone of proximal development emphasizes the role of active involvement in learning in relation to learner's environment. This implies that the environment in which learning is taking place should be well equipped, challenging but also encouraging for effective learning to take place. Despite different methods and strategies adopted by teachers to assist students in the process of learning Biology, poor performance of students in the subject is still recorded at the West African School Certificate Examinations (WAEC, 2011). Active involvement of learners could add an impetus to the much needed paradigm shift from a producing continent of raw materials for western factories to a manufacturing one of finished products. There is the need therefore to investigate other areas that might help to solve the problem of students' poor performance in Biology.

3. Purpose of the Study

In view of the above stated problem, the objectives of this study were to:

- (i) determine the effectiveness of a Modified Laboratory Learning Environment (MLLE) on students' process skills in Biology;
- (ii) compare the process skills of high and low achievers when taught under MLLE.
- (iii) assess the Biology achievement of high and low achievers when taught under MLLE.
- (iv) determine the effectiveness of MLLE in improving the retention ability of students in Biology.

4. Significance of the Study

The results of this study will add to improve how teachers can make their students learn in a scientific environment that will help students to think critically in order to find solutions to identified problems. It will also add to literature and form a basis for further studies on students' Biology process skills.

5. Hypotheses

The following hypotheses were generated from the objectives above:

(i) There is no significant difference between the science process skills performance of students taught under MLLE and those that were taught with teacher expository method.
(ii) There is no significant difference between the science process skills performance of high and low achievers when both were taught under MLLE.
(iii) There is no significant difference in the retention ability of students taught with MLLE and those that taught with teacher expository method.

6. Methodology

A quasi experimental design was used for this study. The target population consisted of all the secondary school Biology students in Osun State, Nigeria. The sample of 274 Senior Secondary School class one (SS1) students was drawn from six intact classes from six randomly selected secondary schools. One class in each school was randomly assigned into experimental group or as a control. Different schools were used for the experiment and control in order to check for interaction among students.

Before the teaching started, the researcher visited the schools to make arrangements and taught the assistant researchers (the schools' Biology teachers), how to use the MLLE instructional package. The teaching assistants taught a concept each to their colleagues using the MLLE instructional package. This enabled the researcher to give necessary corrections and suggestions, based on the assessment schedule (shown below) for the teaching assistants. Plant and animal nutrition were taught to the students for four weeks.

The laboratory learning environment was made accessible to the students as learning materials and equipment were provided. The students were allowed to use the materials and equipment freely and were encouraged to interact with one another and with the teacher. The students were free to ask for assistance and also ask questions during the lessons. The students designed and carried out experiments on the two topics of the research with the assistance of trained assistant researchers under the supervision of the researcher. The lesson plans were prepared to reflect the activities used to assess the students' process skills in an Observation Checklist/Rating Scale (OCRS) used for the study. The instruments used for data collection were the OCRS and Students' Biology Achievement Test (SBAT). The OCRS consisted of 22-item exercises reflecting five science process skills which are planning/organization, observation, analysis/synthesis, reporting and evaluation. The SBAT consisted of 25 multiple choice questions to test the theoretical knowledge gained by the students. The two instruments were used for the pre-test, post-test and retention test. Some of the activities in the OCRS were scored as the students were working in an on-going manner while the others were scored from their reporting. The Observation/Checklist recorded whether a particular activity was carried out or not while the activity was rated on a scale of 1-5 depending on the degree and quality of the exercise carried out by the student.

In order to categorise the students into high and low achievers, their scores in class work, tests and examinations for a term in five randomly selected subjects including Biology were added and the average was calculated. A mark of 50% was taken as the pass mark. Any student who had an average up to 50% and above was categorised as a high achiever and all those whose average was below 50% were low achievers. Data from the study were analyzed using the t-test analysis.

7. Assessment Schedule for Evaluating Teachers' Performance during Training Activities

Yes No

1. The teacher discusses the objectives of the lesson with the students.
2. Materials and equipment for each lesson can be identified and selected from among others supplied.
3. Arranges the equipment for each lesson accurately.
4. The teacher follows the procedure for each experiment systematically.
5. He discusses the observations of the experiments with other teachers and the researcher.
6. He allows other colleagues present to carry out the experiments.
7. Offers assistance where necessary.
8. Repeats explanation of procedure when necessary.
9. Leads colleagues to draw inferences from the results of the experiments.
10. Brainstorms with colleagues to lead them to a conclusion.

The table below shows the trend of performance of Biology students at SSCE, 2003-2010 (WAEC, 2011). There was a gradual increase in credit pass among the candidates through the years, but the increase was still below average.

Table 1: Trend of Performance in the West African Senior School Certificate

Examination May/June, 2003-2010

Year	Total entry	Total examined	Total Absent	Number and Percentage Obtaining Grade		
				CREDIT 1-6	PASS 7&8	FAIL 9
2003	1151283 %	1133461 98.45	17822 1.54	3095533 27.31	331350 29.23	338898 29.89
2004	1044091 %	1021831 97.86	22260 2.13	299638 29.32	329275 32.22	358127 35.04
2005	1084920 %	1063391 98.01	21529 1-98	377716 35.51	315808 29.70	343739 32.32
2006	1172949 %	1147757 97.85	25192 2.14	567339 49.43	296653 25.84	265656 23.14
2007	1267568 %	1243451 98.09	24117 1.90	416107 33.46	399546 32.13	404948 32.56
2008	1360615 %	1332737 97.95	27878 2.04	457267 33.86	347074 26.04	506089 37.97
2009	1364655 %	1340206 98.21	24449 1.79	383112 28.59	413014 30.82	471312 35.17
2010	1325408 %	1300418 98.11	24990 1.89	645633 49.65	318486 24.49	297228 22.86

Source: West African Examination Council, 2011

8. Results

The results and findings of the study based on the generated hypotheses are as presented below.

Table 2: A t-test Analysis of the Pre-test Scores of MLLA and Control Groups on SBAT

Group	N	$\bar{X}$	SD	t	p
MLLE	`136	31.93	7.56	0.198	0.843
Control	138	31.76	6.9		

df = 272, p = 0.05

Table 2 shows the mean scores of MLLA and the control group students, the standard deviation and the t-test value: t = 0.198; p > 0.05. Since the means of the scores of the two groups are similar and the calculated p-value is greater than the critical value, it means that the two groups had no significant difference in their background knowledge of the topics covered in the study before the treatment.

Table 3: A t-test Analysis of the Pre-test Scores of MLLA and Control Groups on the Observation Checklist/Rating Scale Exercises

Group	N	$\bar{X}$	SD	t	p
MLLE	`136	30.46	6.76	0.188	0.745
Control	138	29.48	7.10		

p = 0.05

Table 3 shows the mean scores of the MLLA students and those in the control group, the standard deviation and the t-test value: t =0.188; p > 0.05. The mean scores indicate no significant difference. The calculated p – value is greater than the critical value which indicated that the background knowledge in Biology process skills of the students in the two groups was relatively the same before the treatment using the exercises in the Checklist/rating scale.

9. Hypotheses Testing

Hypothesis One: There is no significant difference between the science process skills performance of students taught under MLLE and those taught with teacher expository method (Control).

In testing this hypothesis, the raw scores of the post-test of two groups in the exercises carried out by the students as contained in the OCRS were compared and subjected to a t-test analysis as presented in Table 4 below.

Table 4: A t-test Analysis of Post-test Science Process Skills Scores of the MLLE and Control Group

Group	N	$\bar{X}$	SD	t	df	p
MLLE	136	79.78	12.36	14.57	272	0.01
Control	138	36.96	13.54			

P = 0.05

The mean score of the control group was less than that of the MLLE group as indicated in Table 4 above. Since the calculated p-value is less than the critical value, $p < 0.05$, it means the MLLE students performed better in the use of Biology process skills than the control group students. Therefore the null hypothesis which states that there is no significant difference in the science process skills used in Biology by students taught with MLLA and those in the control group was rejected.

Hypothesis Two: There is no significant difference between the science process skills performance of high and low achievers when both were taught with MLLE.

In order to categorize the students into high and low achievers, their raw scores in the SBAT pre-test were compared with their scores in other subjects. Their scores in five randomly selected subjects including Biology in the previous term were added and the average was calculated. Those students who scored the average of 50% and above were rated as high achievers while those whose average was below 50% were rated as low achievers. In testing this hypothesis, the post-test scores of both high and low achievers in the OCRS were compared and subjected to a t-test analysis. The results are as presented in Table 5 below.

Table 5: A t-test Analysis of Post-test Scores of Process Skills Performance of High and Low Achievers Taught with MLLE

Group	N	$\bar{X}$	SD	t	df	p
High Achievers	83	73.43	12.64	0.407	134	0.85
Low Achievers	53	70.32	12.00			

P = 0.05

The mean scores and the calculated p – value in Table 5 show that high achievers do not differ significantly from the low achievers in the use of science process skills in Biology practical sessions when they were taught with MLLE ($t = 0.407$; $p > 0.05$). Therefore the null hypothesis which states that there is no significant difference in the science process skills used in Biology by practical exercises by high and low achievers when taught with MLLE, was not rejected.

Hypothesis 3: There is no significant difference in the retention ability of students taught with MLLE and those in the control group.

In order to test this hypothesis, the students were tested after two weeks of the post-test using the same questions in SBAT and OCRS. The results are as shown below.

Table 6: A t-test Analysis of MLLE and Control Groups' Retention Scores on SBAT

Group	N	$\bar{X}$	SD	t	p
MLLE	136	66.01	10.98	20.61	0.02
Control	138	40.27	12.23		

p = 0.05

Table 6 above shows a significant difference between the retention ability of the MLLA and the control groups: t = 20.61, p < 0.05.

Table 7: A t-test Analysis of MLLE and Control Groups' Retention Scores on the OCRS

Group	N	$\bar{X}$	SD	t	p
MLLE	136	67.06	11.09	20.61	0.01
Control	138	46.38	12.68		

P = 0.05

Tables 6 and 7 show a significant difference in the retention ability of the students taught with MLLE when they were tested with the SBAT and OCRS activities. For SBAT, t=20.61; p < 0.05 and OCRS, t =20.61; p < 0.05. The calculated t – value in both test show that MLLE aided retention among Biology students. Therefore hypothesis 3 is rejected.

10. Discussion

The study investigated the impact of a modified laboratory learning environment on the science process skills of high and low achievers in Biology among secondary school students in Osun State, Nigeria. It also determined the effectiveness of MLLE on students' Biology process skills, compared process skills and assessed the Biology achievement of high and low achievers when taught under MLLE. The study also determined the effectiveness of MLLE in improving the retention ability of Biology students.

The results have shown that a modified laboratory learning environment has a significant positive impact on students' use of science process skills. The results also showed that the process skills of low achievers improved significantly when they were taught in a modified laboratory environment. This improvement in students' process skills might have been brought about by the opportunity the low achievers had in interacting with one another and with the learning environment. Hence Ehindero (1994) suggested that curriculum content should provide opportunities for learners to be aware of, understand, interact with and modify the environment if necessary and utilize it for development. Such content allows learners to, among other things develop both survival and vocational skills instrumental in answering questions of survival. In other words, such education becomes functional as is desired in Nigeria specifically and in Africa in general (Ehindero, 2007).

One accidental finding in the study was the confidence that was exhibited by the low learners in asking questions, handling of equipment, discussion and in expressing themselves. It was also shown that students' retention ability was high when they were taught under a modified laboratory learning environment. This is because, as established by Bajah (2000), children who are properly introduced to science through process skills find the skills useful throughout life and while it is possible to easily forget science content learnt, process skills tend to remain with many individuals for a relatively longer period.

11. Conclusion and Recommendations

From the results of the study, one can conclude that a modified laboratory learning environment can improve the science process skills, achievement and retention of students in Biology. The results also showed that students can improve their self confidence by studying in a modified laboratory learning environment.

In view of the results obtained in this study, the following recommendations are made:

1. The laboratory learning environment of students studying Biology should be made to be challenging but encouraging to the students by providing necessary learning materials and equipment.
2. The students should be involved in the teaching/learning process by encouraging them to source for those learning materials which they can easily get from their home or school environment.
3. Teachers should prepare their lesson plans to contain learning activities for the students.
4. The students should be encouraged to discuss their experiments and with the teacher's guidance design and carry out simple experiments to solve problems identified by them.

References

Akubuilo, D. U. (2004). The effects of problem solving instructional strategies on students' achievement and retention in Biology with respect to location in Enugu State. *Journal of the Science Teachers Association of Nigeria. 30 (1&2), 94-100.*

Aladejana, F. O. and Aderibigbe, O. (2007). Scince laboratory environment and academic performance. *Journal of Science Education and Technology. 16, 6, 500 – 506. http://www.jstor.org/stable/40188622. Accessed: 07/06/11.*

Bajah, S. T. (2000). Early learning science series for Africa (ELSSA), *stan@alpha.linkserve.com*

Barron, B. J. S.; Schwartz, D. L.; Vye, N. J.; Moore, A.; Petrosino, A.; Zech, L. and Bransford, D. J. (1998). Doing with understanding: Lessons from research on problem and project-based learning. *The Journal of the Learning Sciences, 7, 271-311.*

Ehindero. O. J. (1994). *The school and curriculum evolution in Nigeria*. Textflow Limited, Ibadan, Nigeria.

Ehindero, O. J. (2007*). Functional education in Nigeria: The way forward.* Keynote Address Delivered at the 3rd National Book Fair, December 4, 2007, Obafemi Awolowo University, Ile-Ife.

Ekpo, J. (1991). *Providing for individual differences in science education.* Readings in educational methods by Unoh, S. O.; Idiong, B. U.; and Chachko, M. C. Calabar Wusan Press.

Fisher, D.; Harrison, A.; Handerson, D. and Hoftein, A. (1998). Laboratory learning environment and practical tasks in senior secondary science classes. *Research in science education. 28, 3, 353-363.*

Gunstone, R. F. and Champagne, A. B. (1990). *Instructional consequences of students' knowledge about physical phenomena*. In L. H. T. West and A. L. Pines (Eds.), Cognitive structure and conceptual change (pp 61-68). New York: Academic Press.

Hofstein, A. and Lunetta, V. N. (2003). *The laboratory in science education: Foundations for the twenty-first century.* 2003 Wiley Periodicals, Inc. *Science* Ed 88: 28-54, 2004; Published online in Wiley Inter Science (www.interscience.wiley.com). D01 10. 1002/ sce. 10106.

Inyang, N. E. U. and Ekpeyong, H. E. (2000). Influence of ability and gender groupings on senior secondary school chemistry students achievement on the concept of redox reactions. *Journal of the Science Teachers Association of Nigeria, 35, (1&2), 36-42.*

Mitzenberg, S. (2005). *The most important science process skill.* Proceedings of Europeans summer school for primary science trainers, Sicily, 1-7.

West African Examination Council, (WAEC, 2011). *Trend of performance in Biology in the West African Senior School Certificate Examination May/June 2003- 2010.* Lagos, Nigeria.