

# Impact of Mathematics Laboratory Technique on Creativity in Circle Theorems among Senior Secondary School Students in Katsina State, Nigeria

**UMAR, Najib Musa**

najibullahumar@gmail.com

Department of Mathematics

Yusufu Bala Usman College of Education and Legal Studies, Daura

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## Abstract

This study investigates the impact of the Mathematics Laboratory Technique (MLT) on the creativity of senior secondary school students in Katsina State, Nigeria, with a specific focus on Circle Theorems. It explores how science and technology enhance education, particularly in mathematics instruction, by promoting active learning, critical thinking, and problem-solving. Drawing on the conceptual foundations of science and mathematics education, the research highlights persistent challenges in mathematics instruction in Nigeria such as abstract content delivery, lack of student engagement, and poor student performance particularly in geometry.

Using a quasi-experimental design, the study involved 375 SSII students across four intact classes from selected schools in Katsina State. The experimental group was taught using the Mathematics Laboratory Technique, while the control group received instruction via the traditional discussion method. Data were collected using a researcher-developed instrument, the Students' Circle Theorems Creativity Test (SCTCT), and analyzed using descriptive statistics and t-tests.

Findings revealed a significant difference in the creativity scores of students taught using the laboratory technique compared to those taught through discussion, favoring the experimental group. However, no significant gender-based differences were observed, indicating the gender neutrality of the MLT. These results affirm that mathematics laboratories can significantly enhance student creativity, understanding, and interest in abstract topics like Circle Theorems.

The study concludes that incorporating practical, laboratory-based methods into mathematics instruction leads to improved learning outcomes and greater student engagement. It recommends that educational stakeholders invest in establishing mathematics laboratories, train teachers in their effective use, and prioritize interactive teaching methods to enhance mathematics education in secondary schools.

**Keywords:** Mathematics Laboratory, Creativity, Circle Theorem

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## Introduction

Science and technology have long been fundamental to enhancing productivity and improving various aspects of human labor. According to Ugwu and Nwagbo (2019), science is a structured approach to acquiring and organizing knowledge through explanations and predictions about the universe. It involves studying nature and natural phenomena to uncover fundamental principles and laws. Science promotes understanding of the natural world through observation and experimentation, aiming to offer effective and lasting solutions to human challenges (Madugu, Kumam, & Egahi, 2021).

Science education encourages students to explore, test ideas, and develop understanding (Ambawati, Putri, & Khaleyla, 2021). To ensure effective science learning, educators must continually innovate and connect their teaching methods to students' interests and real-life

environments. As a vital part of education, science helps explain natural occurrences and supports technological advancement (Olasehinde & Olatoye, 2014).

Rapid advancements in science and technology have reshaped curriculum demands, requiring teachers to equip students with the skills needed for future challenges (Fitria et al., 2023). One of the most essential of these skills is critical thinking. Students must be able to express their ideas, apply prior knowledge, and make informed decisions. A lack of training in critical thinking can hinder problem-solving in real-life situations (Prihatiningsih et al., 2016).

Mathematics serves as a cornerstone for unlocking individual potential and national progress. It fosters lifelong literacy and numeracy, laying the foundation for scientific thinking and reflective reasoning. Mathematics plays a central role in daily life and is often considered the backbone of all other academic disciplines. It equips students to become informed citizens and opens pathways to numerous career opportunities.

The National Policy on Education (FRN, 2013) recognizes Mathematics as a compulsory subject for all students, requiring a credit-level pass for entry into higher education. To reach national educational goals, Nigeria must invest in innovative teaching methods and well-trained mathematics educators. Mathematics not only develops logical reasoning and spatial understanding but also promotes abstract thinking and analytical skills (Curriculum Planning and Development Division, 2007).

Furthermore, the International Commission on Mathematical Instruction (2021) emphasizes the role of mathematics in enhancing learning across disciplines such as science, social studies, and even the arts. Diverse teaching strategies can help students transition from written to mental calculations, fostering creativity, reasoning, and problem-solving skills. Despite its importance, challenges persist in mathematics instruction, requiring research-based solutions to improve teaching and learning outcomes (Hanna & Villiers, 2012).

For a country to develop, it must have adequate human capital to do so. The human capital is obviously obtained through sound education. It is believed that education is a pivotal part of human development, and can positively influence standards of living, health and governance. Schools handle the important responsibility of imparting education to students and developing them into responsible and enterprising citizens. This can only be achieved when the quality of education provided is the top priority of every government and the school in particular (Salmi, 2000). In view of the above statement mathematics is one of the core subjects that a student need to pass before being admitted into any tertiary institution, as such there is need to improve the way mathematics is being taught in our schools. The abstract nature of mathematics should be reduced through demonstration and practical methods. Agwagah cited by Ebele and Abigail (2008) observed that the problem of ineffective teaching can be tackled through planned and intelligent application of the mathematics laboratory. The method of drill and verbal recitation makes learning boring and lacks motivation for further learning. Nature of interactions that takes place in science secondary school classrooms of Katsina State is teachers centered which ranges between 60-90% of the

interaction as against teacher student interactions that had the percentages of 30-70%. This is in sharp contrast with the global standard that encourages teacher-student and student-teacher interactions in a typical science class. And about 70-90% of science teachers in Katsina State secondary schools still employ the use of traditional lecture method (Matazu and Elizabeth, 2018). Wasagu, (2001) pointed out that science is practical oriented and that requires anyone wanting to excel in science related discipline must take practical aspects of sciences very serious.

Mathematics laboratory is a place where students can learn and explore various mathematical concepts and verify different mathematical facts and theories using varieties of activities and material (Igbokwe, 2000).

Other researchers have confirmed low performance in mathematics at both the Senior Secondary certificate examination (SSCE) and placement examination like Unified Tertiary Matriculation Examination – UTME (Okonkwo, 2005). Ale (2012), testified that lack of interest in mathematics and mass failure in mathematics at school certificate level will go along-way to hinder Nigeria from achieving its transformation agenda without promoting the study of sciences through mathematics. Mathematics is a model for thinking, developing scientific structure, drawing conclusion and for solving problems.

Mathematics is one of the school subjects that any nation needs for industrial and technological advancement, useful for most vocation and higher specialized courses of learning (Odili, 2006). Mathematics is an excellent vehicle for the development and improvement of a person's intellectual competence in logical reasoning, spatial visualization, analysis and abstract thought (Curriculum Planning and Development Division, 2007). Students who study Mathematics, therefore, develop numeracy skill, reasoning, thinking skills and problem solving skills through the learning and application of Mathematics. All of these skills can be acquired through the use of mathematics laboratory in teaching mathematics topics.

Mathematics laboratory is a place where students can learn and explore various mathematical concepts and verify different mathematical facts and theories using varieties of activities and material (Igbokwe, 2000). As defined by Adenegan (2003) the mathematics laboratory is a unique room or place, with relevant and up-to-date equipment known as instructional materials, designated for the teaching and learning of mathematics and other scientific or research work, whereby a trained and professionally qualified person (mathematics teacher) readily interact with learners (students) on specified set of instructions. The abstract nature of mathematics should be reduced through demonstration and practical methods. The importance of laboratory works cannot be over emphasized. Ciroma and Bakori (2010) observed that, it promotes long term memory in students, enhances pupil development of dimension of science, instills the spirit of collaboration and active participation among learners, exposes learners to scientific experiences that could ultimately help them in developing scientific attitude and skills and inculcate in the students the spirit of inquiry and scientific mode of thinking. Laboratory activities could influence teaching and learning in such a way that student manipulate laboratory facilities on their own.

**Creativity** is the ability to generate new and original ideas, solutions, or expressions by connecting existing knowledge in novel ways. It involves thinking beyond traditional boundaries to discover possibilities that are imaginative, effective, and sometimes surprising.

## Statement of the Problem

Research reports over the years have not only justified that senior secondary school students perform poorly in mathematics but also indicated that the process errors which students commit while solving mathematics problems most especially in Circle Geometry have contributed to students' poor performance in mathematics. These errors (weaknesses) committed by students in solving mathematics problems has been a thing of concern to mathematics educators, parents and Government of Katsina State. This weakness may somehow be attributed to; lack of qualified mathematics teachers, poor methodology in teaching mathematics, lack of using manipulatives in teaching and learning of mathematic, lack of students' interest in the subject and also the no-use of Mathematics Laboratory. WAEC Chief Examiner's report (2024) identified some areas that Candidates were weak among which is Circle Geometry. The chief examiners annual report in mathematics in the Senior School Certificate Examination (SSCE) conducted by the West African Examinations Council (WAEC) is a good testimony of those facts.

Evidence of poor performance in mathematics by secondary school students point to the fact that the most desired technological, scientific and business application of mathematics cannot be sustained because most of the concepts in mathematics are abstract in nature and these can only be removed through the involvement of students into practical activities. Therefore, the study is designed to find out the impact of using mathematics laboratory in teaching on the academic performance of Secondary School mathematics students in Katsina State.

## Objectives of the Study

The objective of this study was to find out the impact of using mathematics laboratory technique in teaching Secondary school students in mathematics in Katsina State. Specifically, the study determined the following;

- i. if there is any difference between the creativity of students taught circle theorems using mathematics laboratory Technique and those taught using Discussion method.
- ii. if there is any difference between the creativity of male and female students taught Circle Theorems using mathematics laboratory Technique.

## Research Questions

In the process of investigating the impact of mathematics laboratory techniques on creativity of senior secondary school students in Katsina State, the following research questions were formulated to guide this study:

- i* Is there any difference between the creativity of students taught Circle Theorems using Mathematics Laboratory Technique and those taught using Discussion method?
- ii* Is there any difference between the creativity of male and female students taught Circle Theorems using Mathematics Laboratory Technique?

## Research Hypotheses

To carry out this study the following null hypotheses were formulated:

**Ho1:** There is no significant difference between the creativity of students taught Circle Theorems using mathematics laboratory technique and those taught using Discussion method.

**Ho2:** There is no significant difference between the creativity of male and female students taught circle theorem using mathematics laboratory technique.

### **Scope and Delimitation of the Study**

The study covered the whole senior secondary school students in Katsina State. But due to time factor and other constrain the study was limited to only SS II students of Katsina State using four intact classes. The research was delimited to Circle Theorems in terms of content. Students' Circle Theorems creativity Test (SCTCT) on Circle Theorems was used as the instruments for data collection.

### **Research Design**

The study employed quasi-experimental design. Intact class setting was involved in the study. Two groups were identified as experimental groups which were exposed to treatment using Mathematics Laboratory Technique while the other two groups were the control group, which were exposed to the Discussion Method. The pre-test, post-test and post post-test was administered to both the experimental and control groups at the beginning and the end of the study.

### **Population of the Study**

The population of this study comprises of all the secondary schools in Katsina State. There are 340 senior secondary schools in Katsina State with an estimated population of fifty nine thousand five hundred and seventy (59,570) senior secondary school II (SSII) students. The population of the study is shown in Table 2.

**TABLE 1 Distribution of Population by Zones in Katsina State**

S/NO.	ZONE	NO. OF SCHOOLS	MALE	FEMALE	TOTAL ENROLMENT
1.	BAURE	29	1,825	1,648	3,473
2.	DAURA	41	2,142	1,605	3,747
3.	DUTSINMA	22	1,696	1,681	3,377
4.	FASKARI	26	1,853	926	2,779
5.	FUNTUA	35	4,869	3,420	8,289
6.	MALUMFASHI	33	5,786	6,759	12,545
7.	MANI	25	1,901	1,227	3,128
8.	MUSAWA	16	1,223	736	1,959
9.	KANKIA	28	1,826	1,790	3,616
10.	KATSINA	39	5,905	4,024	9,929
11	RIMI	24	2,440	1,302	3,742

12	SAFANA	22	1,909	1,077	2,986
	<b>TOTAL</b>	340	33,375	26,195	59,570

### Sample and Sampling Techniques

The sample of the study was drawn from senior secondary school two (SSII), the researcher employed the use of multi-stage sampling technique involving purposive sampling technique which was used to select the schools, this was because not all the senior secondary schools in Katsina state have mathematics laboratory. Four Intact classes were selected. 180 students of Government Day Secondary School Kofar Sauri were used as experimental group while 105 Students of Government Day Secondary School Mani and 90 students of Government Girls' Secondary School Mani were used as controlled group.

**Table 2: Sample Size for the Study**

Class	Male	Female	Total
Experimental	100	80	180
Control	105	90	195
<b>Total</b>	<b>205</b>	<b>170</b>	<b>375</b>

### Instrumentation

The instrument used in conducting this research was researcher's constructed instrument which was Students' Circle Theorems Performance Test (SCTCT) that was used in finding out the creativity of Students.

### Students Circle Theorem Performance Test (SCTCT)

The SCTCT consist of six (6) theory questions for the students to answer four (4), constructed by the researcher. The questions in SCTCT were designed to evaluate students' creativity in circle theorems. The SCTCT was used in pre-test level and also in Post-Test. Marking scheme was provided for the test.

### Mathematics Laboratory Technique Guide (MLTG)

MLTG is a mathematics teaching technique developed by the researcher in order to explore its usage on creativity among senior secondary school students. The guide contains practical on circle theorems based on SSII curriculum. Different text books were used to provide solutions to serve as teachers' instructional guide, students' class work and assignment.

### Discussion Lesson Plan (DLP)

DLP is a mathematics instructional guide developed by the researcher in order to explore the use of mathematic laboratory techniques guide on students' creativity among senior secondary school students. The guide contains circle theorems based on SSSII curriculum. Different text books were used to provide solutions to serve as teachers' instructional guide, students' class work and assignment.

### **Validity of the Instrument**

The Students' Circle Theorems Performance Test was subjected to face and content validation in order to ascertain its validity. The instrument was given to experts in the Department of Science and Vocational Education, Usmanu Danfodiyo University Sokoto and a staff of usmanu Danfodiyo University Model Staff School. The validation was done to correct ambiguous questions, assess the appropriateness and meaningfulness the instrument. E.g

- (1) The number of questions were increased from five to six.
- (2) Question one was modified, been it too simple.
- (3) Corrections were made on the diagrams and the figures in the diagram.

### **Pilot Study**

A pilot study was carried out using two intact classes of one hundred and ten (130) male students and one hundred (110) female students of senior secondary school II (SSII) at Government Day Secondary School Kofar Yandaka Katsina State. The selected school is part of the population but not part of the sample for this study to ascertain the validity and reliability of the research instrument.

### **Reliability of the Instrument**

To determine the reliability of the instrument, a test re-test was used to establish its reliability; the test was given to the students of a school that did not form parts of the sample used for the study. After two weeks' interval, the second test was administered to the same students. The individual's scores from the tests were recorded and subjected to reliability test by using Persons Product Moment Correlation Co-efficient (PPMCC) and correlation co-efficient was found to be (0.87).

### **Administration of the Instrument**

The Students' Circle Theorem Creativity Test was designed for this study. The mathematics laboratory technique guide was used in teaching and assessing the experimental group of learners while discussion lesson plan was used in teaching and assessing the control group of learners. At pretest level the Students Circle Theorems Creativity Test (SCTCT) was administered to both Experimental and control groups on the same day and the same time with the help of three (3) research assistance who happen to be the mathematics teachers of the selected schools. Training was given to the research assistance on how to administer the instruments. The pretest was conducted before treatment is given to the experimental group. The teaching lasted for a period of 6 weeks using SSII students of. The post-test was administered to all students in the sample schools at the end of six (6) weeks of teaching circle Theorems.

### **Approach to Data Analysis**

After the marking sessions, the raw scores were subjected to analysis. The researcher used descriptive statistics of mean and standard deviation to answer all the research questions. The null hypotheses were tested using t-test to determine the Impact of Mathematics Laboratory Technique on creativity in Circle Theorems among Senior Secondary School Students in Katsina State.

### **Research question 1**

Is there any difference between the creativity of students taught circle theorems using mathematics laboratory technique and those taught using discussion methods? The data collected related to this question was summarized using descriptive statistics and is presented in table 3.

**Table 1: Mean and Standard Deviation of the Experimental and Controlled Groups.**

Groups	N	Mean	S D	M D
Experimental	180	29.25	5.03	9.18
Control	195	20.07	5.66	

Source: Field Work (2024)

Table 1, showed the creativity of students taught circle theorems using mathematics laboratory technique and those taught using discussion method in Katsina state. The result revealed that the mean creativity of students in the experimental class was 29.25 and that of the control group was 20.07. Therefore, the difference between the creativity of students taught circle theorems using mathematics laboratory and those taught using discussion method in Katsina was 9.18 This implies there was a difference between the students circle theorems using mathematics laboratory and those taught using discussion method in Katsina.

### Research question 2

Is there any difference between the creativity of male and female mathematics students taught Circle Theorems using mathematics laboratory techniques?

The data collected related to this question was summarized using descriptive statistics and is presented in table 2.

**Table 2: Mean and Standard Deviation of Male and Female of the Experimental Group.**

Statistics	N	Mean	S D	M D
Male	100	29.45	6.95	1.31
Female	80	28.14	7.27	

Source: Field Work (2019)

Table 2 showed the mean score of male and female students taught using mathematics laboratory technique in Katsina State. From the results it concluded that the mean creativity of male students was 29.45 and that of female students was 28.14, and the difference between the two mean is 1.31. This implies that there was a difference between male and female students taught circle theorem using mathematics laboratory technique.

### Null Hypothesis 1 (H<sub>o</sub> 1)

There is no significant difference between the creativity of students taught circle theorems using mathematics laboratory technique and students taught using discussion method.

To test this hypotheses, the data collected was subjected to t-test analysis and is presented in table 3

**Table 3: Summary of t-test Analysis of Experimental and Control Group**

Groups	N	Mean	SD	DF	T-Value	P-value	Decision
Experimental	180	29.25	5.03				
				373	16.55	0.00	Rejected
Control	195	20.07	5.66				

Source: Field Work (2024)

$\alpha$ -value = 0.05

From table 3, p- value of 0.00 was found to be less than the  $\alpha$ -value of 0.05 ( $p= 0.00 < \alpha= 0.05$ ) hence, the null hypothesis was rejected. This implies that there was significant difference between the creativity of students taught circle theorem using mathematics laboratory techniques and those taught using discussion method.

### Null Hypothesis 2 (H<sub>o</sub>2)

There is no significant difference between the creativity of male and female students taught circle theorems using mathematics laboratory technique. To test this hypothesis, the data collected was subjected to t-test analysis and is presented in table 4.

**Table 4: Summary of t-test Analysis of Male and Female of Experimental Group**

Variables	N	Mean	SD	DF	T-Value	P-value	Decision
Male	100	29.45	6.95				
				178	1.23	0.22	Retained
Female	80	28.14	7.27				

Source field work (2024)

$\alpha$ -value = 0.05

From table 4, the results showed that the  $p$ -value of 0.22 was found to be greater than the  $\alpha$ -value of 0.05 level ( $p= 0.22 < \alpha= 0.05$ ) hence the null hypothesis was retained. This implies that there was no significant difference between the creativity of male and female students taught circle theorems using mathematics laboratory technique in Katsina State is here by retained. Therefore, mathematics laboratory is gender friendly.

### Discussion

The findings of this research showed that, there is significant difference in the creativity of senior secondary school students taught circle theorem using mathematics laboratory technique and those taught using discussion method. This is also in agreement with Ojonubah (2016) who investigated the effectiveness of teaching mathematics using mathematics laboratory on students' mathematical achievements in tertiary institutions. It was reveal that students who were opportune to be taught

mathematics using mathematics laboratory are more creative than their counterparts who were not privileged to be taught mathematics using this technique of teaching.

It also reveals that there was no significant difference between the academic creativity of male and female students when taught circle theorem using mathematics laboratory technique. The findings are also in line with the findings of Ebele and Abigail (2008) who investigated the effect of using mathematics laboratory in teaching on students' achievement in Junior Secondary School Mathematics. The results also showed that no significant difference exists the creativity of male and female mathematics students taught with mathematics laboratory. It is also in line with the findings of Tafashiya (2017) who investigated the use of practical approach on teaching geometric concepts, students' attitudes and performance among junior secondary school II in Katsina metropolis, Katsina State, Nigeria. The findings indicated that practical approach plays a vital role in the teaching and learning process of circle theorem with no significant difference between male and female students.

### **Conclusion**

The following conclusions were drawn from the findings of the study:

1. Mathematics laboratory technique was found to have higher mean than discussion method as a tool for teaching circle theorems in secondary Schools.
2. Students taught circle theorem using mathematics laboratory technique are more creative than those taught using discussion method.

### **Recommendations**

Based on the findings and conclusions drawn from this research, the following recommendations are made:

1. Philanthropies should be encouraged to build mathematics laboratory in all senior secondary schools across Katsina state for effective teaching of mathematics.
2. Teachers should make use of mathematics laboratory to teach students because it develops a better understanding of concept and application of mathematics, it reduces the level of mathematics abstraction and above all it is gender free.
3. Government should ensure that adequate and qualified mathematics teachers are employed to teach the subject. Seminars and workshops should be organized for mathematics teacher on how to use mathematics laboratory techniques to teach mathematics in secondary schools.

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