ARCN International Journal of Advanced Academic and Educational Research
ISSN: 2360-9909. Volume 14, Issue 10, (March, 2024) pages 14 – 26
DOI: 2726145223714102
arcnjournals@gmail.com
https://arcnjournals.org

Effect of Laboratory-Enriched-Conceptual-Instructional Strategy on Attitude and Academic Achievement in Geometry Concepts among Secondary School Students in Niger State, Nigeria

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Abstract: *This study investigated the effect of Laboratory-Enriched-Conceptual-Instructional Strategy (LECIS) on Attitude and Academic Achievement in Geometry Concepts among Secondary School Students in Niger State, Nigeria. The study employed survey research design and pre-test, post-test experimental and control group design. The population of the study comprised of 1,868 JSS III students of Government Secondary Schools in Paikoro Educational Zone of Niger State during the first term of 2023/2024 academic session. The simple random sampling technique was used to select 52 (30 males and 22 females) students from two co-educational secondary schools respectively. The instruments used for data collection were the Geometry Performance Test Questionnaire with Pearson Product Moment Correlation coefficient of 0.72 and the Students' Attitude Towards Geometry Questionnaire with Guttman coefficient of 0.76 respectively. Based on the objectives of the study, four research questions were raised and answered using mean and standard deviation. Four research hypotheses were formulated and tested using Mann-Whitney U-test and t-test at $p \leq 0.05$ significant levels. The major findings of the study revealed that LECIS significantly enhanced students' performance and attitude towards geometry concepts more than the conventional lecture method. The findings also revealed that LECIS is gender-friendly as the achievement gap in favour of the males was statistically insignificant and attitudinal change in favour of female students was also statistically insignificant. Based on the studied subjects, it was concluded that LECIS supported the findings of related studies and proved to be more effective in enhancing students' performance and attitude towards geometry compared to conventional method. It was therefore, recommended that teachers should integrate LECIS into teaching geometry concepts; relevant agencies like Mathematics Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) should organize seminar/ workshops to train and re-train teachers on the use of laboratory – enriched instructional strategies; government should support schools with Mathematics laboratory equipment and further study should be carried out to cover wider population to re-affirm the findings of this study.*

Keywords: *Laboratory-Enriched-Conceptual-Instructional Strategy (LECIS), Attitude, Academic Achievement and Geometry Concept.*

INTRODUCTION

Mathematics is a tool for science and technology, not only through computational aids, but it also enables students to explore concepts with idealized models before trying them in the real world. Students' understanding of basic mathematical concepts will help them move to the next logically connected concepts. Progress made in mathematics literacy will impact positively on science and technology which is one aspect of education that accounts so much for the economic growth of any country (Musa & Dauda, 2014). New development in computing Technology mean that the 21st century will be one where spatial thinking and visualization are vital. Geometry is where those all-important skills are nurtured (Jones & Tzekaki, 2016).

Geometry: the word 'geometry' comes from two ancient Greek words, one meaning earth and the other meaning to measure. It is a branch of mathematics that deals with the measurement, properties, and relationship of points, lines, angles, surfaces, and solids. A useful contemporary definition of geometry is that attributed to the highly-respected British mathematician, Sir Christopher Zeeman: "Geometry comprises those branches of Mathematics that exploit visual intuition (the most dominant of our senses) to remember theorems, understand proof, inspire conjecture, perceive reality, and give global insight" (Jones, 2019). Geometry is an important area in the school curriculum throughout history; it has had great importance in people's lives, originating with the need of human beings to specify quantities, to measure figures, land and earth, and make maps. In order to represent and solve problems in topics of mathematics like trigonometry and in daily life situations, sound geometry knowledge is necessary. According to Sunzuma, Masocha and Zezekwa (2013), geometry is also used in other disciplines such as science (e.g, optics), geography (e.g., making maps), music (e.g., the pattern of the notes), art (e.g., making models), construction, architecture, gardening and traffic signs. Artists, builders, designers, masons, machinist, structural engineers and writers all make use of geometry daily. That is why the National Council of Teachers of Mathematics (NCTM, 2000) emphasized the importance of geometry in school mathematics by stating that geometry and spatial sense are fundamental components of mathematics teaching. Jones (2019) advanced reasons why geometry should be included in the school mathematics curriculum. He observed that the study of geometry contributes to helping students develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof. Furthermore, geometry representations can be used to help students make sense of other areas of mathematics; fractions and multiplication in arithmetic, the relationships between the graphs of functions (of both two and three variables), and graphical representations of data in statistics. Also, spatial reasoning is important in other curriculum areas as well as mathematics; science, geography, art, design and technology. Jones (2019) maintained that geometry provides a culturally and historically rich context within which to do mathematics and that working with practical equipment can also help develop fine motor skills. He opined that presenting geometry in a way that stimulates curiosity and encourages exploration can enhance student's learning and their attitudes towards mathematics.

However, a lot of challenges and difficulties have been identified which affects the successful teaching and learning of geometry in schools. Some of the identified challenges which contribute to students' perceived difficulty in learning geometry include poor reasoning skill on geometry, lack of geometry language comprehension, lack of visualizing abilities, poor background knowledge, students' knowledge of proofs, gender qualities, non-availability of instructional materials, and teaching method, among others (Kulbir,2021; Salistiowati, Herman & Jupri, 2019). Researchers (Soheil &Amani, 2020; Jones, 2019; Ugada, Ramatu & Alfa, 2018; Hamisu, 2017; Omwirhiren &Khalil, 2016; Alake, 2015; Arubayi, 2015) in separate studies have identified that negative attitude and poor achievement of students in geometrical concepts is attributed to the teacher's inability to enrich their teaching approach with appropriate instructional aids and practical activities. According to Fouze and Amit (2021), geometry is perceived as one of the most complicated mathematical areas to teach and that in the past twenty years, numerous studies have demonstrated the existence of a significant gap between teachers' ability to teach geometry and the ability of students to understand the subject matter.

Teaching and Learning Geometry at Junior Secondary School Level.

In the stages of instruction in Van Hiele theory, Van Hiele believed that in order to maintain a successful and effective instruction-learning process, instruction, should be in phases according to the level of thinking of the students, from lower to higher levels, with each stage including specific instructional activities (Fouze & Amit, 2021). According to Fouze and Amit (2021), difficulties in learning geometry appear among young students as early as elementary school and that such difficulties are expressed in the low level of basic skills among students. The National Council of Teachers of Mathematics (NCTM, 2000) provided a standard on how geometry can be taught and learned by publishing a list of geometry standard to guide teachers regarding the appropriate subject matter for each topic and age range. The standards are divided into four main realms of geometrical thinking:

1. The properties of shapes, students must be able to analyze characteristics and properties of 2-and 3-dimentional geometrical shapes and to develop mathematical reasoning regarding geometrical relations.
2. Location-space relationships, students must be able to specify locations and describe spatial relations while using coordinate geometry and other representational systems.
3. Transformations and symmetry, students must be able to apply transformations and use symmetry to analyze mathematical situations.
4. Visualization, students must be able to use visualization, spatial reasoning, and geometric modeling to solve problems.

According to Fouze and Amit (2021) geometry instruction must seek and identify thinking mistakes that children make in identifying shapes according to "standard shapes" or prototypes. Furthermore, it is recommended to conduct activities that facilitate student play with shapes, so that they can change them as they wish. Concepts directly concerned with geometry content at the Junior Secondary School level include construction of solid shapes from nets; copying of figures (Angles and triangles) using protractor and rulers only; an in-depth study of triangles (Classification by angles and by sides) and symmetrical plane figures; areas, perimeters and volumes of geometrical shapes (Plane or Solid), calculation of missing angles, circular faces, sectors and segments etc. This study focused on geometry contents such as definitions of plane and solid shapes, identifying plane and solid figures, and learning about their properties and calculation of lengths, perimeter, area and volume of plane and solid shapes. The instructional sequence was guided by the Van Hiele model on levels of thought in geometry (Visual, descriptive, abstract/ relational, and formal deduction; with more emphasis on visual and descriptive levels). The study was particularly focused on Junior Secondary School Students whose age range favours meaningful learning with conceptual models according to Piaget Cognitive Development Theory (1963). The present study focused on the following instructional approaches:

Conventional method of teaching geometry: It is observed that in the conventional method of teaching, most students graduate with memorized information as they are not given chances of problem-solving aimed at understanding of concepts. (Hamisu, 2017, Kulbir, 2021). Furthermore, a lesson designed to provide routine drill or mere memorization of mathematical facts may be less interesting than lesson whose goal is to stimulate thought or intellectual curiosity (Hamish, 2017). In this method, students are more of passive learners than active participants in the teaching-learning process.

Conceptual Instructional strategy of teaching geometry: Conceptual instructional strategy is a method of teaching mathematics that focuses on the understanding of math concepts rather than memorization of isolated fact, methods, or formulas or steps to find solutions to a math problem as is done in the Conventional method. The major aim of conceptual instruction is understanding of meaning and the workings behind the answer or solution to a math problem. Students taught with conceptual teaching create more sustainable understanding and increase students' procedural abilities and efficiency (Borji, Radmehr & Font, 2019). Conceptual teaching is said to substantially reduce the mathematics anxiety levels of mathematics students

(Khoule, Bonsu & El-Houari, 2017). Conceptual instructional strategy is aimed at helping students understand why a mathematical idea is important and the kinds of contexts in which it is useful. To teach geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in particular processes rather than the students solely learning rules (Kulbir,2021; Jones,2019). This approach involves the use of discussion, group work, guided discovery and hand-on–activity to develop an understanding of the concept learned (Hissan & Ntow, 2021). Hamisu (2017) observed that practical approach of teaching geometry concepts through mathematics Laboratory proved effective in enhancing student's achievement and attitude towards geometry concepts, especially at the junior secondary school level.

Laboratory method of teaching geometry: This is an instructional approach designed to lead students through practical activities to discover mathematical facts. It is based on the principle of learning by doing, learning by observation and proceeding from concrete to abstract. Students do not listen passively to the information, but do something practically (Soheil & Amani, 2020; Ugada, Ramatu, & Alfa, 2018; Omwirhiren & Khalil, 2016). In this method, principles have to be discovered, generalized and established which according to Soheil and Amani (2020) and Hamisu (2017) leads to understanding of geometry concepts and stimulate students interest in learning.

Laboratory-Enhanced–Conceptual–Instructional–Strategy(LECIS): LECIS is the enrichment of conceptual instructional strategy with mathematics laboratory experience. It is a mathematics teaching approach designed to enhance the understanding of concepts through exposure of students to mathematics laboratory activities. This idea was conceived by the researchers in the present study based on the fact that mathematics educators and researchers (Soheil & Amani,2020; Jones,2019; Ugada, Ramatu & Alfa, 2018; Hamisu, 2017; Alake,2015) have observed that majority of mathematics teachers hardly employ laboratory activities in the teaching of geometry concepts. Particularly, Hamisu (2017) noted that, although laboratory instruction is used in many disciplines such as Physics, Chemistry and Biology education, it is usually not used in mathematics education. This, according to her, leads many students developing misconceptions and others failing to go beyond simple visualization of geometric figures. Jones (2019) posits that more effective teaching approaches encourage students to recognize connections between different ways of representing geometric ideas and between geometry and other areas of mathematics. The evidence, according to him, suggests that this is likely to help students to retain knowledge and skills and enable them to approach new geometrical problems with some confidence. Instructional strategy as noted earlier have been identified as the major factor that accounts for students' negative attitude and achievement in geometry concepts. Hence, this study investigated the effect of LECIS on attitude and achievement of Junior Secondary School Students in Niger State, Nigeria.

Attitude and Achievement in Geometry

An attitude is defined as a positive or negative disposition towards an object, concept or situation and also refers to the readiness to react consistently to related objects, concepts, or situations. According to Hamisu (2017) attitude constitutes the affective aspect of mathematics learning such as: Beliefs about mathematics and its usefulness; Interest and enjoyment in learning mathematics; Appreciation of the beauty and power of mathematics; Confidence in using mathematics; Perseverance in solving a problem. In education, particularly in mathematics, attitude is one of the important elements which determines students' success. Students attitude towards mathematics is shaped by their learning experiences (Sulistiowati, Herman, & Jupri, 2019). According to Fouze and Amit (2021), 25% of the variance in academic achievements is explained by emotional characteristics of the students prior to learning processes. It is commonly believed that students with positive attitude towards mathematics will generally excel at it (Jones, 2019; Hamisu, 2017). Unfortunately, many studies reveal that most students dislike geometry concepts and thereby perform poorly in it. (Soheil & Amani, 2020; Sulistiowati, Herman, & Jupri,2019; Jones, 2019; Hamisu ,2017). While previous research (Rodrigueez, Regueiro, Pineiro, Estevez & Valle, 2020; Eccles & Wang, 2015) has suggested that female students tended to exhibit less positive attitude about mathematics than their male classmates. The study by Oluyemo, Musbau, Kukwil, Anikweze and Shaluko (2020) in Niger State Junior Secondary School revealed that female students showed more interest in maths than their male counterparts. These divergent results call for more investigations into gender differences in attitude towards mathematics, especially with regard to geometry concepts using LECIS.

Gender and Achievement in Geometry:

The issue of gender differences has attracted attention from educators and researchers. Gender involves masculinity (male) or feminity (female) and refers to culturally patterned behaviors either actual or normative which are attached to sexes. Student's sex has been a prominent factor in mathematics and geometry learning in particular, it is commonly assumed that the knowledge of mathematics, particularly geometry, between male and female students differs significantly and it is, in most cases, claimed that male students performed better than female students. (Oluyemo, Musbau, Kukwil, Anikweze & Shaluko, 2020; Rodriguez, Regueiro, Pineiro, Estevez & Valle, 2020; Hamisu,2017; Alake, 2015)

Statement of Problem

It has been observed that despite the utility of geometry in real life situations, students have continued to dislike the geometrical concepts and hence perform poorly in examinations, particularly in Nigerian schools (Ugada, Ramatu & Alfa, 2018, Hamisu, 2017, Alake, 2015, Musa & Dauda, 2015). The West African Examination Council (WAEC) Chief Examiner report (2019) indicated that most geometry questions in school certificate examinations are rarely attempted and if attempted they are badly tackled. This result seems to reflect a problem that continually calls into question the effectiveness of teaching-learning processes for mathematics content. This is particularly worrisome in Niger state where the researchers have observed that most secondary schools lack mathematics laboratories for practical activities, except few schools classified as 'Grade A' schools with special government attention. This has resulted to teachers relying solely on the conventional method which prepare students to memorize facts to pass examinations which according to Dauda (2015) are often aided by examination malpractice. Hence, what is even recorded as pass rate today rarely reflect conceptual understanding of mathematical concepts. To curb this type of problem, Jones (2019) opined that when planning approaches to teaching and learning geometry, it is important to ensure that the provision in the early years of secondary school encourages students to develop an enthusiasm for the subject by providing opportunities to investigate spatial idea and solve real life problems. Furthermore, there is also a need to ensure that there is a good understanding of the basic concepts and language of geometry in order to provide foundations for future work and to enable students to consider geometrical problems and communicate ideas. He also asserts that students should be encouraged to use descriptions, demonstrations and justifications in order to develop the reasoning skills and confidence needed to underpin the development of an ability to follow and construct geometrical proofs. It is useful to consider geometry as a practical subject and provide opportunities for students to use a range of resources to explore and investigate properties of shapes and geometrical facts. It is against this background that the present study investigated the effect of LECIS on attitude and academic achievement in geometry concepts among Secondary School Students in Niger State.

OBJECTIVES OF THE STUDY

The main purpose of the study was to examine the effect of Laboratory-Enriched-Conceptual Instructional Strategy (LECIS) on students' attitude and academic achievement in geometry concepts among JSS students in Niger State, Nigeria. Specifically, the objectives of the study were to:

1. Examine the effect of LECIS on the attitudinal change of JSS students towards geometry concepts.
2. Examine the effect of LECIS on academic achievement of students in geometry concepts.
3. Examine gender difference in the attitudinal change of JSS students towards geometry concepts.
4. Examine gender difference in academic achievement of students exposed to LECIS.

RESEARCH QUESTIONS

The study was guided by the following research questions:

1. What is the difference in the attitudinal change towards geometry concepts between students exposed to LECIS and those taught using conventional method?
2. What is the difference between the mean achievement of students exposed to LECIS and those taught using conventional method?
3. What is the difference in the attitudinal change towards geometry concepts between male and female students exposed to LECIS?
4. What is the difference between the mean achievement of male and female students exposed to LECIS?

RESEARCH HYPOTHESES

The following null hypotheses were formulated and tested at 0.05 significant levels:

H_{01}: There is no significant difference in the attitudinal change towards geometry concepts between students exposed to LECIS and those taught using conventional method.

H_{02}: There is no significant difference between the mean achievement of students exposed to LECIS and those taught using conventional method.

H_{03}: There is no significant difference in the attitudinal change towards geometry concepts between male and female students exposed to LECIS.

H_{04}: There is no significant difference between the mean achievement of male and female students exposed to LECIS.

METHODOLOGY

The study employed pre-test, post-test quasi-experimental control group design as proposed by Kerlinger (1973). The study comprised of experimental group (EG) and control group (CG). To establish equivalence in ability before treatment, the experimental group and the control group were both pre-tested. The experimental group (EG) were taught geometry concepts using laboratory-enriched conceptual strategy (LECIS) and the control group were taught using conventional method for a period of six weeks. They both used similar curriculum approved for JSS 1-III for all schools under the Ministry of Education. The experimental group and the control group were post-tested after treatment and were found to be of equal entry ability.

The population of the study comprised of 1,868 JSS III students of 15 Public Co-educational Secondary Schools in Paikoro Educational Zone of Niger State during first term of the 2023/2024 academic session. Two (2) secondary schools which fell into the category of 'Grade A' schools with mathematics laboratory facilities were purposively selected out of the fifteen (15) secondary schools. Access and proximity to the researchers also informed the choice of the schools. A total of 104 Students from intact classes were used and were randomly assigned into the experimental group (GDSS Kaffin-koro) with 52 students for the experimental group (Male, N=30, Female, N=22) and control group (GDSS Chimbi) with 52 Students for the control group (Male, N=30, Female, N=22) .

Two research instruments were used for data collection. The instruments were the Geometry Performance Test Questionnaire (GPTQ) adopted with modification from National Examination Council Junior Secondary School Mathematics Examination of 2015-2019 (objective questions) and Student Attitude Towards Geometry Questionnaire (SATGQ). The SATGQ was attitude towards geometry inventory questionnaire containing 20 Likert type (Strongly Agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly Disagree = 1) closed questions relating to the learning of geometry concepts and teachers' instructional strategy which was modified from Fennema-Sherman Attitude scale in (Sunzuma, 2013). The items of the GPTQ covered JSS 1-III Geometry Mathematics curriculum currently being used in the schools. The SATGQ contained 3 questions on positive attitudes towards geometry, and 8 questions on negative attitudes toward geometry, 4 questions were on usefulness of geometry and five questions were on effect of teachers' instructional strategy.

The GPTQ and SATGQ items were validated by two experienced senior mathematics and Science educators at A.B.U, Zaria and F.U.T Minna, Niger State to ascertain their appropriateness. The instruments were pilot tested on 60 students who did not comprise the sample of the study. The reliability and internal consistency of the test scores were ascertained using the split-half method (odd and even serial numbers). The scores of the two halves were correlated using Pearson Product Moment Correlation (PPMC) coefficient. The reliability of GPTQ was found to be 0.72. The SATGQ administered produced Guttman coefficient of 0.76. both instrument were certified reliable.

After the preliminary procedures of pre-testing both the experimental and control groups with the developed items, both groups were subjected to six weeks teaching covering the selected geometry topics by mathematics teachers with similar qualifications. Mathematics laboratory was set up for use in the experimental school where students were exposed to practical use of concrete models relating to geometry concepts. At the end of the teaching exercises, the groups were post-tested using the pre-test items to examine the effect of the instructional strategies on attitudinal change towards geometry concepts and achievement.

Results

Data obtained were used for statistical analysis to answer research questions and test the hypotheses formulated. The descriptive statistics, mean and standard deviation were used to answer the research questions while the research hypothesis one and three were tested using Mann-Whitney U-test and research hypothesis two and four were tested using t-test at 0.05 significant levels respectively.

Research Question One: What is the difference in the attitudinal change towards geometry concepts between students exposed to LECIS and those taught using conventional method?

Table 1: Mean Attitude Scores of students taught Geometry using LECIS and the Conventional Method.

Groups	Symbols	Pre-test	Post-test	Mean Difference
Experimental	N	52	52	29.1
	Mean	26.40	55.50	
	SD	3.06	2.07	
Conventional	N	52	52	
	Mean	26.70	26.80	0.1
	SD	3.07	1.10	

Table 1. Shows the Pre-test and Post-test comparison between the mean attitude scores of students in both the experimental and control groups. The table indicates that the mean gain difference of the experimental group (29.1) is higher than the mean gain difference of the control group (0.1) after the administration of treatment (LECIS). This shows that students taught geometry using LECIS scored higher mean attitude compared to those taught using conventional method.

Null Hypothesis One: There is no significant difference in the attitudinal change towards geometry between students exposed to LECIS and those taught using conventional method.

Table2: Summary of Mann-Whitney U-test of Significant Difference in Attitude towards Geometry of Students in Experimental and Control Groups After Treatment

Group	N	Mean	Mean Difference	U-cal	df	P-Value	Remark
Experimental	52	55.50	28.70	1131.40	102	0.01	Sig.
Control	52	26.80					

Significant at $p \leq 0.05$ level of significance

Table 2 indicates that the observed p-value = 0.01 corresponding to the U-value of 1131.40 is less than 0.05 level of significance. Hence, the null hypothesis is rejected. This shows there is significant difference in the attitudinal change towards geometry concepts between those exposed to LECIS and those exposed to conventional method. This implies those exposed to LECIS showed better attitudinal change towards geometry after treatment with a mean difference of 28.7 compared to those exposed to conventional method.

Research Question Two: What is the difference between the mean achievement of students exposed to LECIS and those taught using conventional method?

Table 3: Mean Scores of Achievement of Students taught geometry using LECIS and the conventional method.

Group	N	Mean	SD	Mean Difference
Experimental	52	61.25	13.45	13.89
Control	52	47.36	11.72	

Table 3 indicates that the mean (61.25) of the experimental group is higher than that of the control group (47.36). these shows that the performance of the experimental group was better than that of the control group after treatment with a mean difference of 13.89.

Null Hypothesis Two: There is no significant difference between the mean achievement of students exposed to LECIS and those taught using conventional method.

Table 4: Summary of t-test of Significant Difference in the Mean Achievement of Experimental and Control Group Students

Group	N	Mean	SD	df	t-value	P-value
Experimental	52	61.25	13.45	102	4.01	0.0000*
Control	52	47.36	11.72			

*Significant at $p \leq 0.05$

Table 4 reveals that at 102 degrees of freedom, the p-value, 0.0000* which corresponds to the t-value of 4.01 was less than 0.05 level of significance set for this study. Hence, the test was significant at 0.05 significant level and the null hypothesis was therefore rejected.

Research Question Three: What is the difference in the attitudinal change towards geometry concepts between male and female students exposed to LECIS?

Table 5. Mean Attitude Scores of Male and Female Students taught Geometry using LECIS

Gender	Symbol	Pre-test	Post-test	Mean diff
Male	N	30	30	
	Mean	24.10	67.50	43.40
	SD	0.81	1.06	
Female	N	22	22	
	Mean	23.70	67.19	43.49
	SD	1.08	1.09	

Table 5 Shows the pre-test and post-test comparison between the mean attitude scores of male and female students exposed to LECIS. The Table reveals that the mean gain difference of female students (43.49) is higher than the mean gain difference of male students (43.40). This shows that female students scored higher mean attitude difference compared to their male counterparts after exposure to LECIS.

Null Hypothesis Three: there is no significant difference in the attitudinal change towards geometry concepts between male and female students exposed to LECIS.

Table 6: Summary of Mann-Whitney U-test of significant difference in attitude towards Geometry of male and female students exposed to LECIS.

Gender	N	Mean	Mean diff	U-cal	df	P-value	Remark
Male	30	67.50					
			0.31	1.716	50	0.09	Not Sig.
Female	22	67.19					

Significant at $p \leq 0.05$ level of significance

Table 6: Shows that the observe p-value = 0.09 corresponding to the U-value of 1.716 is greater than 0.05 level of significance. Hence the null hypothesis is accepted. This shows that the difference in attitudinal change towards geometry concepts between male and female students exposed to LECIS is not statistically significant.

Research Question Four: What is the difference between the mean achievement of male and female students exposed to laboratory-enriched conceptual instructional strategy (LECIS)?

Table 7: Mean and Standard Deviation (SD) Scores of Students in the Experimental Group by Gender

Gender	N	Mean	SD	Mean Difference
Male	30	60.71	41.25	
Female	22	59.84	4.36	0.11

The results in Table 7 reveals that the mean achievement (60.71) of male students was higher than the mean achievement (59.84) of female students. This showed that the male students performed better than the female students with a mean difference of 0.11.

Null Hypothesis Four: There is no significant difference between the mean achievement of male and female student exposed to LECIS.

Table 8: Summary of t-test of Significant Difference in the Mean Achievement of Male and Female Students in the Experimental Group.

Gender	N	Mean	SD	df	t-value	P-value
Male	30	60.71	4.36	50	0.14	0.7861*
Female	22	59.84	4.25			

*Not significant at $p > 0.05$

Table 8 indicates that at 50 degrees of freedom, the p-value, 0.7861* corresponding to the t-value 0.14 was greater than 0.05 level of significance set for this study. Hence, the null hypothesis was upheld. This implies that although male students recorded higher mean score than female students as seen in Table 6, the difference was not significant.

Discussion of the findings

The result in Table 1 and 2 which provided answers to the research question one and hypothesis one revealed that students exposed to LECIS recorded significantly higher mean attitude score compared to those exposed to conventional method. This implies that LECIS might have impacted positively on the students' attitude towards geometry concepts. The findings of this study corroborate the findings of other mathematics and science researchers (Soheil & Amani, 2020; Hamisu, 2017; Ugada, Ramatu & Alfa, 2018; Alake, 2015; Arubayi, 2015; Mari & Gumel,2015) that exposing students to laboratory and activity based learning enhances students' attitude towards the learning of geometry concepts. The study recorded significant difference in the geometry achievement of students exposed to LECIS and those exposed to the conventional method as indicated in Table 3 and 4 respectively. The results showed that those taught geometry using LECIS achieved significantly higher mean scores in geometry concepts compared to their counterparts in the conventional group. This study has further supported the findings of other researchers (Soheil & Amani;2020; Hamisu, 2017; Ugada, Ramatu & Alfa,2018; Alake, 2015) who found that laboratory aided instruction improved students' achievement in geometry concept better than the conventional teacher-centered method.

The findings in table 5 revealed that the mean gain difference in attitudinal change towards geometry concepts of the female students is higher than that of their male counterparts after exposure to LECIS. This implies that female students showed better attitudinal change towards geometry concepts after exposure to LECIS compared to the male students. The findings of this study negates previous research (Rodriguez, Regueiro, Pineiro, Estevez & Valle, 2020;

Soheil & Amani,2020; Eccles & Wang, 2015) that suggested that female students tended to exhibit less positive attitude about mathematics than their male counterparts. However, this study further supported the findings of Oluyemo, Musbau, Kukwil, Anikweze and Shaluko (2020) who in their study of gender differences in mathematics interest and achievement in Junior Secondary School students in Niger State, Nigeria revealed that female students showed more interest in mathematics than their male counterparts. The findings in Table 6, however, revealed that there is no significant difference in attitudinal change towards geometry concepts between male and female students. This showed that both male and female students gained higher mean attitudinal difference after exposure to LECIS. This implies that LECIS impacted positively on the attitude of both male and female students.

The results in table 7 and 8 revealed that the difference between the mean achievement of male and female students exposed to LECIS was not statistically significant. The results supported what previous finding in the related literature (Rodriguez, Regueiro, Pineiro, Estevez & Valle, 2020; Ghasemi, Burley & Safadel,2019; Hamisu, 2017; Ugada, Ramatu, & Alfa, 2018; Alake, 2015) has suggested that there were no statistically significant large differences observed comparing the performance of male and female students in mathematics achievement. However, a study of gender differences in mathematics interest and achievement in Junior Secondary School students of Niger State by Oluyemo, Musbau, Kukwil, Anikweze and Shaluko (2020) found a significant difference between mean achievement of male and female students in mathematics and concluded that male student excelled in mathematics than their female counterparts. This result could be due to the content and instructional strategy used in their study. However, the present study has shown that using LECIS has proved effective in narrowing down gender gap in mathematics achievement.

CONCLUSION

The findings of the study revealed that the use of laboratory-enriched-conceptual instructional strategy (LECIS) is effective in enhancing students' attitude and achievement in geometry concepts. The enhancement of students' attitude and achievement in geometry concepts was consistent for both male and female students and thereby proved LECIS to be gender-friendly. The result strengthened the view that laboratory-enriched conceptual instructional strategy where students are exposed to the use of concrete models or manipulatives in learning proved to be more effective in enhancing students' attitude and achievement compared to the conventional method. Hence, the conceptual understanding of mathematics required for science and technology development can be achieved through the utilization of LECIS for teaching and learning geometry concepts, especially at Junior Secondary School level of education.

Recommendations

1. The state government should provide more funds for setting-up more mathematics laboratories in Niger State Secondary Schools to encourage conceptual understanding of mathematics through LECIS to curb the problem of rote learning through the conventional method.

2. The Ministry of Education in conjunction with relevant mathematics and science association such as Mathematical Association of Nigeria (MAN) and Science Teachers Association of Nigeria (STAN) should organize seminars, workshop, conferences for the training and re-training of teachers on the use of LECIS for teaching and learning mathematics.

3. Mathematics educators should be encouraged to integrate LECIS in the teaching of geometry concepts, especially at the Junior Secondary School levels.

4. Further studies should be conducted to cover wider population to reaffirm the findings of this study.

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