Research Article

EFFECTS OF ETHNO-MATHEMATICS INSTRUCTIONAL APPROACH AND PROBLEM-BASED LEARNING STRATEGY ON STUDENTS' INTEREST, ACHIEVEMENT AND RETENTION IN GEOMETRY IN BENUE STATE, NIGERIA

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ABSTRACT: This study examined the effects of the Ethno-mathematics instructional approach and Problem-based learning strategy on students' interest, achievement, and retention in geometry in Benue State, Nigeria. Quasi-experimental design involving pretest, posttest, and post-posttest with two experimental groups and one control group. Twelve research questions guided the study and twelve hypotheses were tested at 0.05 level of significance. The population comprised 20,213 Junior Secondary Two (JS II) students, with a sample of 1,200 students selected using simple random sampling. Two instruments were used for data collection namely; Geometry Interest Ratings Scale and Geometry Achievement Test. Content validity index for GIRS was 0.78 and construct validity for GAT was 0.88. The reliability of GIRS was tested using Cronbach Alpha formula which yielded an index of 0.81 and K-R_{21} was used to determine the reliability index of GAT which yielded an index of 0.75. Data were analyzed using mean and standard deviation for research questions and Analysis of Covariance (ANCOVA) for hypotheses The findings indicated a significant difference in the mean interest ratings of students taught geometry using the ethno-mathematics instructional approach, problem-based learning strategy, and conventional teaching approach. However, no significant difference was found in the mean interest scores between male and female students taught geometry using the ethno-mathematics instructional approach or problem-based learning strategy. Additionally, there was a significant difference in the mean achievement and retention scores of students taught geometry using these approaches compared to the conventional teaching approach. No significant difference was found in the mean achievement or retention scores between male and female students taught using these approaches. The ANCOVA result on the interaction effect between methods and gender on retention indicates that there is no significant interaction effect between Ethno-mathematics instructional approach, Problem-based learning strategy and gender on retention. Based on the findings of this study, it is recommended that: Students should be subjected to consistent utilisation of ethno-mathematical operations within their culture, adoption of the ethno-mathematics instructional approach in the school system, and training of mathematics teachers in the use of ethno-mathematics instructional approach to improve students' interest, achievement and retention in geometry.

KEYWORDS: Ethno-mathematics, Geometry Problem-based Approach, Retention, Achievement, Interest.

INTRODUCTION

Mathematics is a science of magnitude and number as well as the science that sustains the daily practices of man. It is the only core science subject that acts as pivot on which national development and wealth of any nation is created. Competency in mathematics learning is vital and sustainable to every individual's meaningful and productive life. Mathematics learning is very important in enhancement and sustainability of human existence because mathematics is all about finding solutions to human problems and physical challenges. The importance of mathematics education in Nigeria's educational system cannot be overemphasized because it is the core of science and technology which every country needs to improve its human, material and natural resources. Where mathematics education is already faulty, the nation is faced with reduction in both scientific and technological input and output.

Geometry is a fundamental branch of mathematics that studies the sizes, shapes, positions, angles and dimensions of objects. Geometry is one of the most useful and important branches of mathematics. Geometry concepts were developed from the beginning of civilization. Geometry is an integral component of mathematics which contains more verbal and abstraction problems related to points, lines, curves, angles, shapes of objects, trajectories and manifolds which are directly related to our daily life problems. The problem of learning geometry in Nigeria primary and post-primary school levels has continues to be topical and attracts the attention of Researchers in the field. The incessant low level of achievement in geometry among Nigerian pupils and students is a clear manifestation of inappropriate teaching approach of this perceived problem (Unodjaku, 2016). The high rate of failure of students in geometry at secondary school level is no news in the global setting. The recurrent poor achievement of secondary school students in West African Examination Council (WAEC) in Nigeria is disturbing and embarrassing. For instance, the results released by WAEC in 2013 to 2022 revealed poor achievement in mathematics of the candidates who sat for the examination did not obtain credit level pass in mathematics.

To provide solution to the problem of poor achievement in geometry, Abiam, Abonyi, Ugama and Okafor (2016) has recommended that method of teaching geometry should be practical, applicable and project oriented to reflect the immediate cultural environment of the learner. This will help the education system achieve the national objectives of inculcating the right type of values and attitudes for the survival of the individual, the training of the mind, abilities and competences and so on as required for the individual to live and contribute meaningfully to the growth and development of the society. Ethno-mathematics is highly relevant in the learning of geometry as it connects mathematical concepts to cultural experiences and backgrounds (Sunzuma, 2020). By incorporating ethno-mathematics approaches, teachers can make geometry more meaningful and relatable for students (Sunzuma, 2020). Ethno-mathematics allows for the exploration of mathematical ideas within different cultures, providing a more diverse and inclusive perspective on geometry (Sunzuma, 2020). It also helps to decentralize Eurocentric thinking in mathematics education and promotes the understanding of cultural mathematical manifestations (Souza, 2020).

Integrating ethno-mathematics into geometry education has several potential benefits. Firstly, it can enhance students' understanding and learning of geometry concepts (Sunzuma, 2020). By incorporating cultural context and traditional practices, such as the use of religious symbols and specialized teaching materials, students can develop a deeper appreciation for geometry and its relevance to their own lives (Supriyadi, 2022). Secondly, integrating ethno-mathematics can improve students' creative thinking skills (Supriyadi, 2022). For the mathematical instruction to improve the achievement and interest of the learner there is a need for geometry teaching approach that has the student’s cultural background that bridges the gap between indigenous mathematics and Euro-centric mathematics which will mold students into becoming good problem solvers. In this study, ethno-mathematics instructional approach and Problem-based Learning Strategy will be employed to determine their effects on students’ interest, achievement and retention in geometry.

Problem-based Learning Strategy (PBLS) is an instructional strategy that provides students with knowledge suitable for problem solving. It is a carefully constructed, open-ended problem that is used by groups or individual students to work through content to a solution. Problem-based Learning Strategy is a student-centered approach, students find it more enjoyable and satisfying, it encourages greater understanding, develops lifelong learning skills and students with Problem-based Learning Strategy experience rate their abilities higher. Interest is related to a student’s preparedness or mastery of subject matter background knowledge that enables the learner to cope with more or subsequent higher levels of subject matter or related learning task learning. Interest is an aspect of learning prerequisites which determine the extent to which concentration and attention is maintained towards teaching and learning encounter. Retention in mathematics is not acquired by mere rote-memorization but through appropriate teaching approach (Iji, 2016 & Chianson, 2018). If students achieve so much in geometry, will they also retain what they have learnt if exposed to ethno-mathematics teaching approach? This question further motivates this study. Retention has been defined as the process of ensuring the continued availability of a replica or newly acquired knowledge or repeated performance by a learner who has paid for the knowledge Siemon *et al. (*2016).

Gender is a socially constructed trait that separates females and males. Numerous research findings in Nigeria indicated that boys perform better than girls in mathematics on average, despite being placed in the same school environment. Boys achieve much more than girls in geometry as a result of their retention rate (Abiodun & Nchelem, 2020). Adegun and Adegun (2013) found that there is no disparity in the performance of male and female students in geometry. Gender has no specific effect on the learning of geometry while Udousoro (2017) was of the opinion that mathematics is male gender friendly. This study therefore, set out to determine the effects of ethno-mathematics instructional approach and problem-based learning strategy on students’ interest, achievement and retention in geometry. Also, gender was employed as a moderating variable for this study.

STATEMENT OF THE PROBLEM

Globally, geometry is a crucial part of the mathematics curriculum, intersecting significantly with science and technology. However, many students find it challenging, resulting in a widespread phobia. This difficulty is attributed to the abstract nature of geometry, leading students to struggle with understanding basic computations, logic, fundamental principles, and processes. Consequently, students often resort to rote memorization, resulting in consistently poor performance and a lack of interest in the subject. To address these challenges, it is suggested that school mathematics should be rooted in the local environment of the students. This approach would move from culturally familiar concepts to unfamiliar ones, making the subject more relatable and engaging. Conventional teaching methods have failed to leverage the students' geometrical experiences from their home environments, resulting in a persistent gap in understanding and interest. Recent research has explored various teaching methods, including discovery, lecture, project, visual, heuristic, case study, survey, expository, laboratory, inquiry, targettask, delayed formalization, computer-aided instruction, and problem-solving methods. Despite these efforts, the situation remains dire, particularly at the junior secondary school level. There is a pressing need for a method that utilizes familiar, culturally relevant materials to engage students and improve their performance.

This study investigated the effects of the Ethno-mathematics Instructional Approach and Problem-Based Learning Strategy on students' interest, achievement, and retention in geometry in Benue State, Nigeria. The Ethno-mathematics Instructional Approach leverages local cultural artifacts and home-based materials, making learning more relatable and practical. Both teachers and students use familiar materials from their environment to teach and learn geometry, enhancing the ability to solve real-life problems. The study aims to determine whether these strategies can effectively increase students' interest, achievement, and retention in geometry compared to conventional teaching methods.

OBJECTIVES OF THE STUDY

The main purpose of the study was to examine the effects of Ethno-mathematics Instructional Approach and Problem-based Learning Strategy on Students' Interest, Achievement and Retention in Geometry in Benue State, Nigeria. The specific objectives of the study were to:

1. ascertain the effect of ethno-mathematics instructional approach and problem-based learning strategy on students' interest in geometry.
2. determine the effect of gender on students' interest in geometry when taught using ethno-mathematics instructional approach.
3. establish the effect of gender on students' interest in geometry when taught using problem-based learning strategy.
4. examine the effect of ethno-mathematics instructional approach and problem-based learning strategy on students' achievement in geometry.
5. determine the effect of gender on students' achievement in geometry when taught using ethno-mathematics instructional approach.
6. establish the effect of gender on students' achievement in geometry when taught using problem-based learning strategy.
7. ascertain the effect of ethno-mathematics instructional approach and problem-based learning strategy on students' retention in geometry.
8. determine the effect of gender on students' retention in geometry when taught using ethno-mathematics instructional approach.
9. examine the effect of gender on students' retention in geometry when taught using problem-based learning strategy.
10. find out interaction effects of ethno-mathematics and problem-based approach and gender as measured by Geometry Interest Rating Scale.
11. find out interaction effects of ethno-mathematics and problem-based approach and gender as measured by Geometry Achievement Test.
12. ascertain the interaction effects of ethno-mathematics and problem-based approach and gender as measured by Geometry Retention Test.

The hypotheses of the study were stated in line with the specific objectives of the study.

LITERATURE REVIEW

CONCEPTUAL FRAMEWORK

The conceptual framework was explored under the following sub-headings; Geometry, Ethno-mathematics Instructional Approach (EIA), Problem-based Learning Strategy (PBLS) in Geometry, Students' Interest in Geometry, Students' Achievement in Geometry, Students' Retention in Geometry, and Gender issues in Geometry.

GEOMETRY

Geometry (from Ancient Greek γεωμετρία (geōmetría) 'land measurement'; from γῆ (gê) ' earth, land', and μέτρον (métron) 'a measure') is a branch of mathematics concerned with properties of space such as the distance, shape, size, and relative position of figures. Geometry is, along with arithmetic, one of the oldest branches of mathematics. Geometry is a fundamental branch of mathematics that deals with the study of shapes, sizes, properties, and the relative positions of figures and spaces. It plays a crucial role in various aspects of our lives, from architecture and engineering to art and nature (Serra, 2017). The term "geometry" is derived from the Greek words "geo" (earth) and "metron" (measurement), reflecting its historical roots in land measurement and surveying (Usiskin, 2018). One of the foundational concepts in geometry is the point, which is a location in space with no size or dimension. Points are used to define other geometric elements such as lines and planes. A line consists of an infinite number of points and extends infinitely in two opposite directions. When two lines intersect, they form angles, another essential concept in geometry. Angles measures the amount of rotation needed to bring one line into alignment with another (Serra, 2017).

Geometry is often categorized into two main branches: plane geometry and solid geometry. Plane geometry deals with objects and figures in a two-dimensional space, such as triangles, circles, and polygons. Solid geometry, on the other hand, involves three-dimensional shapes like cubes, spheres, and pyramids. These geometric principles are applied in various fields, including engineering, architecture, and computer graphics, where they are essential for designing and modeling structures and objects. Geometry is a foundational and versatile field of mathematics that investigates the properties and relationships of geometric objects in both two and three-dimensional space. Its applications are vast, ranging from practical uses in construction and engineering to its role in explaining complex physical phenomena in the universe (Leikin, Berman & Zaslavsky, 2017). Understanding the concepts and principles of geometry provides a valuable foundation for many other branches of mathematics and sciences, making it a crucial field of study in both academia and everyday life.

ETHNO-MATHEMATICS INSTRUCTIONAL APPROACH (EIA)

Ethno-mathematics was coined in 1986 by Ubiratan D'Ambrosio, a Brazilian mathematics instructor. This concept is strongly ingrained in Paul Freire's beliefs and philosophy. Ethno is a prefix that refers to a particular ethnic group or culture. It is derived from the Greek word "ethnos" which means "people" or "nation". The term "ethno" indicates a focus on the study of a particular cultural ethnic D'Ambrosio, (2009). Thus, ethno-mathematics as defined by Davidson (2019) is the art or approach of explaining, knowing and comprehending multiple cultural situations. Additionally, Shirley (2019) asserted that ethno-mathematics has evolved to encompass the documentation and research of culturally specific learning techniques. It is discovered to aid in the development of mathematics students, particularly female students. Ethno-mathematics assumes that mathematics, like many other human endeavors, is a cultural product of human experience, that it varies between groups, and that it is contingent upon social power relations.

Ethno-mathematics presupposes that mathematics, like many other human endeavours, is the cultural product of human experience; that it may vary from one group to another and that it depends on social power structures (Terry, 2019). Ethno-mathematics began as a topic of academic research during the 1980s by the Brazilian Researcher Ubiratan D'Ambrosio, (1985) who claimed that the "standard" mathematics generally accepted in Europe and North America is not the only mathematics in existence, and that various social, ethnic and cultural groups have their own kinds of mathematics (D'Ambrosio, 1985).

An ethno-mathematical curriculum brings a broader understanding about the importance of geometry to pedagogical activities developed in the mathematics classrooms (Borba, 2022). Most mathematics curricula focus on the mastery of skills, accumulation of facts, rules, and algorithms that are necessary for official examinations. Since the curriculum is experienced as mathematical content, most students leave school thinking that geometry is something to be done only at school and that it has no relevance to their lives.

PROBLEM-BASED LEARNING STRATEGY (PBLS) TO LEARNING GEOMETRY

Problem-based Learning (PBLS) is an instructional strategy for teaching mathematics in general and geometry in particular which has been neglected especially in Nigeria. In Problem-based Learning Strategy, complex problems rooted in real life or world situation are used to motivate students into discovering important concepts, their interconnections and making generalizations. This means that learning begins with a problem presented in the same context, as it would be encountered in real life (Abonyi, 2015). Problem-based Learning Strategy is a cooperative and or active learning approach. When presented with the problem, students begin by organizing their ideas and previous knowledge to define the problem's broad nature. When they reach the point where certain information is lacking, or where they feel they do not understand the problem any longer, they assign responsibilities to one another to experiment on the problem or learning issues. In the next class they teach one another the result of their research findings. They summarize their presentations in a way that allows for integration into the problem context. Where assumptions are made, the student continues to dig progressively deeper into underlying contents and concepts. This therefore means that Problem-based Learning Strategy is not a single strategy but rather a collection of strategies, which can be assembled, in different forms. It uses intellectual curiosity as a driving force for students learning (Amalia, Surya & Syahputra, 2017; Nweke, 2015; Adeoye, 2015).

Problem-based strategy is a student centered teaching method in which students understand a topic by working in groups. Problem-Based Learning (PBL) strategies are diverse and cater to different learning environments and objectives. Here are several key types:
Case-Based Learning (CBL) uses detailed scenarios (cases) based on real-life situations that require problem-solving. Discussion**: CBL immerses students in realistic contexts, promoting critical thinking and application of knowledge, often involving group discussions that allow students to collaboratively explore and analyze the case, leading to deeper understanding and retention.

Project-Based Learning (PBL) involves students working on a project over an extended period, culminating in a final product or presentation. Project-Based Learning emphasizes hands-on, real-world challenges, encouraging students to engage in sustained inquiry, problem-solving, and creation, fostering skills such as project management, teamwork, and communication as they navigate the complexities of their projects.
Inquiry-Based Learning (IBL) involves students formulating questions, conducting research, and deriving solutions or new understandings, placing students at the center of their learning journey to promote curiosity and self-directed learning while developing research skills and critical thinking as they learn to ask pertinent questions, gather and analyze information, and draw conclusions.

Collaborative Learning involves students working together in groups to solve problems or complete tasks, harnessing the power of group dynamics to enhance learning by building communication, teamwork, and interpersonal skills as students share knowledge, debate ideas, and support each other's learning processes.
Design Thinking is a solution-based approach that starts with understanding the user's needs, ideating possible solutions, and prototyping and testing these solutions, encouraging creativity, innovation, and user-centered problem-solving by involving empathy, experimentation, and iterative learning to help students develop practical and human-centric solutions.
Role-Playing involves students assuming roles within a scenario to explore different perspectives and solve problems, enhancing empathy, communication, and perspective-taking by allowing students to immerse themselves in various roles, understand different viewpoints, and develop problem-solving strategies from multiple angles.
Simulation-Based Learning uses simulations to mimic real-world processes or systems for learning purposes, providing a safe environment for experimentation and decision-making, helping students understand complex systems, practice skills, and apply theoretical knowledge in controlled, yet realistic settings.

Each of these PBL strategies offers unique benefits and can be adapted to various educational contexts to enhance student engagement, understanding, and skill development. However, the best problem-based learning strategy that aligns with the study is Project-Based Learning (PBL). The study aimed to examine the effects of the Ethno-Mathematics Instructional Approach and Problem-Based Learning Strategy on students' interest, achievement, and retention in geometry. Project-Based Learning (PBL) involves students working on a project over an extended period, culminating in a final product or presentation. This aligns with the description of the study where students were engaged in learning geometry over time, with a focus on achieving specific outcomes (interest, achievement, and retention) related to the project-based approach. Additionally, PBL emphasizes hands-on, real-world challenges, encouraging students to engage in sustained inquiry, problem-solving, and creation. The study utilized a quasi-experimental design involving pretest, posttest, and post-posttest with two experimental groups and one control group, which is characteristic of PBL's approach to project-based learning. Therefore, Project-Based Learning (PBL) is the most suitable strategy to explain the study due to its alignment with the research objectives and methodology described.

CONVENTIONAL METHOD TO LEARNING GEOMETRY
In conventional method of teaching geometry typically involves a teacher-centered approach where the teacher present mathematical concept and procedures to students and students are expected to memorize and apply these procedures to solve problems. This approach has been the dominant model of mathematics teaching for many years. It has come under criticism in recent years for its limitation. The conventional method to learning geometry revolves round the teacher and it is more of group-oriented and teacher centered (Borba, 2022). Conventional method is the oldest form of teaching geometry. It requires the teacher to go into the classroom, tell the content development line

by line, allow the students to pay attention and to copy. The teacher assumes that position of knowing it all in the teaching and learning situation and provides information which he feels that students do not have (Nweke, 2015). Conventional method is that approach where the teacher prepares the lesson plan and comes to the class, express the knowledge to the students who passively take down with regards whether the student understand or not. Conventional method makes the students passive learners in the classroom without active participation as a result, there is no opportunity to express themselves or ask questions.

STUDENTS' INTEREST IN GEOMETRY

Interest in geometry can be defined as students' willingness and eagerness to engage with the subject. When students have a strong interest in geometry, they are more likely to be motivated to learn, explore and master the subject. Interest has to do with preparedness or mastery of a subject matter background knowledge that can enable the learner to cope with further or next higher level of learning of the subject matter or related learning task (Idigo, 2019). This suggests that geometry interest test for Junior Secondary School level has to do with mastering the requisite skills in Junior Secondary School (JSS) level geometry that enable the JSS students cope with further learning of geometry at the next higher level of mathematics teaching and learning. Geometry interest test can be developed and used as an indicator of success in geometry, particularly in geometry.

Lack of interest to learn geometry is caused partly by mathematics phobia and distractions from peer group. According to Idigo (2018), factor associated with geometry interest includes: students' factors, teachers' factors, mathematics anxiety, government, lack of infrastructural facilities for teaching and learning. A qualified mathematics teacher can arouse students' interest in geometry through the use of appropriate instructional strategies in teaching. If a teacher presents his/her lessons in an attractive manner, it will stimulate students' interests in the learning task. Achi (2016) observed that many students in Nigerian schools are absenting themselves in geometry lesson and have no interest in geometry. Teaching approaches and students' interest are connected to students' achievement in geometry and helps to improve student's level of understanding in geometry.

STUDENTS' ACHIEVEMENTS IN GEOMETRY

Achievement refers to a student's level of understanding and mastery of mathematical concepts and skills. It is typically measures through assessment such as tests, quizzes and examination and is important indicator of a student**'s** mathematical proficiency. Students' achievement in geometry could be seen as the level of proficiency and knowledge demonstrated by an individual after learning has occurred. Iwudu (2019) stressed that, the yardsticks for measuring one's academic achievements is assessing the academic performance of the individual through tests and systematic observation. Academic achievement can be described as high or low. When academic achievement is measured, one can observe it as being high when a student excels and perform extra-ordinary well in geometry by scoring high mark. But when students perform poorly in geometry by scoring very low marks, geometry achievements are said to be low. The measurement of achievement in geometry focuses on the poor performance of students.

STUDENTS' RETENTION IN GEOMETRY

Retention refers to students' ability to retain and remember geometry especially, geometry concepts and skills over a period of time, when a student retain what they have learned in geometry, they are better equipped to build upon their knowledge and skills in the subject. Retention has been described as the process of maintaining the availability of a replica of the acquired new knowledge or repeat performance by a learner with an acquired price of knowledge (Nneji, 2019).

Retention also refers to the ability to remember or utilize already acquired knowledge or skills, knowledge, habits, attitude or other responses initially acquired. Retention plays an important role for what is learned to be effectively applied. Students' poor retention in geometry may not be unconnected with rote learning that is prevalent in schools. Geometry concepts cannot be learnt properly by memorization through rote learning as human beings have limited capacity for memorization. To effectively use or apply whatever one had learnt, retention plays an important role. To Ausbel (2018) retention is the process of maintain the availability of replica of the acquired new meaning or some part of geometrical concepts. Teaching approaches, interest, achievement and retention have been linked with gender, with some studies establishing male have more interest, achieve and retain more in geometry than their female counterpart.

GENDER ISSUES IN GEOMETRY

Gender in geometry refers to the unequal representation and achievement of males and females in geometry education. The issues of gender in geometry have attracted attention from educators and Researcher. Gender refers to cultural patterned behaviours either actual or normative which are attached to sex. Tiedemann (2020) observed that in the first through third grades, females tend to perform better than males in geometry. Tiedemann (2020) stated that when teachers are consulted, they believe that the difference in achievement between males and females is prevalent because males are more logical and therefore, they have built in advantages over the females because geometry is logic.

Lawrence and Palhares (2016) stated that males excel higher confidence levels in their geometrical abilities, because males view geometry as a male dominated arena. Teaching and learning of geometry should adopt approach that encourages the manifestation of the derived attributes irrespective of individual and gender differences that exists. It is common assumption that knowledge of geometry between male and female students differ significantly. In most cases, the male students are claimed to be better in geometry. Having reviewed all the basic concepts in this study, the next section reviews the empirical studies on which this study is anchored.

EMPIRICAL STUDIES

Adamu (2022) conducted a study titled "Effects of Ethno-mathematics Teaching Approach on Students' Achievement, Interest, and Retention in Geometry in Benue State, Nigeria." Using a sample of 270 students and a quasi-experimental design, data were analyzed with linear regression and ANCOVA. The study found that the ethno-mathematics approach negatively affected achievement but positively and significantly influenced students' interest and retention. Male students had higher achievement, while female students had greater interest with this approach compared to conventional methods.

Achor, Imoko and Uloko (2017) carried out a study on Improving Some Nigeria Secondary Students' Achievement in Geometry used a non-equivalent pre-test, post-test control group quasi experiment design, on intact classes assign to the experimental and control groups. ANCOVA was used to analyze the data that there was a significant difference between the mean achievement of the group taught geometry using team approach and the group that interacted with their class teachers using problem solving approach. (F_1, 287=117.96, $p<0.05$). However, male and female students taught geometry did not differ in their mean achievement significantly (F_1, 287=9,690, $p>0.05$), There was significance interaction effect of gender and method on student achievement in geometry.

Also, Achor, Imoko and Uloko (2019) examined the Effect of Ethno-mathematics Teaching Approach (ETA) on Senior Secondary Students' Achievement and Retention in Locus. Results from the analysis revealed that students exposed to ETA were superior in achievement and retention than those taught with conventional approach. Thus there were significant differences between the mean score of the students taught Locus with ETA and those taught with the conventional approach in both achievement (F_1, 248 = 241.317, p = 0.000) and retention (F_1, 248 = 270.421, p = 0.000

However, Kurumeh, Onah and Mohammed (2014) carried out a study on improving students' retention in Junior Secondary School statistics using the ethno-mathematics teaching approach in Obi and Oju Local Government Areas of Benue State, Nigeria. The results revealed among others that the ethno-mathematics teaching approach was more effective in facilitating and improving students' retention in statistics than the conventional approach. The ethno-mathematics teaching approach did not significantly differentiate between the sexes (male and female) retention scores in statistics. These findings have implications for all mathematics teachers and stakeholders in mathematics education.

Furthermore, Unodiaku (2013) ascertain the effect of Ethno-mathematics Teaching Materials on Students' Achievement in
Mathematics. Findings of the study showed that the ethno-mathematic Achievement Test was effective in enhancing students' achievement in mensuration with particular reference to volumes of cylinder and hemisphere.

Again, Ozofor and Onos (2018) examined the Effect of Ethno-mathematics on Senior Secondary School Students' Achievement in Ikwuano Local Government Area, Abia State, Nigeria. The results revealed among others that ethno-mathematics approach was more effective in facilitating students' achievement. Both gender benefited significantly in achievement using Ethno-mathematics approach. The study revealed that interaction effect between method and gender was significant in interest.

Additionally, Umar, Tudunkaya and Muawiya (2019) determined the effectiveness of ethno-Mathematics Teaching Approach on Performance and Retention in Trigonometry in Zaria Local Government Area of Kaduna State, Nigeria. The results from the analysis revealed that students exposed to Ethno-mathematics Teaching Approach were superiors in performance and retention than those taught with conventional Approach. Thus there were significant differences between the mean performance scores and retention scores of the students taught Trigonometry concepts with Ethno-Mathematics Teaching Approach and those taught with conventional approach. It was recommended that necessary attention should be accorded to application of Ethno-mathematics concepts in real life situation by the mathematics teachers.

Moreover, Abiodun and Nchelem (2020) employed a quasi-experimental research design to investigate the effects of Integrating Ethno-mathematics into Secondary School Mathematics Curriculum for Effective Artisan Creative Skill Development in Abia State, Nigeria. The findings revealed that students taught by integrating Ethno-mathematics Instructional Approach (EIA) via practical had the greatest mean gain in the acquisition of creative skills. There was a significant difference in the creative skills acquired by students for artisan skills development when taught using EIA and CIA.

However, Abiam, Abonyi, Ugama and Okafor (2016) examined the Effects of Ethno-mathematics based Instructional Approach on Primary School Pupils' Achievement in Geometry. One (1) research question and one (1) null hypothesis, tested at 0.05 levels of significance guided the study. The results of the study revealed among others, that the Ethno-mathematics-based instructional approach was superior to the conventional method in enhancing pupils' achievement in Geometry.

On the other hand, D'Ambrosio and Rosa (2017) examined Ethno-mathematics and its Diverse Approaches for Mathematics Education. This concept of Ethno-mathematics is primeval in recognizing the emergence of perceptions of space and time and the techniques of observing, comparing, classifying, ordering, measuring, quantifying and inferring that are different styles of abstract thinking in the school curricula. This is can be achieved by the application of the trivium curriculum, which is an innovative Ethno-mathematical approach that needs more investigations to address its pedagogical purposes.

Conversely, Ajai, Imoko and Okwu (2018) carried out a study on Comparison of the Learning Effectiveness of Problem-Based Learning (PBL) and Conventional Method of Teaching Algebra in Department of Science Education, Faculty of Education, Taraba State University, Jalingo, Taraba State, Nigeria. Findings of the study showed that students taught using PBL achieved significantly higher in the post test than those taught algebra using conventional method. The interaction effects on achievement due to methods and gender was not significant. The study proved the efficacy of Problem-Based Learning.

Consequently, Achor, Imoko and Ajai (2010) carried out a study on Sex Differentials in Students' Achievement and Interest in Geometry Using Games and Simulations Technique. Findings reveal that male and female students taught using games, and simulations did not differ significantly both in achievement and in interest. It was recommended among others that mathematics teacher should always use relevant games and simulations in teaching mathematics concepts but paying equal attention to the learning needs of both male and female students, and that school administrators should be encouraged to provide local games that could facilitate meaningful learning of mathematics.

THEORETICAL FRAMEWORK

The theoretical framework for this study was based on Vygotsky's Social Constructivist Theory (1978) and Bruner's Discovery Learning Theory (1960).

VYGOTSKY'S SOCIAL CONSTRUCTIVIST THEORY (1978)

Vygotsky's Social Constructivist Theory (1978) forms the basis of the socio-cultural approach, emphasizing the role of culture and environment in learning. In geometry classrooms, this theory promotes problem-solving in real-life contexts to connect previous knowledge with new concepts and transfer them to practical situations. The theory advocates for an ethno-mathematics instructional approach and Problem-based Learning Strategy, highlighting the importance of cultural geometry concepts in learning. Teachers are encouraged to connect geometry teaching to students' experiences, fostering acceptance and combating racism. The theory suggests using alternative teaching methods like ethno-mathematics, especially during situations like the pandemic, to stimulate cognitive development. It emphasizes the importance of challenging students slightly beyond their competence level but within their zone of proximal development to promote cognitive growth. Overall, Vygotsky's theory underscores the active role of the child in a cultural context, emphasizing social and cultural influences on cognitive development.

BRUNER'S DISCOVERY LEARNING THEORY (1960)

Jerome Seymour Bruner, America Psychologist and educator propounded this theory. According to the theory, learners should be encouraged to build on past experiences and knowledge, use their intuition, imagination and creativity and search for new information to discover facts, correlations and new truths. Learning should not equal absorbing what was said or read, but actively seeking for answers and solutions". Discovery is used according to this theory as all forms of obtaining knowledge for oneself by use of one's mental processes. According to Bruner (1960), two forms of discovery process exist; in one form, a student spontaneously recognizes a new situation that is familiar to one of the elements in his existing structure of knowledge and he easily assimilates it. In the second form, a new situation is incompatible with the existing structure of knowledge. The learner first restructures his cognitive framework so that the new learning materials can be accommodated. Therefore, assimilation and accommodation are two (2) forms of discovery learning. When the learner recognizes potential incongruities or contradictions within his sources of information, he is stimulated to make new discovery through cognitive restructuring in order to either assimilate the learning material or to accommodate it into the existing knowledge, possessed by the learner.

Bruner believes that the essence of learning is that one connects the similar things and organizes them into meaningful structures, and learning is the organization and reorganization of cognitive structures. Knowledge learning is to form the knowledge structure of all subjects in the minds of students. Bruner holds that cognitive structure is a general way for people to perceive and generalize the external physical world, and it is a psychological structure formed in the process of human activities to recognize the external things. Cognitive structure is progressive and multi-level, developing from low level to advanced level. It is formed on the basis of past experience and is constantly changing in the process of learning. In addition, the formation of cognitive structure is an important internal factor and foundation for further learning and understanding of new knowledge.

RESEARCH METHODOLOGY

RESEARCH DESIGN

This study adopted the quasi-experimental research design with a pre-test and post-test control group. The quasi experimental research design was adopted because the study used intact classes in order not to disrupt the classroom arrangement in the schools. Specifically, a pretest, post-test, non-equivalent control group design was used. Both the experimental and control groups were given the same pre-test on geometry before the commencement of the experiment. The treatment group was taught geometry: Recognition and identification of 2-Dimentional shapes, Recognition and identification of 3-Dimentional shapes, Recognition and identification of 2-Dimentional shapes, 2-Dimensional shapes and their properties, 3-Dimensional shapes and their properties, Area and perimeter of plane shapes, Types of triangle and angles, Plane and solid shapes and Surface area of Cube and Cuboid, using ethno-mathematics instructional approach and problem-based learning strategy whereas the control group was taught the same topics using the conventional teaching method. The three (3) groups were given a post-test after the experiment.

The design for the study is as represented in figure 3.1.

EG_1	O_1	X_1	O_2	O_3
EG_2	O_1	X_2	O_2	O_3
CG	O_1	----	O_2	O_3

Figure 3.1: Schematic Representation of the Research Design

Keys:

EG 1 = group 1 (Ethno-mathematics Instructional Approach)
EG 2 = experimental group 2 (Problem-Based Learning Strategy)
CG = control group
O_1 = pretest
O_2 = posttest (achievement test)
O_3 = post posttest (retention test)

X_1 = treatment for group 1(Ethno-mathematics Instructional Strategy)
X_2 = treatment for group 2 (Problem-based Learning Strategy)
= No treatment for control group (Conventional method)

POPULATION, SAMPLE AND SAMPLING TECHNIQUES
The population, sample and sampling techniques adopted for this study are described below:
POPULATION
The population of the study comprised 20,213 (10,819 males and 9,394 females) Junior Secondary two (JS II) students in the 2022/2023 academic session in 204 Public Junior secondary schools spread across the three senatorial districts in Benue State (Department of Planning, Research and Statistics, Benue State Ministry of Education, Makurdi, 2023).

SAMPLE AND SAMPLING TECHNIQUES
The sample for study comprised 1,200 of JS II students (in the intact classes with N=217 males and N = 183 females for the group taught geometry using ethno-mathematics instructional approach, N = 195 Males and N = 205 females for the group taught geometry using problem-based learning strategy and N = 225 males and N=175 females for the control group) randomly selected from 18 Junior secondary schools from the three senatorial districts in Benue State, Nigeria.
The sample for this study was drawn using the simple random sampling technique 'lucky-dip' with replacement technique. A total number of 18 Junior secondary schools were selected. Two schools from each senatorial district were assigned for the ethno-mathematics instructional approach, problem-based learning strategy and conventional method respectively. The use of the intact classes was done to ensure that the academic programmes of the schools were not disrupted during the time of the experimental study. The selection of six schools from each senatorial district was to give opportunities culture inclusiveness as regard ethno-mathematics instructional approach.

METHOD OF DATA COLLECTION
The method of data collection is described under the following sub-headings: Instruments for Data Collection, Validity of Instruments, Reliability of Instruments, Research Tools and Administration of Instruments.

INSTRUMENTS FOR DATA COLLECTION
In this study, two instruments were used for data collection namely: Geometry Achievement Test (GAT) was used for the pretest and the posttest and Geometry Interest Rating Scale (GIRS). Geometry Retention Test (GRT) was used to detect if there is any change of interest in both the experimental and control groups. The Geometry Achievement Test (GAT) was adapted from the Federal Capital Territory (FCT) Basic Education Certificate Examination (BECE) past questions. The instruments were used to measure students' achievement in geometric concepts. This test consists of items that are covered in geometry. The content involved Recognition and identification of 2-Dimentional shapes, Recognition and identification of 3-Dimentional shapes, Recognition and identification of 2-Dimentional shapes, 2-Dimensional shapes and their properties, 3-Dimensional shapes and their properties, Area and perimeter of plane shapes, Types of triangle and angles, Plane and solid shapes and Surface area of Cube and Cuboid. The test contained 25 items which was scored out of 100 marks. The distribution of the test items over the concepts was done by the use of a table of specification. Table of specification of GAT was prepared as shown in Table 1.1. In this study, all the six levels of cognitive processes of knowledge, comprehension, application, analysis, synthesis and evaluation were used according to Bloom's level of taxonomy.

Table 1.1: Specification for Content Validity of Geometry Achievement Test (GAT)

S/N	Content	Knowledge 20%	Comprehension 20	Application 15%	Analysis 15%	Synthesis 20%	Evaluation 10%	Total 100%
1	Recognition and identification of 2-Dimensional shapes	(Q 23)	(Q24)	()	( )	( )	(Q1)	**3**
2	Recognition and identification of 3-Dimensional shapes	(Q3)	(Q10)	(Q14)	(Q18)	( )	( )	**4**
3	2-Dimensional shapes and their properties	(Q9)	()	(Q 15)	(Q7)	()	()	**3**
4	3-Dimensional shapes and their properties	(Q 22)	(Q6)	( )	()	()	(Q5)	**3**
5	Area and Perimeter of plane shapes	(Q4)	(Q11)	(Q8)	(Q 21)	(Q25)	()	**5**
6	Types of triangles and Angles	(Q2)	(Q13)	(Q 16)	( )	()	()	**3**
7	Area, volume of Plane and Solid shapes	(Q 12)	( )	( )	( )	(Q 19)	( )	**2**
8	Surface Area of cube and Cuboid	(Q 17)	(Q20)	( )	( )	( )	( )	**2**
	TOTAL	**8**	**6**	**4**	**3**	**2**	**2**	**25**

The Geometry Interest Rating Scale (GIRS) consist of 20 items that were used to test for a change in interest after teaching geometry. The items were adapted to reflect on geometry. The interest scale administered to both the experimental and control group and the purpose of this, in this study is to determine whether students' increase interest or decrease interest toward geometry. The Geometry interest rating scale was based on four point scales of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). Numerical value of 4, 3, 2 and 1 respectively were allotted to the responses. Negative items were however scored in the reverse order. Geometry Retention Test (GRT) that was used to detect if there is any change in the experimental and control groups.

VALIDITY OF THE INSTRUMENTS

The Geometry Interest Rating Scale (GIRS) was subjected to construct validation and Geometry Achievement Test (GAT) was subjected to face and content validation by three (3) experts who are well experienced in test construction. They comprised three senior lecturers in mathematics and science education. The Validators were requested to among other things check the suitability, reliability and validity of the test; check if the language used in construction of the instruments is suitable for students and teachers; remove unnecessary and ambiguous items and test the instrument. All corrections pointed out by the Validators were incorporated into the instruments. The validation index obtained for Geometry Achievement Test (GAT) is 0.88 and for Geometry Interest Rating Scale (GIRS) is 0.78.

RELIABILITY OF THE INSTRUMENTS

To determine the reliability of the Geometry Achievement Test (GAT) and Geometry Interest Rating Scale (GIRS), the items were trial tested using a small comparable group of 40 students (22 males and 18 females) which did not form part of the sample respondents. Copies of the GAT and GIRS were administered to the students of the school. The conduct of the trial test was to enable the researcher to determine the clarity, readability, appropriateness, adequacy and duration for the test and possibility of any difficulty that may arise in the process of answering the questions by the respondents. Kuder-Richardson 21 ($K\text{-}R_{21}$) was used to determine the reliability coefficient of Geometry Achievement Test, the reliability coefficient obtained was 0.75. Cronbach Alfa was used to determine the reliability coefficient of Geometry Interest Rating Scale (GIRS) and the reliability coefficient obtained was 0.81.

RESEARCH TOOLS

Research tools used in the study includes:
Pre-test and Post-test assessment: to measure students' initial understanding and progress in geometry before and after the intervention.

Interest surveys/questionnaires: to gauge students' level of interest in geometry before and after the intervention.
Achievement test: to assess students' academic performance in geometry after the intervention compared to conventional method.

Retention tests: to evaluate students' long term retention of geometry concepts learned through the Ethno-mathematics instructional approach and problem-based learning strategy.
Lesson: The lesson plan comprised of ethno mathematics instructional approach, problem-based learning strategy and conventional method.

TECHNIQUES OF DATA ANALYSIS

Mean and standard deviation were used to answer research questions. Analysis of Covariance (ANCOVA) were used to test the hypotheses at 0.05 level of significance.

JUSTIFICATION OF METHODS

Quasi experimental design of non-equivalent pretest, posttest and post-posttest were used. The design was considered most appropriate due to the fact that it is not possible to have a complete randomization of the subjects. Hence, intact classes were used for the treatment since interrupting the existing class setting in a school will not be possible. Co-educational schools were used for the study because gender was used as a moderating variable for the study and the Government has the sole control of such schools. Mean and standard deviation were used show the differences in mean interest, achievement and retention. Analysis of Covariance (ANCOVA) were used to justify on grounds that it takes care of initial differences of sampled items or objects being tested. Analysis of Covariance (ANCOVA) were used so as to take care of possible lack of initial equivalence in the group with the application of Statistical Package for the Social Sciences (SPSS) version 26.0.

DATA PRESENTATION AND ANALYSIS
RESEARCH QUESTION ONE

What are the mean interest rating of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach?

Table 1.2: ANCOVA Result of Mean Interest Ratings of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	344776.089[a]	3	114925.363	860.301	.000	.683
Intercept	181139.499	1	181139.499	1355.963	.000	.531
PreInterest	7.377	1	7.377	.055	.814	.000
Group	**201973.369**	**2**	**100986.685**	**755.960**	**.000**	**.558**
Error	159770.510	1196	133.587			
Total	3323271.000	1200				
Corrected Total	504546.599	1199				

a. R Squared = .683 (Adjusted R Squared = .683)

Table 1.2 reveals $F_{(2,1196)} = 755.96$ with associated exact probability value of 0.000 ($F_{(2,1196)} = 755.96$; $p = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there is a significant difference in the mean interest ratings of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach. Based on the established difference in the mean interest ratings of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference.

Table 1.3: Bonferroni Multiple Comparisons Results of Mean Interest Ratings of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
EthnoMaths	PBL	.200	.817	1.000	-1.760	2.159
	CM	36.197*	1.011	.000	33.774	38.621
PBL	EthnoMaths	-.200	.817	1.000	-2.159	1.760
	CM	35.998*	1.018	.000	33.557	38.438
CM	EthnoMaths	-36.197*	1.011	.000	-38.621	-33.774
	PBL	-35.998*	1.018	.000	-38.438	-33.557

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 1.3 shows that there was a significant difference in the mean interest rating scores of students exposed to Ethno-Mathematics and Problem-Based Learning Strategy and the Conventional method. Ethno-mathematics instructional approach and Problem-Based Learning Strategy had a p value of $1.000 > \alpha = 0.05$, since 1.000 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean interest ratings of students exposed to ethno-mathematics instructional approach and Problem-Based Learning Strategy.

Ethno-mathematics instructional approach and Conventional method had a p value of $0.000 < \alpha = 0.05$, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean interest ratings of students exposed to Ethno-Mathematics and the conventional method in the favour of the Ethno-Mathematics instructional approach. Problem-Based Learning Strategy and Conventional approach had a p value of $0.000 < \alpha = 0.05$, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean interest ratings of students exposed to Problem-based Learning Strategy and Conventional method in favour of the Problem-based Learning Strategy.

RESEARCH QUESTION TWO

What are the mean interest ratings of male and female students taught geometry using ethno-mathematics instructional approach?

Table 1.4: ANCOVA Results on the Interest of Male and Female Students Taught Geometry Using Ethno-Mathematics Instructional Approach

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	48.331[a]	2	24.166	.149	.862	.001
Intercept	89699.881	1	89699.881	551.742	.000	.582
PreInterest	48.247	1	48.247	.297	.586	.001
GenderEthno	**.151**	**1**	**.151**	**.001**	**.976**	**.000**
Error	64542.566	397	162.576			
Total	1531233.000	400				
Corrected Total	64590.898	399				

a. R Squared = .001 (Adjusted R Squared = -.004)

Table 1.4 reveals that $F_{(1, 397)} = 0.001$ was obtained with an exact associate probability value of 0.976 ($F_{(1,397)} = 0.001$; $p = 0.976 > \alpha = 0.05$). Since the associate probability (0.976) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean interest ratings of male and female students taught geometry using ethno-mathematics instructional approach.

RESEARCH QUESTION THREE

What are the mean interest ratings of male and female students taught geometry using problem-based learning strategy?

Table 1.5: ANCOVA Results on Interest of Male and Female Students Taught Geometry Using Problem-Based Learning Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	134.759[a]	2	67.380	.384	.681	.002
Intercept	98019.968	1	98019.968	558.849	.000	.585
PreInterest	56.830	1	56.830	.324	.570	.001
GenderPBL	**78.860**	**1**	**78.860**	**.450**	**.503**	**.001**
Error	69632.241	397	175.396			
Total	1526616.000	400				
Corrected Total	69767.000	399				

a. R Squared = .002 (Adjusted R Squared = -.003)

Table 1.5 reveals that $F_{(1, 397)} = 0.450$ was obtained with an exact associate probability value of 0.503 ($F_{(1,397)} = 0.450$; $p = 0.503 > \alpha = 0.05$). Since the associate probability (0.503) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean interest ratings of male and female students taught geometry using problem-based learning strategy.

RESEARCH QUESTION FOUR

What are the mean achievement scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach?

Table 1.6: ANCOVA Result of Mean Achievement Scores of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	217488.439[a]	3	72496.146	504.098	.000	.558
Intercept	61958.574	1	61958.574	430.825	.000	.265
Pretest	96.304	1	96.304	.670	.413	.001
Group	**76537.136**	**2**	**38268.568**	**266.098**	**.000**	**.308**
Error	172001.131	1196	143.814			
Total	3017216.000	1200				
Corrected Total	389489.570	1199				

a. R Squared = .558 (Adjusted R Squared = .557)

Table 1.6 reveals $F_{(2,1196)}$ = ratio of 266.098 was obtained with associated exact probability value of 0.000 ($F_{(2,1196)} = 266.098$; $p = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there is a significant difference in the mean achievement scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach. Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference.

Table 1.7: Bonferroni Multiple Comparisons Results of Mean Achievement Scores of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
EthnoMath	PBL	-.517	.848	1.000	-2.551	1.516
	CM	29.143*	1.336	.000	25.939	32.346
PBL	EthnoMath	.517	.848	1.000	-1.516	2.551
	CM	29.660*	1.350	.000	26.423	32.897
CM	EthnoMath	-29.143*	1.336	.000	-32.346	-25.939
	PBL	-29.660*	1.350	.000	-32.897	-26.423

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 1.7 shows that there was a significant difference in the mean achievement scores of students exposed to Ethno-mathematics instructional approach and Problem-Based Learning Strategy and the Conventional method. Ethno-mathematics instructional and Problem-Based Learning Strategy had a p value of $1.000 > \alpha = 0.05$, since 1.000 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean achievement scores of students exposed to Ethno-mathematics instructional and Problem-based Learning Strategy.

Ethno-mathematics instructional and Conventional had a p value of $0.000 < \alpha = 0.05$, since 0.000 is greater than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean achievement scores of students exposed to Ethno-mathematics instructional and the conventional method in the favour of the Ethno-Mathematics approach. Problem-Based Learning Strategy and Conventional method had a p value of $0.000 < \alpha = 0.05$, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean achievement scores of students exposed to Problem-Based Learning Strategy and Conventional method in favour of the Problem-Based Learning Strategy.

RESEARCH QUESTION FIVE

What are the mean achievement scores of male and female students taught geometry using ethno-mathematics instructional approach?

Table 1.8: ANCOVA Result on Achievement of Male and Female Students Taught Geometry Using Ethno-Mathematics Instructional Approach

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	260.063[a]	2	130.032	.725	.485	.004
Intercept	23927.599	1	23927.599	133.371	.000	.251
Pretest	122.224	1	122.224	.681	.410	.002
GenderEthno	**129.138**	**1**	**129.138**	**.720**	**.397**	**.002**
Error	71224.497	397	179.407			
Total	1328574.000	400				
Corrected Total	71484.560	399				

a. R Squared = .004 (Adjusted R Squared = -.001)

Table 1.8 reveals that $F_{(1, 397)} = 0.720$ was obtained with an exact associate probability value of 0.397 ($F_{(1,397)} = 0.720$; $p = 0.397 > \alpha = 0.05$). Since the associate probability (0.397) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean achievement scores of male and female students taught geometry using ethno-mathematics instructional approach.

RESEARCH QUESTION SIX

What are the mean achievement scores of male and female students taught geometry using problem-based learning strategy?

Table 1.9: ANCOVA Result on Achievement of Male and Female Students Taught Geometry Using Problem-Based Learning Strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13.001[a]	2	6.501	.032	.968	.000
Intercept	22787.665	1	22787.665	113.422	.000	.222
Pretest	6.903	1	6.903	.034	.853	.000
GenderPBL	**5.701**	**1**	**5.701**	**.028**	**.866**	**.000**
Error	79761.436	397	200.910			
Total	1359501.000	400				
Corrected Total	79774.438	399				

a. R Squared = .000 (Adjusted R Squared = -.005)

Table 1.9 reveals that $F_{(1, 397)} = 0.028$ was obtained with an exact associate probability value of 0.866 ($F_{(1,397)} = 0.028$; $p = 0.866 > \alpha = 0.05$). Since the associate probability (0.866) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean achievement scores of male and female students taught geometry using problem-based learning strategy.

RESEARCH QUESTION SEVEN

What are the mean achievement scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach?

Table 1.10: ANCOVA Result of Mean Retention Scores of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	782408.382[a]	3	260802.794	4043.440	.000	.910
Intercept	264453.840	1	264453.840	4100.045	.000	.774
Posttest	.135	1	.135	.002	.963	.000
Group	**346089.894**	**2**	**173044.947**	**2682.858**	**.000**	**.818**
Error	77142.277	1196	64.500			
Total	5155943.000	1200				
Corrected Total	859550.659	1199				

a. R Squared = .910 (Adjusted R Squared = .910)

Table 1.10 reveals $F_{(2,1196)}$ = ratio of 2682.858 was obtained with associated exact probability value of 0.000 ($F_{(2,1196)} = 2682.858$; $p = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there is a significant difference in the mean retention scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional method. Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference.

Table 1.11: Bonferroni Multiple Comparisons Results of Mean Interest Ratings Scores of Students Taught Geometry Using Ethno-Mathematics and Problem-Based Learning Strategy and Those Taught Using Conventional Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Ethnomath	PBL	-1.665*	.568	.010	-3.027	-.304
	CM	53.340*	.789	.000	51.448	55.232
PBL	Ethnomath	1.665*	.568	.010	.304	3.027
	CM	55.006*	.796	.000	53.098	56.913
CM	Ethnomath	-53.340*	.789	.000	-55.232	-51.448
	PBL	-55.006*	.796	.000	-56.913	-53.098

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 1.11 shows that there was a significant difference in the mean retention scores of students exposed to Ethno-mathematics instructional and Problem-Based Learning Strategy and the Conventional method. Ethno-mathematics instructional and Problem-Based Learning Strategy had a p value of $0.010 < \alpha = 0.05$, since 0.010 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean achievement scores of students exposed to Ethno-mathematics instructional and Problem-Based Learning Strategy in favour of the Ethno-Mathematics instructional approach.

Ethno-mathematics instructional and Conventional had a p value of 0.000 <α = 0.05, since 0.000 is greater than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean retention scores of students exposed to Ethno-mathematics instructional and the conventional method in the favour of the Ethno-Mathematics approach. Problem-Based Learning Strategy and Conventional approach had a p value of 0.000 <α = 0.05, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean retention scores of students exposed to Problem-Based Learning Strategy and Conventional approach in favour of the Problem-Based Learning Strategy.

RESEARCH QUESTION EIGHT
What are the mean retention scores of male and female students taught geometry using ethno-mathematics instructional approach?

Table 1.12: ANCOVA Result on Mean Retention Scores of Male and Female Students Taught Geometry Using Ethno-Mathematics Instructional Approach

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	33.924[a]	2	16.962	.209	.811	.001
Intercept	131296.978	1	131296.978	1619.693	.000	.803
Posttest	26.793	1	26.793	.331	.566	.001
GenderEthno	**8.382**	**1**	**8.382**	**.103**	**.748**	**.000**
Error	32181.973	397	81.063			
Total	2407051.000	400				
Corrected Total	32215.898	399				

a. R Squared = .001 (Adjusted R Squared = -.004)

Table 1.12 reveals that $F_{(1, 397)} = 0.103$ was obtained with an exact associate probability value of 0.748 ($F_{(1,397)} = 0.103$; $p = 0.748 > \alpha = 0.05$). Since the associate probability (0.748) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean retention scores of male and female students taught geometry using ethno-mathematics instructional approach.

RESEARCH QUESTION NINE
What are the mean retention scores of male and female students taught geometry using problem-based learning strategy?

Table 1.13: Mean Retention Scores and Standard Deviations of Male and Female Students Taught Geometry Using Problem-Based Learning Strategy

GenderPBL		Posttest	Retention
	Mean	56.44	79.02
Male	N	195	195
	Std. Deviation	13.879	8.290
	Mean	56.68	78.43
Female	N	205	205
	Std. Deviation	14.416	8.374

Table 1.13 reveals the mean retention scores of male and female students in the Problem-Based Learning Strategy group. For the male students, the post-test score is 56.44, with a standard deviation of 13.879 and retention score is 79.02, with a standard deviation of 8.290. For the female students, the post-test score is 56.68, with a standard deviation of 14.416 and the retention score is 78.43, with a standard deviation of 8.374.

HYPOTHESIS NINE
H_{O9}: There is no significance difference in the achievement scores of male and female students taught geometry using problem-based learning strategy.

Table 1.14: ANCOVA Result on Mean Retention Scores of Male and Female Students Taught Geometry Using Problem-Based Learning Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	50.892[a]	2	25.446	.366	.694	.002
Intercept	142420.154	1	142420.154	2047.083	.000	.838
Posttest	17.129	1	17.129	.246	.620	.001
GenderPBL	34.182	1	34.182	.491	.484	.001
Error	27620.186	397	69.572			
Total	2506249.000	400				
Corrected Total	27671.077	399				

a. R Squared = .002 (Adjusted R Squared = -.003)

Table 1.14 reveals that $F_{(1, 397)} = 0.491$ was obtained with an exact associate probability value of 0.484 ($F_{(1,397)} = 0.491$; $p = 0.484 > \alpha = 0.05$). Since the associate probability (0.484) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that no significant difference is found to exist in the mean retention scores of male and female students taught geometry using problem-based learning strategy.

RESEARCH QUESTION TEN

What is the interaction effect of ethnomathematics and problem-based approach and gender as measured by Geometry Interest Scale?

Table 1.15: ANCOVA Result on the Interaction Effect Between Methods and Gender on Interest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	86.438[a]	4	21.609	.128	.972	.001
Intercept	187678.804	1	187678.804	1111.149	.000	.583
PreInterest	.223	1	.223	.001	.971	.000
Group	9.142	1	9.142	.054	.816	.000
Gender	41.419	1	41.419	.245	.621	.000
Group * Gender	**36.371**	**1**	**36.371**	**.215**	**.643**	**.000**
Error	134279.661	795	168.905			
Total	3057849.000	800				
Corrected Total	134366.099	799				

a. R Squared = .001 (Adjusted R Squared = -.004)

Table 1.15 reveals that the $F_{(2, 795)} = 0.215$ was obtained with an exact associate probability value of 0.643 ($F_{(2,795)} = 0.215$; $P = 0.643 > \alpha = 0.05$). Since the associate probability (0.643) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that there is no significant interaction effect between ethno-mathematics and problem-based approach and gender on interest.

RESEARCH QUESTION ELEVEN

What is the interaction effect of ethno-mathematics and problem-based approach and gender as measured by Geometry Achievement Test?

Table 1.16: ANCOVA Result on the Interaction Effect Between ethno-mathematics and problem-based approach and Gender on Achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	286.378[a]	4	71.595	.377	.825	.002
Intercept	46678.405	1	46678.405	245.720	.000	.236
Pretest	91.939	1	91.939	.484	.487	.001
Group	63.858	1	63.858	.336	.562	.000
Gender	43.070	1	43.070	.227	.634	.000
Group * Gender	94.990	1	94.990	.500	.480	.001
Error	151023.120	795	189.966			
Total	2688075.000	800				
Corrected Total	151309.499	799				

a. R Squared = .002 (Adjusted R Squared = -.003)

Table 1.16 reveals that the $F_{(2, 795)} = 0.500$ was obtained with an exact associate probability value of 0.480 ($F_{(2,795)} = 0.500$; $P = 0.480 > \alpha = 0.05$). Since the associate probability (0.480) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that there is no significant interaction effect between ethno-mathematics and problem-based approach and gender on achievement.

Table 1.17: ANCOVA Result on the Interaction Effect Between ethno-mathematics and problem-based approach and Gender on Retention

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	595.641[a]	4	148.910	1.978	.096	.010
Intercept	273558.465	1	273558.465	3633.990	.000	.821
Posttest	.302	1	.302	.004	.949	.000
Group	565.005	1	565.005	7.506	.006	.009
Gender	36.021	1	36.021	.479	.489	.001
Group * Gender	**4.820**	**1**	**4.820**	**.064**	**.800**	**.000**
Error	59845.779	795	75.278			
Total	4913300.000	800				
Corrected Total	60441.420	799				

a. R Squared = .010 (Adjusted R Squared = .005)

Table 1.17 reveals that the $F_{(1, 795)} = 0.064$ was obtained with an exact associate probability value of 0.800 ($F_{(1,795)} = 0.064$; $P = 0.800 > \alpha = 0.05$). Since the associate probability (0.480) is greater than 0.05 set as level of significance, the null hypothesis was not rejected. This implies that there is no significant interaction effect between ethno-mathematics and problem-based approach and gender on Retention.

DISCUSSION OF FINDINGS

The findings from this study revealed that a significant difference was found to exist in the mean interest ratings of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional method in favour of ethno-mathematics instructional approach. The difference in mean interest scores was significant showing that ethno-mathematics instructional approach was effective in increasing the interest of the students. It is important to note that when students are taught with materials and method that are indigenous to them, it enhances their level of interest which brings about creativity and curiosity that sustain their ability to achieve their learning goals. There was an enhanced interest from the students taught with ethno-mathematics instructional approach which was intrinsically sustained all through the teaching and learning process. Unodiaku (2013) opined that Ethno-mathematics instructional approach is such approach that students will find quite reinforcing and interesting to use and will hopefully increase their participation and wipe out their phobia in mathematics learning.

Oraneto and Omile (2021) and Adamu (2022) who asserted that the interaction of native culture and mathematics ideas can be mutually reinforcing. As a result, the application of native culture situations to the mathematics classroom helps the students to see the connection between mathematics and culture thereby enhances their interest and achievement. Abiodum and Nchelem (2015) opined that ethno-mathematics instructional approach was effective in increasing the interest of the students in mathematics and this is in agreement with the findings of this study. The findings from also revealed that, no significant difference existed in the mean interest rating scores of male and female students taught geometry using ethno-mathematics instructional approach. This finding contradicts the finding of Adamu (2022) who discovered that a significant difference existed in the mean interest rating scores of male and female students in favour of the female students.

Findings also showed no significant difference existed in the mean interest scores of male and female students taught geometry using problem-based learning strategy. The findings also showed no significant difference between the mean interest ratings of male and female students who were exposed to Problem based learning Strategy. This finding is in agreement with the findings of Anaduaka and Uche (2014), Achor, Imoko, and Ajai (2015) and Abdullah, Tarmizi and Abu (2017) who opined that gender has no significant difference in the students' interest in mathematics. Male students' interest did not differ from their female counterparts when exposed to Problem based learning Strategy probably because the male students did not explore their learning environment more than their female counterparts. The female did not find it difficult to do practical activities like their male counterparts. This could have improved their interest.

The findings from this study showed that, a significant difference in the mean achievement scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach in favour of the ethno-mathematics instructional approach. This superiority in achievement was significant based on the result of the study. The effectiveness of ethno-mathematics based instructional approach can be attributed to the fact that ethno-mathematics based instructional approach used materials that students are conversant with in their daily activities and relate it in solving problems for the students within the classroom environment. Abiam, Abonyi, Ugama and Okafor (2016); Ozofor and Onos (2018); Umar, Tudunkaya and Muawiya (2019); Age and Akaazua (2021); Oraneto and Omile (2021); Woji and Charles-Ogan (2022); Omere and Ogedengbe (2022) and Adamu (2022) opined that ethno-mathematics instructional approach is superior to conventional method in fostering student's achievement in geometry. The reason for this higher achievement by ethno-mathematics instructional approach group could be that the students were able to integrate or link their background of study and their immediate environment with the foreign aspect of the learning of trigonometrical concepts.

This finding is in agreement with that of Uloko and Usman (2018). The teaching was done in a practical way and as such it flows from home to school and from school to one's trade and to everyday living (Uloko and Ogwuche, 2017). Thus the abstract nature of teaching and learning of mathematics seemed to have been reduced. This agreed with the definition of ethno-mathematics by D'Ambrosio (2001) who states that it is an approach of teaching and learning of trigonometry that builds on the background, and environment in terms of content and method, and his past and present experiences. This also agrees with earlier observations that failure in mathematics in Nigeria is due to the fact that the teaching and learning is purely foreign in nature (Kurumeh, 2014; Uloko, 2016; Uloko & Imoko, 2017; Uloko & Ogwuche, 2017). The high achievement of students in this study also shows that when ethno-mathematics instructional approach is used in a practical way it could be an effective teaching approach. This agrees with the view of D'Ambrosio (2014) which states that ethno-mathematics based instructional approach can also be used in a practical way. Thus as Harbor- Peters (2014) stated, low achievement of students in mathematics could therefore be attributed to non-utilization of appropriate teaching approach. These could be that, as students focus was on the concepts and techniques actually used by their cultural group rather than the possible mathematical theories available, they gained more knowledge. The idea of considering mathematics to be too abstract was also put away. By so doing the students' had greater understanding of the materials being learned. Their cultural interaction also helped the students to develop an instinctive kind of common mathematics knowledge that could be handed over to their next generation.

The findings revealed that, no significant difference is found to exist in the mean achievement scores of male and female students taught geometry using ethno-mathematics instructional approach. This finding is in agreement with the that of Woji and Charles-Ogan (2022) who found out that gender had no significant on the achievement of students when exposed to ethno-mathematics instructional approach. But the finding is in disagreement with the findings of Omere and Ogedengbe (2022) and Adamu (2022) who found out that female achieved better when exposed to ethno-mathematics instructional approach than their male counterparts. The reason for the improved achievement could be that, the female students explored their learning environment and did not find it difficult to do practical activities like their male counterparts. This could have improved their achievement.

Also, findings showed no significant difference existed in the mean achievement scores of male and female students taught geometry using problem-based learning strategy. This finding is in agreement with the findings of Anaduaka and Uche (2014), Ajai and Imoko (2015), Achor, Imoko and Ajai (2015) who observed that gender has no significant difference in the achievement of students. But in disagreement with findings of Josiah and Tobiloba (2015) and Madu and Hogan- Bassay (2015) who observed that gender has significant effect on students' achievement. Male students' achievement did not differ from their female counterparts when exposed to Problem based learning Strategy probably because the male students did not explore their learning environment more than their female counterparts. The female did not find it difficult to do practical activities like their male counterparts. This could have improved their achievement.

From the findings, it was revealed that a significant difference in the mean retention scores of students taught geometry using ethno-mathematics instructional approach, problem-based learning strategy and those taught geometry using conventional teaching approach. The finding of this study also supports that of Achor, Imoko and Uloko (2019); Umar, Tudunkaya and Muawiya (2019); Age and Akaazua (2021) and Adamu (2022) who revealed that ethno-mathematics is superiority to the lecture method in enhancing students' retention ability. Their findings confirmed that students who were subjected to the ethno-mathematics were able to retain the concepts of locus more than those students who were taught using the conventional method. Similarly, Igboko and Ibeneme (2016) posited that the retention scores obtained by the experimental group were higher than the control group. Ethno-mathematics therefore, allows the interplay of thought and action with a consequential development of creative and cultural background which could possibly enhance achievement and retention. These findings are completely in line with the finding of the present study.

The findings revealed that no significant difference was found to exist in the mean retention scores of male and female students taught geometry using ethno-mathematics instructional approach. This is in disagreement with the findings of Adamu (2022) who opined that female students retained geometric concepts better that their male counterparts. This could be as a result of instructions from the teachers which helped in the improvement of the students' cultural interactions and retention. Also, no significant difference was found to exist in the mean retention scores of male and female students taught geometry using problem-based learning strategy. And there was no significant interaction effect between ethnomathematics and problem-based approach and gender on interest and achievement. This finding shows a reduction in gender gap due to the teachers' effort in presenting well-designed tasks to the students which in turn challenged the female students to give their best thus reducing the gender gap.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The result of this study revealed that students taught geometry using Ethno-mathematics Instructional Approach had higher interest ratings, achievement and retention scores than those exposed to Problem-based Learning Strategy and Conventional Method. The result of the study showed that Ethno-mathematics Instructional Approach enhances students' engagement, learning outcomes and long-term knowledge, retention in the field of geometry. Gender has no significant effects on ethno-mathematics and problem-based approach as regards to interest, achievement and retention in geometry. Ethno-mathematics Instructional Approach uses cultural artifacts that are found in the learners' locality in teaching geometry. Using Ethno-mathematics instructional is not only more effective and superior; it is one approach that could enhance classroom instructional delivery in secondary school. Again, geometry phobia which is associated with lack of interest that students face while learning the subject will be reduced.

RECOMMENDATIONS

Based on the findings of this study, it was recommended that:

i. Students should be subjected to consistent utilization of ethno-mathematical operations within their culture in carrying out mathematical tasks.
ii. Ethno-mathematics Instructional Approach should be adopted in our school system. If geometry and mathematics is to gain popularity, capture the interest of the learners and challenge their intellect, the content must be made more appealing in terms of basic instructional approaches. This is done by linking instruction to the learners' immediate environmental experience. This makes it relevant to their daily activities. These incorporate ethno-mathematics concepts, materials and techniques in a system and well-organized way and thereby help improve mathematics instruction in our school system and foster achievement of better result.
iii. Mathematics Teachers should also strive to use Ethno-mathematics Instructional Approach in teaching of geometry to improve students' achievement and retention. Teachers should be trained on the use and importance of Ethno-mathematics Instructional Approach. This training should be done through organizing workshops, seminars, conferences, in-service training, annual teachers' vacation courses and re-fresher courses. This is to provide them with tools to stimulate and sustain students' interest in mathematics.
iv. Periodic government sponsored in-service training, in form of long vacation training programmes, workshops, conferences and seminars on the nature, scope and use of ethno-mathematics should be organized for Junior Secondary School Mathematics teachers.
v. Curriculum planners and authors of mathematics textbooks should generally reflect the background of a typical Nigerian society. This method of instruction should reflect our education background, culture and philosophy. This will help to generate interest in the learning of mathematics, which is said to be the foundations of modern mathematics
vi. Emphasis on the use of Ethno-mathematics Instructional Approach materials should be made in the National Mathematics curriculum for Junior Secondary Schools, as technique to be used in teaching the concepts of volumes of cylindrical and hemispherical shapes.
vii. Professional bodies such as Science Teachers Association of Nigeria (STAN), Mathematical Association of Nigeria (MAN) among others, should organize workshops and seminars to popularize and sensitize mathematics teachers on the use of Ethno-mathematics Instructional Approach materials as approach in teaching students the concepts of volumes of cylinders and hemispheres.
viii. Teacher training institutions of learning should include the use of Ethno-mathematics Instructional Approach materials as method in the mathematics method course content. This will guarantee that after the teacher training, they will be equipped on how to teach the concepts of volumes of cylinder and hemisphere effectively.
ix. Authors of mathematics textbook should generally reflect the background of a typical Nigerian society. This method of instruction should reflect our education background, culture and philosophy. This will help to generate interest in the learning of mathematics, which is said to be the foundations of modern mathematics.

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