



ILORIN JOURNAL OF EDUCATION

ISSN: 0189-6636

VOLUME 35 FEBRUARY, 2016

PUBLISHED BY THE FACULTY OF EDUCATION,
UNIVERSITY OF ILORIN, ILORIN, NIGERIA

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EFFECTS OF LABORATORY COMPONENT OF TEACHING AND ASSESSMENT STRATEGY ON SENIOR SCHOOL STUDENTS' PERFORMANCE IN MATHEMATICS IN ABUJA, NIGERIA

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Abstract

An important factor in the promotion of students' understanding, retention and success in Mathematics is undoubtedly the adoption of appropriate strategy for both instruction and assessment. This is crucial given literature account and dismal performance of students which in turn could affect any nation's quest for full integration of technology which is rooted in Mathematics knowledge. This paper reports an investigation of the effects of using laboratory component of teaching and assessment strategies on students' performance in mathematics. In this study, a total of 169 (M=88; F=81) Senior School Students of three purposively selected schools formed the sample frame. The schools, labeled as X, Y, and Z served as experimental I, II and control group respectively. The three research questions raised and the corresponding hypotheses were tested using t-test statistics. The findings indicated significant difference in the mean gain scores obtained by the groups, that is, experimental groups I and II (t-value = -6.085, p-value = 0.000 and $p < 0.05$). This was in favour of the experimental group I, that is, students taught and assessed using laboratory component of teaching and assessment strategies. It is therefore recommended that the use of laboratory component should be encouraged and harnessed for an improved performance of students in mathematics.

Keywords: Laboratory, Assessment, Strategies, Students, Performance, Mathematics

Introduction

Mathematics at the basic and senior school levels serves as precursor for building sound scientific and technological base of any nation. In the Nigeria education system, the contents and objectives of mathematics curriculum are sequenced and patterned to encourage precise, logical, critical thinking, computational skills and, develop the ability to recognize and solve problems among the learners.

Every student of mathematics expectedly is to learn mathematics process. This is targeted at ensuring full realization of the objectives and production of functional mathematics literate individuals. As corollary, the expectation is that mathematics education is still the needed tool that can birth forth a complete scientifically knowledgeable citizenry. In essence, to have functional individuals in the society, a good understanding and application of mathematics knowledge is required. This is so because; mathematics has a great influence on sciences, social sciences and humanities. According

to Adeyegbe (1987), the scope of mathematics research, teaching and techniques has expanded greatly in recent time. The scholar submitted that the penetration of mathematics to all human endeavours has also called for renewal of old and, or adoption of new teaching strategies that can accommodate prevailing learning situation across the globe.

Adolphus (2011) reported that the foundation of most mathematics teachers in geometry is poor which is majorly responsible for their inability to effectively teach the topic since you cannot give what you don't have, From the West African Examination Council (WAEC) chief Examiner's report (2007, 2009, 2011, 2012, 2013 & 2014) students experience difficulty in dealing with problems in geometry and this is linked to poor knowledge of the rubrics of construction, low skill in accurate measuring, poor techniques in drawing, arrangement and rearrangement of objects, low mastery of construction using only straight edge and compasses, inability to identify alternate, corresponding, exterior, adjacent, vertically opposite angles and confusion on both the plane and solid geometry.

Several researches have shown conflicting reports on the influence of gender in the teaching and learning of mathematics while Wonu and Ogunkunle (2015) and Attah and Guwam (2015) reported that gender has no effects on the teaching and learning of mathematics despite using different instructional strategy, George and Charsles-Ogan (2015) reported that male students perform better in the study which they carried out in mathematics. Therefore, gender was also considered as a moderating variable in this study.

Accordingly, in an audit of *inter alia* modes of learning, teaching and assessment conducted by Mathematics Turning Group (2002) in some Universities in Europe, the group, first identified that teaching and learning takes place mostly in the combinations of: Lectures, Exercise Session, Homework, Laboratory, Individual Projects, Group Projects and Dissertation modes of teaching and learning. In the second phase of the audit, the group requested academics to rank the identified modes of teaching and learning in relation to learners' competencies. The finding, using keys 1-7 as interpretation of the assessment is captured in table 1.

Table 1: Ranking Of Commonly Used Approaches To Learning And Assessment In Mathematics

Learning / Teaching mode	1	2	3	4	5	6	7
Lectures	X	X	X	X	X		X
Exercise Session	X	X	X	X	X		X
Homework			X		X	X	X
Laboratory			X				X
Individual Projects		X	X		X	X	X
Group Projects		X	X		X		X
Dissertation			X	X		X	X

Source: Mathematics Turning Group (2002).

Key

1. Facility with abstraction including the logical development of formal theories and the relationships between them
2. Ability to model mathematically a situation from the real world and to transfer mathematical expertise to non-mathematical contexts
3. Readiness to address new problems from new areas
4. Ability to comprehend problems and abstract their essentials
5. Ability to formulate complex problems of optimization and decision making and to interpret the solutions in the original contexts of the problems
6. Ability to present mathematical arguments and the conclusions from them with clarity and accuracy and in forms that are suitable for the audiences being addressed, both orally and in writing
7. Knowledge of the teaching and learning processes of mathematics

From table 1, Lectures and Exercise Session were rated high, followed by individual projects. However, the laboratory mode was adjudged to provide the learners with readiness to address problems from new areas in addition to presenting knowledge of the teaching and learning process of mathematics. This, according to the group, is no doubt the needed ingredients for effective teaching and learning processes of the modern time. According to Wiles and Bondi (2001), teachers of mathematics of this age will have to create instructional strategies which will enhance a high degree of individualization for each student to address new problems from new idea in a new area.

As a result, the power of thinking, understanding and retention are developed amongst students could enhance better performance and positive interest towards mathematics learning. The researchers opined that when we program a learning instruction, we expect something to happen. Thus, the use of concrete objects should be seen as an important part of any learning and assessment plan contrary to what is obtainable today. They suggested the need for mathematics teachers to see assessment as complementary venture that makes learning more and more purposeful. They submitted that laboratory teaching strategy offers this opportunity (for teaching and assessment) which is yet to be harnessed. Carry (1974) observed that mathematics teachers often administers Test/examination that do not directly assess the teachers' objectives which usually results to low performance of students in the subjects while Afolabi(2014) recommended the splitting of the 'ONE BIG' mathematics essay in both WAEC and National Examination Council (NECO) into two in order to accommodate the adoption of another mode of assessment.

In laboratory component of teaching and assessment, facts are developed by seeing, doing and feeling. It involves investigating, testing, analyzing, reflecting and applying theories in order to make abstract mathematics' concepts to be more concrete both during the teaching and assessment. According to Ezike and Obodo (1990), the mathematics laboratory is a place/room/hall where things can be counted, ordered,

recorded, packed, grouped, arranged, rearranged, measured, joined, partitioned, constructed, experimented, among many other activities.

In addition, Fitzgerald, Williams (1974) had earlier positioned that in general, a mathematics laboratory is activity-centered where the child is placed in a problem-solving situation and through self-exploration and discovery provides a solution based on his/her experiences, needs and interest.

This study is based on Piaget, Brunners and Diennes theories of learning. One of the most important contributions of Piaget (1971) is that children learn best from concrete activities. In his theory of learning Bruner (1969) suggest that teaching students the structure of a discipline as they study particular content leads to greater active involvement on their part as they discover basic principles for themselves. Also like Piaget and Bruner, Dienes (1969) justifies extensively for active students' involvement in the learning process, such involvement routinely involves the use of a vast amount of concrete materials. The implication and, or the assumption is that teaching and assessing students using laboratory component of teaching and assessment provides wide scope for effective communication between teachers and students and, could further result in achieving the desired target of better students' performance in mathematics being the dream of any nation. Hence, the need to investigate the effects of laboratory component of teaching and assessment strategy on students' performance in mathematics. Specifically, this study used laboratory component of teaching and assessment strategy in Geometry.

Research Questions

As a guide for this study, three research questions were raised and answered. They are:

- i. Will there be any difference in the performance of students when taught and assessed in geometry using laboratory component of teaching and assessment strategy and students not exposed to laboratory component of teaching and assessment strategy?
- ii. Do students taught and assessed in geometry using laboratory component of teaching and assessment strategy perform better than students taught but not assessed using laboratory component teaching and assessment strategy?
- iii. What will be the difference in the performance of students taught and assessed in geometry using laboratory component of teaching and assessment strategies on the basis of gender?

Research Hypotheses

The following null hypotheses which have corresponding research questions were tested:

HO₁: there is no significant difference in the performance of students taught and assessed in geometry using laboratory component of teaching and assessment strategies and students not taught and assessed using laboratory teaching and assessment strategies.

HO₂: there is no significant difference in the performance of students' taught and assessed using laboratory component of teaching and assessment strategies and students taught but not assessed with laboratory component of teaching and assessment strategies.

HO₃: there is no significant difference in the students' performance on the basis of gender when taught and assessed using laboratory component of teaching and assessment strategies.

Procedures:

(a) Using mathematics laboratory to teach and assess students

The researcher taught an intact class group1 (X) for ten weeks for one hour per day for five days in a week using mathematics laboratory strategy, at the eleventh week, the students were then assessed using laboratory strategy(students were given a wooden cone: manipulating concrete objects during the assessment to find for example the area of the cone)

(b) Using mathematics laboratory to teach but assessing them using the normal method

A properly trained research assistant taught another intact class group 2(Y) for ten weeks for one hour per day for five days in a week using mathematics laboratory strategy, at the eleventh week, the students were then assessed using the normal method (students were just provided with information and ask to find for example the area of cone)

(c) Using the lecture method to teach and assess students

(d) A properly trained research assistant taught another intact class (group Z) for ten weeks for one hour per day for five days in a week using lecture method, at the eleventh week, the students were then assessed using the normal method(students were just provided with information and ask to find for example the area of cone)

The study was a quasi-experimental research. It adopted 2 x 2 x 2 design. Three schools were purposively sampled, experimental groups being 2 and 1 control group. The schools were labeled X, Y and Z respectively. 169 students drawn from an intact class of senior school (SS2) participated in the study. The first experimental group, X, comprising 64 students; second experimental, Y, comprising 57 and 48 students in the control group, Z. This is as shown on table 2.

Table 2: Sample Frame

Label	NO	M	F
Experimental Group 1(X)	64	34	30
Experimental Group 2(Y)	57	30	27
Control Group 3(Z)	48	24	24

This study was based on the principles of 'learning and assessment by doing', 'learning and assessment by observation' proceeding from concrete to abstract which is an extension of inductive technique (Bruner 1969).

The instruments used for this study were Mathematics Performance Test (MPT) and Mathematics Laboratory Assessment Performance Test (MLAPT). The instruments were validated by two Mathematics educators and one Measurement and Evaluation expert. The face and contents validity of the instruments yielded 0.52 and 0.73 difficulty indexes. The researchers with the help of two other mathematics teachers of the participating schools administered the test. The data collected was analyzed using t-test and analysis of variance at 0.05 level of significance.

Data Analysis and Results

Research Question 1: Will there be any difference in the performance of students when taught and assessed in geometry using laboratory component of teaching and assessment strategies and students not exposed to laboratory component of teaching and assessment strategies?

Table 3: Mean Gain Scores of Students' Performance in Experimental Group I and Control Group

Group	Group Statistics	Pretest	Posttest	Mean Scores	Gain	Difference
Control Group	N	48	48			
	Mean	38.19	48.46	10.27		
	Std Dev.	8.24	7.71			
Exp. Group I	N	64	64			11.90
	Mean	35.14	57.31	22.17		
	Std Dev.	8.82	7.55			

Table 3 shows the mean gain scores of students that participated in the Mathematics Performance Test. The mean gain score of the students in the experimental group I (students taught and assessed using laboratory component of teaching and assessment strategies) was 22.17 while the mean gain score of students in control group (students not taught and assessed using laboratory component of teaching and assessment strategies) was 10.27. The mean gain score of the experimental group I was 11.90 higher than that of the control group. Hence, there was a difference in the group's performance in favour of experimental group I. To further ascertain if the difference was statistically significant, hypothesis 1 was tested and reported in table 4.

HO₁: there is no significant difference in the performance of students taught and assessed in geometry using laboratory component of teaching and assessment strategies and students not taught and assessed using laboratory component of teaching and assessment strategies.

Table 4: Independent samples t-test of the experimental group I and the control group

	T	df	t-test for Equality of Means				
			Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
						Lower	Upper
Pretest Scores	1.860	110	.066	3.047	1.638	-.199	6.293
Posttest Scores	-6.085	110	.000	-8.854	1.455	-11.738	-5.971

Table 4 shows that there was no significance difference in the performance of the students taught and assessed in geometry using laboratory component of teaching and assessment strategies and students not taught and assessed using laboratory component of teaching and assessment strategies in the pretest (t-value = 1.860, p-value = 0.66 and $p > 0.05$). This implies that the students in the groups were academically equivalent before the treatment.

However, the t-test analysis indicates a significant difference in the performance of students taught and assessed in geometry using laboratory component of teaching and assessment strategies and students not taught and assessed using laboratory teaching and assessment strategies in the posttest (t-value = -6.085, p-value = 0.000 and $p < 0.05$). This implies that students in the experimental group I performed better significantly than their counterparts in the control group after the treatment. This implies that the use of laboratory component of teaching and assessment strategies in teaching of Mathematics improved students' academic performance in the subject.

Research Question 2: Do students taught and assessed in geometry using laboratory component of teaching and assessment strategies perform better than students taught but not assessed using laboratory component of teaching and assessment strategies?

Table 5: Mean Gain Scores of Students' Performance in both Experimental Group I and Experimental Group II

Group	Group Statistic	Pretest	Posttest	Mean Gain Scores	Difference
Experimental Group I	N	64	64		
	Mean	35.14	57.31	22.17	
	Std Dev.	8.821	7.551		6.57
Experimental Group II	N	57	57		
	Mean	35.21	50.81	15.60	
	Std Dev.	7.660	6.965		

Table 5 reveals the mean gain scores of students who participated in the Mathematics Performance Test. The mean gain score of the students in the experimental group I (students taught and assessed using laboratory component of teaching and assessment strategies) was 22.17, while the mean gain score of students in experimental group II (students taught with but not assessed with laboratory component of teaching and assessment strategies) was 15.60. The mean gain score of the experimental group I was 6.57 higher than that of experimental group II. To corroborate or refute this, hypothesis 2 was tested and reported in table 6.

HO₂: there is no significant difference in the performance of students' taught and assessed using laboratory teaching and assessment strategies and students taught with but not assessed with laboratory teaching and assessment strategies.

Table 6: Independent samples t-test of the experimental group I and experimental group II

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
						Lower	Upper
Pretest Scores	-.046	119	.963	-.070	1.511	-3.061	2.921
Posttest Scores	4.906	119	.000	6.505	1.326	3.880	9.131

The results from table 6 indicates that there is no significance difference in the performance of the students' taught and assessed using laboratory component of teaching and assessment strategies and students taught with but not assessed with laboratory component of teaching and assessment strategies in the pretest (t-value = -0.046, p-value = 0.963 and $p > 0.05$). This affirmed the equivalence of the students in the two groups academically prior the treatment. The t-test analysis however shows a significant difference in the performance of students' taught and assessed using laboratory component of teaching and assessment strategies and students taught with but not assessed with laboratory component of teaching and assessment strategies in the posttest (t-value = -6.085, p-value = 0.000 and $p < 0.05$) in favour of the students' taught and assessed using laboratory component of teaching and assessment strategies. This implies that students' taught and assessed using laboratory component of teaching and assessment strategies significantly performed better than their counterparts who were taught with but not assessed with laboratory component of teaching and assessment strategies. This again affirms the potency of the use of laboratory component of teaching

and assessment strategies in teaching of Mathematics as it improved students' academic performance in the subject.

Research Question 3: What will be the difference in the performance of students taught and assessed in geometry using laboratory component teaching and assessment strategies on the basis of gender?

Table 7: Mean Gain Scores of Performance of male and female students taught and assessed using laboratory teaching and assessment strategies

Group	Group Statistic	Pretest	Posttest	Mean Gain Scores	Difference
Male	N	34	34		
	Mean	35.76	57.76	22.00	
	Std Dev.	8.763	7.636		0.37
Female	N	30	30		
	Mean	34.43	56.80	22.37	
	Std Dev.	8.982	7.549		

Table 7 shows the mean gain scores of male and female students taught and assessed using laboratory component of teaching and assessment strategies. The mean gain score of male students taught and assessed using laboratory component of teaching and assessment strategies in mathematics was 22.00, while the mean gain score of female students taught and assessed using laboratory teaching and assessment strategies in mathematics was 22.37. The mean gain score of male students was 0.37 lower than that of female students. Further analysis to test whether the difference in the means was statistically significant is as shown in table 8 based on hypothesis 3 tested.

HO₃: there is no significant difference in the students' performance on the basis of gender when taught and assessed using laboratory teaching and assessment strategies.

Table 8: Independent samples t-test of the experimental group I based on gender

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
						Lower	Upper
Pretest Scores	.599	62	.551	1.331	2.221	-3.108	5.771
Posttest Scores	.507	62	.614	.965	1.903	-2.839	4.768

The t-test analysis shown in table 8 reveals that there was no significant difference in the performance of male and female students taught and assessed using laboratory component of teaching and assessment strategy in the pretest (t-value = 0.599, p-value = 0.551 and $p > 0.05$). This implies that the male and female students taught and assessed using laboratory component of teaching and assessment strategy have similar academic background. Similarly, based on the t-test analysis of the posttest scores, male and female students' taught and assessed using laboratory component of teaching and assessment strategy, there was also no significant difference in the performance of male and female students taught and assessed using laboratory component of teaching and assessment strategies (t-value = 0.507, p-value = 0.614 and $p > 0.05$). This implies that male and female students taught and assessed using laboratory component of teaching and assessment strategies significantly performed equivalently in the posttest even after the treatment.

Discussion of Result

This study was conducted to investigate the potency of mathematics laboratory component of teaching and assessment on students' performance in geometry. In the study the two experimental group which were exposed to mathematics laboratory components of teaching statistically performed better than the control group in their mean gained scores (group 1 gained 22.7, group 2 gained 15.60 and control group gained 10.27), experimental group 1 mean gained score was higher as a result of been assessed with mathematics laboratory component which the other two groups were not assessed with in geometry

Conclusions

On the basis of the findings emanating from this study, it is important to note that the potency of laboratory component of teaching and assessment strategy as it relates to students' academic performance in mathematics is established. It was evident that both male and female students benefitted equally when exposed to the treatment. Thus, it

could be concluded that, of all commonly used strategies of learning, teaching and assessment of mathematics using laboratory component is impactful and if utilized, could serve as an effective approach to achieving desired learning outcomes and improved students' ability to construct and develop logical arguments with clear identification of assumptions and products. This position corroborate the findings of Chaugale (2008) who discovered that using mathematics laboratory strategy enhances students performance in geometry and Akanmu and Fajemidagba (2014) were the researchers, respectively, advocated the adoption of mathematics laboratory an alternative method of instruction and, use of graphical materials is capable of promoting mathematical understanding and sustaining learners' interest in anticipation that students will apply whatever they have learnt in practical term

Recommendations

Having arrived at these conclusions, the following recommendations are made:

- (i) The use of laboratory component of teaching and assessment strategy should be encouraged in the teaching and assessment of mathematics. This may allow greater engagement of the students and remove fear leading to better academic performance.
- (ii) There is the need to treat the students irrespective of their gender in the same way in an attempt to sustain equal level of motivation, interest and positive attitude towards mathematics. This recommendation is in line with the finding of this study which confirmed that male and female students significantly performed equivalently given the treatment.
- (iii) Mathematics teachers are advised to have a blend of the teaching and assessment strategy. This is important because, each of the commonly used strategy has its own strength and usefulness just as the potency of laboratory strategy have revealed

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