

**MATHEMATICS LABORATORY AND STUDENTS' CONCEPTION OF MENSURATION
USING DEMONSTRATION AND COLLABORATIVE APPROACHES IN RIVERS STATE**

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ABSTRACT

The study investigated the possible effect of mathematics laboratory in enhancing students' conception of mensuration in senior secondary school mathematics using demonstration and collaborative approaches in Rivers State. Pre-test, post-test control group with 4x2 factorial quasi experimental design was adopted. The population for this study was eight-hundred (800) senior secondary two (SS2) students in six (6) government secondary schools in the Okrika Local Government Area. Based on some criteria, a purposive sampling of 105 students participated in the study. A researcher designed instrument titled Test on Understanding of the Concept of Mensuration (TOUCM) was used for data collection. The instrument was subjected to face and content validation by experts in mathematics education. The estimated value of the reliability coefficient using Kuder-Richardson Formula for TOUCM was 0.86. Two research questions and two hypotheses guided the investigation. Mean, standard deviations were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test hypotheses. The findings established that students who were taught using demonstration with Mathematics laboratory approach outperformed all their counterparts in terms of understanding of concepts of mensuration. The mathematics laboratory using demonstration and collaborative approaches impacted significantly on student understanding of the concept of mensuration. Gender factor did not significantly affect students understanding of the concept of mensuration. It was recommended among others that mathematics teachers should incorporate mathematics laboratory using demonstration and collaborative approaches in the teaching of the concept of mensuration.

KEYWORDS: Mathematics, Laboratory, Understanding, Concept, Mensuration.

INTRODUCTION

Mathematics according to (Nwoke & Nnaji, 2011) is the study of quantity, structures, space and change. It developed through the use of abstraction and logical reasoning from counting, calculation, measurement, and the study of the shapes and motion of physical objects. The ingredient for the effective articulation of the abstract elements of science that gives impetus

to the development of technologies of any nation is based on mathematics. The indispensability of mathematics in human day to day activities cannot be over emphasized; therefore considered as the bedrock of all scientific and technological breakthrough and advancement for all the activities of human development. It is the language and culture common to all studies (Harbor-Peters, 2000).

Mathematics involves thinking logically and reasonably so as to understand how formulae are derived and their applications. The study of mathematics has been and will continue to be of tremendous importance to humanity for its ability to explain natural phenomena and everyday occurrences as well as its central role in the world's technological development. Rahman and Amoo (2004) have noted that the importance of mathematics does not only lie in its development but also in its utility in day to day interactions. Ogunkunle (2007) noted that the widespread utility of mathematics in scientific and technological applications has made mathematics education a key predictor of scientific competitiveness.

Moore (2005) asserted that mathematics is the logical language for expressing ideas, shapes, quantities, sizes, order, change and dynamism in the system, and for explaining the complexities of modern society in the business, economic, academic, engineering and medical settings. This suggests why the Federal Republic of Nigeria (2004) in the National Policy on Education accorded prominence to mathematics at both Primary and Secondary Schools as it is made compulsory and taught five times in a week. Despite the perceived importance of mathematics in scientific and technological development of the nation, students' performance in Nigerian institution has not been encouraging (Adedayo, 2001). Mathematics comprises number and numeration, algebra, trigonometric, geometry, mensuration, statistics and probability.

A close look at the secondary mathematics curriculum shows that there is no academic year that students do not learn mensuration. Kolawale and Oluwatayo (2004) stated that the knowledge of mathematical concepts with the corresponding knowledge of their application to real life seems to be deteriorating. This goes a long way to indicate how important the concept of mensuration is to both the individual learner and the society.

Mathematics laboratory is a place where students can explore mathematical objects, shapes and symbols to learn and verify mathematical facts and theorems through a variety of activities using different materials. These activities may be carried out by both the teachers and the students to explore, learn, stimulate interest and develop favourable attitude towards mathematics (Sreedharal, 2008).

Olatunde (2010) studies the adequacy of resource materials (Mathematics laboratory) and students mathematics achievement of senior secondary schools in south western, Nigeria. The study revealed that out of 1750 senior secondary school students and 123 mathematics teachers selected from 2 schools of the senatorial districts (75%) have a, good perception about the need for mathematics laboratory and students exposed to use of mathematical laboratory performed better (65%) than those who were not exposed to it. The use of Mathematics Laboratory as a Pedagogical approach in teaching and identifying students' difficulties in mensuration has been effective. Nwoke and Nnaji (2011) showed that the use of Mathematics Laboratory was more effective than the lecture method in teaching and learning mathematics with respect to students' achievement. Similarly, Sidhu (2006), considered mathematical laboratory as a place where things can be stored, kept, counted, ordered, recorded, packaged, unpackaged, grouped, ungrouped, arranged, re-arranged, mantle and dismantle, measured, joined, portioned, among numerous other activities.

Sreedharal (2008) supported this advocacy by positing that the activities carried out in the mathematics laboratory make students enjoy and rejoice with mathematics. Mathematics Laboratory is further seen to enhance students' ability to carry out their projects and other activities which provide active sensory mathematical experiences (Ukpebor, 2011). Hence, mathematics laboratory should be a focal point of all mathematics work in schools.

Ogunkunle (2007) opined that secondary school teachers use conventional methods in teaching mathematics concept and this method does not impact positively on academic achievement of students in mensuration which requires mastering of concepts before computation. The teaching and learning of mathematics concepts should be by practical, exploration and experiment, using a mathematics laboratory. This will make students organize their true potentials, talents, cultivate habits of hard work, high moral, ethical standards to learning mathematics and description of its value system to real life situations and national economic growth.

In mathematics laboratory, abstract concepts should be demonstrated using concrete materials. This is capable of enhancing students' interest in mathematics (Onwuka, Moseri and Iweka, 2010). One of these abstract concepts is mensuration. Mensuration refers to that branch of mathematics which deals with the measurement of geometric magnitudes, such as areas of surfaces and volumes of solids. It is a practical branch of mathematics. It is divided into two parts: namely plain mensuration and solid mensuration.

i) Plain mensuration deals with the measurements such as those of perimeters and areas of plane figures like polygons among others.

(ii) Solid mensuration deals with the measurement of surfaces, areas and volume of cube, cuboids, sphere, cone, cylinder among others.

Furthermore, by hierarchical nature of mathematics, the knowledge gained at any level using the laboratory materials could improve students' performance. Subsequently, mensuration appear to be the core component of all the depth knowledge in mathematics especially as it concerns measuring, calculating and estimating length, areas and volumes as well as the construction of three dimensional objects. It is speculated in this study that using improvised materials to teach concepts in mathematics especially in mensuration could go a long way to accomplish the expectations of all to bring about enhanced achievement. Students' dismal performance in mathematics examination over the years at the West African Senior Secondary Certificate Examination(WASSCE), General Certificate in Education (G.C.E) and National Examination Council (NECO) has been rated very poor and discouraging to the public. For instance, the Chief Examiner's report (2012) indicated that most students avoid problems in mensuration. Could it be due to lack of manipulative skills, misconceptions on the part of the students or teaching strategy used by the teachers? A close look at the past WASSCE questions revealed that there is no year; questions on mensuration are not set in the objective and theory. This perhaps shows the role mensuration plays in the development of students' cognitive domain.

Mohammed & Kurumah (2012) carried out research work on the use of montessori approach (Mathematics laboratory approach) in promoting students' interest in mensuration. The result of this study showed gender as statistically significant in which the male students performed better than the female students ($F=10.248$, $p < 0.05$). Although, in the view of Obarakpo(2009), in determining the effect of active learning in students' achievement in mensuration, the male students did not perform significantly better than the female students. However, Achor, Ajai and Imoko(2010) in a study of geometry and mensuration using Mathematical Laboratory (games and simulations) in Eastern Nigeria among SSS1 students(158 boys and 129 girls) the male students performed better than the female students. Analysis of the performances of the students in WASSCE Mathematics in the year 1991 – 2012, as shown on Table 1, indicates that it was only in the year 2004 and 2012 that up to 50% of the students had credit in mathematics. All other years' result (twenty years) had below 50% of students who had credit pass in subject. The above result shows the dismal

performances of students in mathematics over twenty two years' period of (1991 -2012). A close examination of Table I show the average on an alarming high percent failure of over 80% for 11 out of 22 years' results considered. Commenting on the performance of students in mathematics as this failure seems to be re-occurring every year where so many people are involved.

Table 1: WASSCE Results of General Mathematics (May/June, 1991 – 2012)

Year	Total Entries	Total No. who sat	No. of failures	% of failure	No. of students' who obtained Credit & above	% of Credit & above
1991	299,338	294,079	261,352	87.3	32,727	11.1
1992	366,196	361,506	282,480	77.1	79,026	21.9
1993	498,775	491,755	438,196	87.9	53,559	10.9
1994	526,525	518,118	434,926	82.6	83,192	16.1
1995	466,971	462,273	386,193	82.7	76,080	16.5
1996	519,656	514,342	462,755	89.1	51,587	10.0
1997	621,841	616,923	569,671	91.6	47,252	7.7
1998	640,624	635,685	565,098	88.2	70,587	11.1
1999	648,120	642,819	584,961	90.3	57,858	9.0
2000	537,266	530,074	356,258	66.3	173,816	32.8
2001	886,909	843,991	493,245	55.6	350,746	41.6
2002	1,004,308	949,139	806,550	80.3	142,589	15.0
2003	550,029	518,516	281,139	51.1	237,377	45.8
2004	309,660	309,531	142,992	46.2	166,539	53.8
2005	943,371	634,604	426,460	45.2	208,244	32.8
2006	1,040,117	1,023,102	649,147	62.4	373,955	36.6
2007	925,288	908,235	598,826	64.7	309,409	34.1
2008	968,475	940,200	661,855	68.3	278,345	29.6
2009	998,282	902,350	559,692	62.0	342,658	38.0
2010	1,004,308	949,139	806,550	80.3	142,589	15.0
2011	1,045,317	1,004,102	895,540	89.2	148,690	14.8
2012	1,695,878	1,046,722	397,566	37.0	649,156	62.0

Source: Test Development Division, West African Examination Council (WAEC) Lagos. Year 2012

The consistent poor performance of students in mathematics poses a great threat to the much desired scientific and technological advancement of nation as it partly explains the shortfall in the number of qualified candidates' requires fill the quota of 60:40 in favour of science and science related disciplines.

Students' have been found to have difficulty in some areas of mathematics and that those difficulties could be as a result of insufficient use of teaching facilities, absent of inadequate mathematics laboratory.

Statement of the problem: Poor performance of students in mathematics as shown in (Table 1) has been of great concern to many people. This because a credit pass in mathematics is needed for registration inn science, engineering, medical and related courses. Mensuration refers to the branch of mathematics which deals with the measurement of geometric

magnitudes such as areas of surfaces and volumes of solid; for instance, it is needed in technological development. However, according to Chief examiners' report (2012), most students avoid answering questions in mensuration. This probably, maybe as a result of improper understanding of the concept, which in turns could be attributed to poor approach of teaching in secondary schools. Ogunkunle (2009) established that school teachers in Port Harcourt were ineffective in teaching mathematics as they apply conventional approach in almost all topics taught. Could the poor performance of students' beas a result of insufficient students' involvement and exposure to instructional materials? This study therefore, tends to investigate the possible effects of mathematics laboratory inenhancing students' conception of mensuration in senior secondary schools in Rivers State.

Objectives of the Study:

The main purpose of the study was to investigate the effects of mathematics laboratory on students' conception of mensuration in senior secondary school mathematics.

Specifically, the objectives of the study are to:

1. Examine the effect of mathematics laboratory on students' understanding of the concept of mensuration using demonstration and collaborative approaches
2. Compare the effect of mathematics laboratory on the male and female students' understanding of the concept of mensuration

Research Questions:

The following research questions guided the study:

1. What is the effect of mathematics laboratory on student understanding of the concept of mensuration using demonstration and collaborative approaches?
2. What effect does the mathematics laboratory have on male and female students' application of the concept of mensuration?

Research Hypotheses

The following null hypotheses were tested at .05 significance alpha level.

H01: There is no significant difference between the students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches.

H02: There is no significant difference between male and female students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches respectively.

METHODOLOGY

The design adopted for this study was the quasi experimental and a 4x2 factorial design. Specifically, pre-test-post-test control group design was used. This implies the use of intact classes (Nwankwo, 2006). In this design two experimental groups and one control group were used. The first experimental group used demonstrative approach with mathematics laboratory and the second experimental group used collaborative approach with mathematics laboratory. The control group used the charts. The population for this study is about eight-hundred (800) senior secondary two (SS2) students in six (6) Co-educational public secondary schools in Okrika Local Government Area of Rivers State, Nigeria. The purposive sampling technique was adopted so that the samples of 105 students were obtained by randomization from three schools, selected on the bases of the following criteria:

- The schools' with qualified graduate mathematics teacher(s)
- The schools' with adequate facilities in Mathematics such as classroom space
- The concept of mensuration must not have been taught in the schools.
- The schools that have presented candidates for senior secondary school certificate examination (SSCE) for the past six (6) years.
- The schools that will be comparable in terms of performance in external examinations.

The three schools were randomly selected from the schools that met the criteria. The selected schools were randomly assigned to control and experimental conditions. In the schools, the researcher randomly selected one arm in each school for the study. All the students from the arms selected took part in the treatments, but at the end only thirty five (35) students in each school were used for study. This was done to avoid disorganisation of the classes and to obtain equivalent number of participants in each group. The Table 2 shows the number male and female students used in each school.

Table 2. Distribution of the participants based on gender, strategy and schools.

School	Group	Gender	N
1	Demonstration with Math Lab	Male	20
		Female	15
2	Collaboration with Math lab	Male	18
		Female	17
5	Charts	Male	18
		Female	17
Grand Total			105

A validated research instrument titled Test on Understanding of the Concept of Mensuration (TOUCM) which was developed by the researcher was used for data collection. TOUCM consisted of 50-items multiple choice questions with four options (lettered A to D) each, of which only one option was the correct answer. This TOUCM was expected to measure the understanding of the concept of mensuration. A table of specification was constructed to guide in the allocation of questions into the cognitive (lower and higher) learning outcomes. Each test item was allotted one (1) mark. Each correctly answered question scores 1 mark while a wrongly answered question scores 0. The total score on TOUCM was 50. The reliability of the instrument obtained based on data obtained from a pilot study on TOUCM and a coefficient of 0.86 was obtained.

Test on understanding of the concept of mensuration (TOUCM) was administered as pre test to both the experimental and control groups. The students in the experimental and control groups were then taught with three different approaches. After each group was taught with the specific instructional approach, the TOUCM was administered to them as post test, their responses were graded and scores obtained. In order to analyze data obtained in this research, the descriptive statistical tools such as mean and standard deviation were used to answer the research questions. Inferential statistics, Analysis of Covariance (ANCOVA) was used to test the hypotheses at .05 level of significance.

RESULTS

Research question one: What effect has mathematics laboratory on students' understanding of the concept of mensuration using demonstration and collaborative approaches?

Table 3: Gain scores of conceptual understanding of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches

Approach	N	Pre-test		Post-test		Gain	SD
		Mean	SD	Mean	SD		
Demonstration with Math Lab	35	30.6857	9.50471	69.6000	12.69368	38.9143	18.02184
Collaboration with Math Lab	35	39.8857	10.41428	66.0571	16.63791	26.1714	17.38405
Charts	35	32.2286	7.27237	51.4286	10.12361	19.2000	13.71303

Table 3 showed that the mean gain score of students taught using demonstration with Mathematics laboratory was 38.9143 ± 18.02184 . Those taught using collaboration with Mathlab had 26.1714 ± 17.38405 and those taught using the charts had mean score of 19.71303 ± 13.71303 .

Research question 2: To what extent do mathematics laboratory affect the male and female students' understanding of the concept of mensuration?

Table 4: Gain score of male and female students on the conceptual understanding of mensuration when taught using mathematics laboratory

Approach	Gender	N	Pretest		Posttest		Gain	SD
			Mean	SD	Mean	SD		
Demonstration with Math Lab	Male	20	30.4000	7.27215	71.7000	11.01721	41.3000	14.85757
	Female	15	31.0667	12.13888	66.8000	14.55629	35.7333	21.68432
Collaboration with Math Lab	Male	18	39.7778	10.51361	66.2222	17.52832	26.4444	18.32460
	Female	17	40.0000	10.63015	65.8824	16.17824	25.8824	16.88891
Charts	Male	18	31.2222	7.10058	49.2222	6.44027	18.0000	9.04889
	Female	17	33.2941	7.51469	53.7647	12.74524	20.4706	17.58592

Table 4 showed that the mean gain score in conceptual understanding of mensuration among male students taught using Demonstration with Math lab was 41.3000 ± 14.85757 , while that of their female counterparts was 35.7333 ± 21.68432 . The mean gain of male students taught using Collaboration with Math Lab was 26.4444 ± 18.32460 while that of their female counterparts was 25.8824 ± 16.88891 . The male students taught using the conventional approach had mean score of 18.0000 ± 9.04889 while their female counterparts had 20.4706 ± 17.58592 .

RESEARCH HYPOTHESES

H01: There is no significant difference between the students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches.

Table 5: Summary of ANCOVA on the difference between the students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches

Source of variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6513.128 ^a	3	2171.043	11.945	.000
Intercept	27845.108	1	27845.108	153.202	.000
Pretest	17.738	1	17.738	.098	.755
Approach	6508.834	2	3254.417	17.906	.000
Error	18357.119	101	181.754		
Total	433216.000	105			
Corrected Total	24870.248	104			

a. R Squared = .262 (Adjusted R Squared = .240)

Table 5 showed that there is significant difference between the students' understanding of the concept of mensuration when taught with mathematics laboratory activities using demonstration and collaborative approaches ($F_{2, 101}=17.906, p<.05$). The hypothesis one was rejected.

H02: There is no significant difference between male and female students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches respectively.

Table 6 Summary of ANCOVA on the difference between the male and female students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches

Source of variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6905.671 ^a	6	1150.945	6.279	.000
Intercept	27775.146	1	27775.146	151.518	.000
Pretest	23.069	1	23.069	.126	.724
Approach	6250.455	2	3125.227	17.049	.000
Gender	.852	1	.852	.005	.946
Approach * Gender	391.901	2	195.950	1.069	.347
Error	17964.576	98	183.312		
Total	433216.000	105			
Corrected Total	24870.248	104			

a. R Squared = .278 (Adjusted R Squared = .233)

Table 6 shows that there is significant difference between male and female students' understanding of the concept of mensuration when taught with mathematics laboratory

activities using demonstration and collaborative approaches respectively ($F_{1, 98}=1.069$, $p>.05$). Hypothesis 2 was retained.

DISCUSSION OF FINDINGS

Effects of mathematics laboratory on student understanding of the concept of mensuration using demonstration and collaborative approaches

Result on Table 3 showed that students who adopted the demonstration approach with Math lab had the highest learning gain in conceptual understanding of mensuration amongst the three groups. Furthermore, result on Table 5 showed that there is significant difference between the students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches. Hypothesis one was rejected. The result of the present study is consistent with the earlier studies which indicated that mathematics laboratory activities in schools can be useful in solving problems on mensuration (Central Board of Secondary Education, 2005). Nwoke and Nnaji (2011) showed that the use of Mathematics Laboratory was more effective than the lecture method in teaching and learning mathematics with respect to students' achievement. Olatunde (2010) in evaluating the adequacy of resource materials (mathematics laboratory) and students' mathematics in which teachers adapted a demonstration method. Results showed that the experimental group performed better (65%) than those not exposed to it (control group) despite low infrastructural facilities available in the schools.

Mathematics laboratory on male and female students' understanding of the concept of mensuration

The result Table 4 showed that the highest gain in conceptual understanding of mensuration was had by the male students who adopted the demonstration approach with Math lab while the male students who adopted the charts had the least gain in learning. Furthermore, the result showed that Table 6 shows that there is significant difference between male and female students' understanding of the concept of mensuration when taught with mathematics laboratory using demonstration and collaborative approaches respectively. The hypothesis two was retained. The result of the presents study was consistent with an earlier work by Obarakpo(2009), in which indicated that effect of gender had no significant effect on the achievement of male and female students in an active learning instruction. However, this finding is inconsistent with the study of Mohammed and Kurumeh, (2012) who carried out a

study on the use of montessori approach (Mathematics laboratory approach) in promoting students' interest in mensuration. The result of this study showed gender as statistically significant in which the male students performed better than the female students. Achor, Ajai and Imoko (2010) also conducted a study of geometry and mensuration using Mathematical Laboratory (games and simulations) in Eastern Nigeria among SSS1 students, the male students performed better than the female students.

CONCLUSIONS

The use of mathematics laboratory was found to improve student understanding and of concept of mensuration. Students who were taught using demonstration with Mathematics laboratory approach outperformed their counterparts in terms of understanding of concepts of mensuration. The male students in the experimental group who adopted demonstration with mathematics laboratory activities also outperformed their counterparts with respect to understanding of concept of mensuration. Mathematics laboratory using demonstration and collaborative approaches impacted significantly on student understanding of concept of mensuration. Gender factor did not significantly affect student understanding and application of the concept of mensuration respectively.

Recommendations

Based on the findings of the study the following recommendations were made:

1. Mathematics teachers should incorporate mathematics laboratory activities using demonstration and collaboration approaches in the teaching of concepts in mensuration, and all other concepts in mathematics.
2. Teachers should equally involve students of both sexes in the teaching of mathematics in the secondary school level.
3. Curriculum planners should emphasize on interactive instructional approaches like demonstration and collaborative learning approach as they plan mathematics curriculum.

Suggestions for further study

- Further studies should take into account the ability levels of the students as a moderator variable in determining the effects of the activity based approach on the student understanding and application of concepts in mensuration.

- Studies trying to replicate the present one should consider the effects of school location on student understanding and application of concepts of mensuration which was outside the scope of the present study.
- Similar study should be carried out in other Local Government Area of Rivers State.

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