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EFFECTS OF INQUIRY BASED TEACHING STRATEGY AND GENDER ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN STEREOCHEMISTRY IN ENUGU EDUCATION ZONE

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Abstract
The students' consistent low performance in internal and external examinations undermined the efficacy of chemistry teachers' methods of instruction. Thus, the purpose of the research is to find out how inquiry-based learning can impact students' academic achievement in stereochemistry in Enugu education zone. The study was guided by two research questions and three research hypotheses. The study employed a pretest-posttest non-equivalent control group design. 4,532 SS2 Chemistry students made up the study's population. A combination of random and purposive sampling procedure was used to select 96 students. While the control group received instruction via lectures, the experimental group was taught using an inquiry-based teaching strategy. The Chemistry Achievement Test (CAT) was the instrument used for data collection, and its reliability index was evaluated using Kuder-Richardson's formula-20 which yielded coefficient of 0.84. The mean, standard deviation, and analysis of covariance were used to analyze the data. The findings demonstrated that students exposed to the inquiry-based teaching strategy outperformed their peers who received instruction via lectures. For improved students' achievement, it was recommended that Chemistry teachers should use inquiry based teaching strategy when teaching chemistry.

Keywords: Inquiry-Based teaching, Chemistry, achievement, Gender and Stereochemistry.

Introduction

Science is a disciplined body of knowledge that investigates nature in a testable and verifiable way using a methodical methodology. Broadly speaking, science before the modern period and was present in many ancient cultures. Science does not engage with supernatural explanations; instead, it only considers the natural world (Igboegwu, 2012). It is a means of gaining knowledge about the elements of the natural world, including people, societies, ecosystems, animals, plants, rivers, seas, deserts, mountains, soils, air, and every other element of the physical universe. According to Wilson (2012), science is a methodology of knowledge acquisition that organizes a body of information using the scientific process or method. According to Onah and Nwankwo (2024), science is a trustworthy method of education that verifies theories using information obtained from the natural world (Onah & Achufusi, 2022). According to Idoko (2014), science is

the dynamic and objective process of learning about nature that produces new discoveries and insights into the recurring themes in ideas. According to Ezeano (2013), science is composed of three fundamental subjects: biology, chemistry, and physics.

The study of matter's makeup, characteristics, and behavior in a particular environment is known as chemistry. Atoms and how they interact with one another, especially the characteristics of chemical bonds, is the subject of chemistry. Chemistry is a scientific discipline that methodically examines the characteristics, makeup, and functions of both organic and inorganic substances. In school science curricula designed for pupils thinking about a career in science, chemistry is a major subject. According to Helmenstine (2012), this field of study connects other natural sciences including physics, geology, and biology, earning it the moniker "the central science." Chemistry is a discipline of science that deals with identifying the substances that make up matter (Bagley, 2017). According to Okon (2012), chemistry has been recognized as a highly significant scientific stem. It has been well documented how vital it is to the particular and technical advancement of any country. Chemistry was made a core subject among the physical sciences and a requirement for studying many science-related courses like medicine, pharmacy, biochemistry, nursing, engineering, industrial Chemistry, anatomy, etc. In Nigerian's institution due recognition has been given to Chemistry for the development of man and his environment. Stereochemistry being a key topic in the scientific curriculum at school, chemistry permeates every aspect of our daily lives (Eze & Omeje, 2023). When we breathe, eat, or read, chemicals respond. The scientific field of chemistry has contributed to the growth of the following industries: cement; pharmaceuticals; clothes through the textile industry; transportation; cleanliness; control of air and water pollution; and agriculture, which produces food and facilitates agricultural activities more quickly and easily. Students may learn about the scientific method and develop their critical thinking, logical reasoning, problem-solving, and communication abilities by studying chemistry (Durukan, 2011). Early and efficient chemistry instruction may boost students' academic performance and provide them with a wide range of transferable abilities that they can use in their future employment. For attainment of these careers in chemistry, it is important to have grasped knowledge of arrangement of atoms and molecules like in the concept of stereochemistry.

Stereochemistry is the study of the relative arrangement of atoms in molecules and their manipulation. A major area of stereochemistry is the study of isomers which is introduced below. Isomers are species with the same atoms in the same numbers, i.e., the same molecular formula but are arranged differently in space. Constitutional isomers have a different sequence of bonds that may result in another skeleton, i.e., skeletal isomers, different reactive features: functional groups isomers, or the same reactive features but placed at different locations-positional isomers. Stereochemistry explores the complex world of atom placement inside molecules and the techniques used to change these configurations. One of the most important aspects of this field is the study of isomers, which are molecules with the same atomic makeup but different spatial

arrangements. These differences fall into a number of categories, each of which illuminates a distinct facet of molecular behavior and structure. One of the fundamental classes in isomeric research is constitutional isomers. These molecules exhibit differences in their bonding sequences, which may result in modifications to the underlying skeleton. These differences might show up as skeletal isomers, which have different molecular arrangements at the core and hence different molecular shapes and characteristics. Conversely, differences in the functional groups of constitutional isomers might result in its formation, functional group isomers, which have different chemical re-activities and characteristics, may arise from constitutional isomers that display differences in their functional groups. Furthermore, reactive groups within molecules might occupy distinct spatial locations, which can influence their behavior and interactions during chemical reactions, giving rise to positional isomers. Consequently, the study of isomers reveals the significant influence of spatial arrangements on chemical characteristics and reactivity in addition to the intricacy of molecular architecture. This idea has a big influence on actual life as it makes it possible to meet fundamental needs on a regular basis through production of useful substances like polytene.

Despite chemistry's importance to national development, academic achievement in the subject often falls short of the expectations. Academic achievement is defined as a student's scholastic standing at a given moment, reflected through grades and performance on educational tests, as well as cumulative indicators like degrees and certificates (Eze & Omeje, 2023). An examination conducted by West African Examinations Council (WAEC) for senior secondary school (SSS) Chemistry students' revealed that students' performance in Nigeria specifically Enugu State is consistently below the expectation in the subject. For instance, in the 2022 West African Examinations Council (WAEC) session, out of the total 71,452 candidates who registered and sat for the examination in Enugu state, only 16,077 students, representing 22.5%, passed Chemistry at the credit level. In the subsequent years, the trend persisted. In 2023, there was a further decline in the number of students passing, with only 20.7% achieving credit and above. This was made more evident in Joint Admission and Matriculation Board (JAMB), 2024 as it showed that about 85.5% of the candidates that sat the examination scored below 50%. Despite some improvements, student achievement in chemistry remains generally unfavorable in Enugu education zone. The WAEC Chief Examiner noted that many students struggled with questions on stereochemistry due to their inability to apply concepts. The examiners attributed poor performance to the prevalent use of the lecture method, which lacks opportunities for practical application. According to Onah (2023), the teachers poor instructional approach has been accounted for students' poor achievement in physics in particular and science in general. This poor instructional approach has been engulfed with traditional lecture method.

The traditional lecture method is a type of instruction that uses speaking and chalk pedagogy to effectively impart thoughts and ideas to pupils. It does not, therefore,

encourage genuine learning. This method places a strong emphasis on textbooks and workbooks for curriculum exercises. Even when pupils don't grasp the key ideas, the majority of teachers still follow it (Ibe & Abonyi, 2014). Among the characteristics of the traditional lecture techniques are: Science instructors in Nigeria have embraced rote memorization of textbooks and other materials, excessive chatting, and note copying after the class. Once again, the traditional lecture method uses an expository approach to teaching rather than an inquiry-based approach, which does not only bias students toward hands-on learning activities but rather piques their curiosity about science and the teaching process that foster forensic learning of chemistry (Duran, 2011)

Inquiry based learning is a teaching strategy where the teacher answers students' questions with guiding counter-questions instead of giving them direct answers. Inquiry-based learning (IBL) was once intended to be a classroom-based approach to teaching with the goal of raising students' chemistry achievement. The first step in inquiry-based learning is to pose queries, issues, or scenarios. Students' enthusiasm to learn and their comprehension of the nature of science are both enhanced by the inquiry-based learning approach. Additionally, it fosters students' capacity for inquiry, which is a crucial component of lifelong learning. Given the importance of inquiry in education in the twenty-first century, Nigeria, a developing nation, has not lagged behind in implementing inquiry-based learning strategies and guaranteeing gender parity in all facets of the teaching and learning process (Ghumdia, 2016). The major goals are to include students and help them comprehend strategic concepts for industrial development (Dushimimana & Mugabo, 2022). Making inquiries about novel solutions and problems when you are learning new knowledge is made possible via inquiry. In IBL, questions are developed, observations are made, research is conducted to determine what information is already recorded, experimentation techniques are developed, instruments for data collection are developed, data is collected, analyzed, and interpreted, potential explanations are outlined, and predictions are made for further study. According to Sola and Ojo (2017), Problem-based learning is a component of inquiry-based learning, which is typically used to small-scale studies and projects. The development and use of thinking abilities is most directly linked to inquiry-based education (Oluchukwu, 2016). A facilitator frequently offers assistance to the process. In order to expand their knowledge or find answers, inquirers study problems and questions. Problem-based learning is a component of inquiry-based learning, which is typically applied in small-scale projects and research. The development and use of thinking abilities is most tightly linked to inquiry-based training. Inquiry-based learning is divided into three categories by Cheval and Hart (2005). According to Ghumdia (2016), structured inquiry, guided inquiry, and open inquiry are forms of inquiry teaching strategy used for teaching science. When taught properly, any of these inquiry methods may help children learn science. Guided inquiry will be employed in this investigation. The process of inquiry learning promotes students' understanding and achievement of the nature of science as well as the motivation for learning. Inquiry learning strategy engages students on active learning of

chemistry which was evident in their improved achievement (Dushimimana & Mugabo, 2022). It also develops students' inquiry skills which is a key aspect of lifelong learning. Considering the key role of inquiry in the 21st century education, Nigeria as a developing country has not been left behind in using inquiry-based teaching method as well as ensuring gender equality in all aspects of the teaching and learning process. The Theoretical Framework is anchored on Piaget's theory of constructivism.

Constructivism according to Piaget (1976) is the learning theory that serves as the foundation for the inquiry-based teaching approach. The dissatisfaction with behaviorism's didactic teaching approaches gave rise to this theory. In contrast to didactic teaching approaches, students in constructivism learning environments create and co-create their knowledge through an interactive process of inquiry, debate, sharing, and reflection. Instead of being viewed as passive recipients of knowledge from the teacher. When students make connections between what they already know and what they are learning, it fosters a deep comprehension of the material. "To understand is to discover, or reconstruct by rediscovery, and such conditions must come through constant inquiry. According to Piaget, if in future individuals are to be productive, there is need to inquire about the present, past, and future. Instead of being spoon-fed knowledge passively, constructivism learning empowers students to take charge of their education through active engagement with the teacher for feedback with gender curiosity. As a result, regardless of gender, chemistry teachers should look for a teaching strategy that may inspire and pique students' attention like inquiry based learning (Maris, 2019).

Researchers have seen throughout the years that success in Chemistry and related fields is influenced by gender (Akumah, 2013). Orefor (2016) went so far as to emphasize that women belong in the humanities and arts, while men belong in science, technology, and associated fields. According to this theory, girls tend to demonstrate a greater predisposition toward the arts and humanities, whereas boys seem to have a naturally favorable attitude toward scientific and technical topics. The issue is made worse by the fact that, according to Onah (2022), the majority of science teachers view science disciplines like chemistry and physics as having a masculine bent, which discourages women from pursuing these fields in favor of biology, agricultural science, and home economics. Other researches (Orefor, 2016; Nwankwo & Okoye, 2015) believed that gender had no impact on how well pupils performed in the sciences. Girls who get all of these and associated therapies develop a fear of science and science-related courses, which will undoubtedly have an impact on their final career choice and level of success. There is a need to try such an innovative strategy as the inquiry based teaching strategy to see what effect it will have on achievement of male and female students in the sciences, especially Chemistry. There is a lack of consensus regarding the issue of gender preference in science. More importantly, it is important to capture the interest of/bias girls and subsequently improve their achievement in chemistry and other science-related subjects.

In view of the problems of the study, the following specific purposes were raised to guide the study:

1. To determine the difference between the mean achievement scores of students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching.
2. To determine the difference between the mean achievement scores of male and female students taught stereochemistry with inquiry based teaching strategy.
3. Interaction effect of teaching strategies and gender on students' achievement in stereochemistry.

In lieu of the purpose of the study, the following research questions were developed to guide the study

1. What is the difference in the mean achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching?
2. What is the difference in the mean achievement scores of male and female students' taught stereochemistry with inquiry based teaching strategy?

The following research hypotheses were formulated for the study; which were tested at 0.05 level of significance

1. There is significant difference in the mean achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching.
2. There is significant difference in the mean achievement score of male and female students taught stereochemistry with inquiry based teaching strategy.
3. There is significant interaction effect of gender and teaching strategies on students mean achievement scores in chemistry concept of stereochemistry.

Method

A pretest-posttest non-equivalent control groups design was used for the study. The primary reason for this is that participants in the control and experimental groups were not assigned at random. Classes in secondary schools are structured groupings, and the administration does not permit the disassembly and reconstruction of classes for study (Nworgu, 2018). The population of the study consisted of 4, 532 SS 2 Chemistry students in all the 33 public secondary schools in Enugu Education Zone. 96 SS II chemistry students (52 females and 44 males) drawn from two coeducational secondary schools in Enugu North Local Government Area were selected for the study using a purposive sample technique. Firstly the selection of Enugu North Local Government Area using a basic random sample approaches. Secondly the two coeducational schools in the local government area were chosen using purposive sampling. The selection process was based on the presence of well-equipped chemistry laboratories and qualified

teaching chemistry instructors in those schools and gender integration. Next, the schools were assigned to experimental and control treatments using a simple random sample procedure (precisely balloting of lucky dip). Intact classes were used in the sampled schools so as not to disrupt the normal school activities. The technique was used so as to provide classes where boys and girls work together under the same classroom environment. Four weeks were used for the experiment. Each week had two periods (double periods each) of 40 minutes per period. The control group was taught using the lecture method which involves content-rich activities such as demonstrations, lecture, experiments and quantitative problem-solving which does not involve the students in concept mapping strategy and processes. For the experimental class, the same set of activities for the control group was carried out for both double periods; but in addition to discussing and writing schematic notations and chemical equation of the concept, students were engaged in a group of 5 students according to teacher's description. Each group was assigned a task within the context of the topic to carry out. The feedback of students' in the group was reported back to the teacher on a regular interval for corrections and further directives on what to do next. This formed the strategy employed in the inquiry based learning. The Chemistry Achievement Test (CAT), was the instrument utilized to gather the data. There were 25 multiple-choice items with four alternatives (prep-50) in the questions from 2017 to 2023. Three experts validated the instruments' face and content using table of specification provided, and Kuder Richardson 20 (KR-20) was used to verify the instruments' reliability. The results showed a coefficient of 0.84. The device is dependable and appropriate for data collecting, as evidenced by its excellent dependability index (Idoko, 2014). Students were given the test as a pretest and a posttest, respectively, before and after the treatment. The researcher graded the examination in order to prevent bias. The mean and standard deviation (SD) were used to answer the research questions, and analysis of covariance (ANCOVA) using SPSS version 24 was used to test the hypotheses.

Procedure/ Authorization

Data was gathered following official authorization from relevant authorities like school principal through the classroom teacher and laboratory assistant. A consistent set lesson plan as tools and guidelines were provided to research assistants and respondents for completing research instruments. Additionally, research assistants underwent thorough training. All data collecting sessions were conducted under identical class settings to reduce disparities and potential mistakes. The research instrument was distributed to students during a single class session, with a designated 30-minute time frame for completion, although most students finished within approximately 25 minutes.

Results

Research Question 1:

What is the difference in the mean achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching?

Answer to Research question 1 is presented in Table 1

Table 1: Mean and Standard deviation of achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching.

Teaching Strategy	Pretest			Posttest			
	N	Mean	SD	N	Mean	SD	Mean Gain
Inquiry Based Learning	48	24.17	12.49	48	67.00	12.25	42.83
Lecture method	48	25.67	11.16	48	58.29	17.10	32.62

Table 1 shows the pretest and posttest mean achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy were 24.17 and 67.00 while the gain in mean score was 42.83. Their counterpart taught using the lecture method had 25.67, 58.29 and 32.62 as pre-test, post-test and gain in mean scores respectively. This shows a 10.21 difference in gain in mean scores between the two groups in favor of the students taught with inquiry based learning strategy. The result also shows a remarkable difference in mean gain scores between students taught chemistry using stereochemistry with inquiry based teaching strategy than their counterparts in lecture method.

Hypothesis 1: There is no significant difference in the mean achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy and those taught using lecture method of teaching.

Table 2: Summary of Analysis of Covariance of effect of inquiry based teaching strategy on students' achievement in chemistry by Treatment and Gender

Dependent Variable: Posttest Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2552.683[a]	4	638.171	2.896	.026	.113
Intercept	54510.481	1	54510.481	247.364	.000	.731
Pretest	698.426	1	698.426	3.169	.078	.034
Strategy	1697.698	1	1697.698	7.704	.007 *	.078

Gender	3.103	1	3.103	.014	.906	.000
Strategy * Gender	13.543	1	13.543	.061	.805	.001
Error	20053.276	91	220.366			
Total	399358.000	96				
Corrected Total	22605.958	95				

a. R Squared = .113 (Adjusted R Squared = .074)

Table 2 shows that at .05 level of significance, there was a significant main effect of the teaching strategy on students' academic achievement in chemistry concept of stereochemistry, *F (1, 91) = 7.704, P (.007) <.05.* Therefore, the Research hypothesis was confirmed and accepted. Thus, there is significant difference in mean achievement scores of students taught Chemistry concept of stereochemistry with inquiry based teaching strategy and those taught using lecture method. In favour of the experimental group (Inquiry based learning strategy)

Research Question 2: What is the difference in the mean achievement scores of male and female students' taught stereochemistry with inquiry based teaching strategy?
Answer to Research question 2 is presented in Table 3

Table 3: Mean and Standard deviation of achievement scores of chemistry students taught stereochemistry with inquiry based teaching strategy

Gender	Pretest			Posttest			
	N	Mean	SD	N	Mean	SD	Mean Gain
Male	29	26.48	14.24	29	67.38	11.72	40.90
Female	19	20.63	8.35	19	66.42	13.31	45.79

Table 3 shows the pretest and posttest mean achievement scores of male students (26.48 and 67.38) and their female counterpart (20.63 and 66.42) taught stereochemistry with inquiry based teaching strategy. The gain in mean score for male students was 40.90 while that of the female counterpart was 45.79. This indicates a mean difference of 4.89 in favor of the female students.

Hypothesis 2: There is no significant difference in the mean achievement score of male and female students taught stereochemistry with inquiry based teaching strategy.

Table 2 shows that at .05 level of significance, there was no significant influence of gender on the effect of teaching strategy on students' academic achievement in chemistry concept of chemical bonding, *F (1,91) =.014* P (.906) > .05. Therefore, the research hypothesis was rejected. Thus, gender has no significant influence on the academic achievement of students in Chemistry concept of stereochemistry.

Hypothesis 3: There is no significant interaction effect of gender and teaching strategies on students mean achievement scores in chemistry concept of stereochemistry.

Table 2 further revealed that at .05 level of significance, there was no significant interaction effect of gender and the teaching strategy on students' academic achievement in chemistry, $F\ (1,\ 91) = .061,\ P\ (.805) > .05$. Therefore, the research hypothesis was rejected. Thus, there is no significant interaction effect of gender and the teaching strategy of inquiry based learning on students' academic achievement in chemistry.

Discussion of the Findings

Firstly, the study revealed that there is significant difference in the achievement scores of the chemistry students taught stereochemistry with inquiry based learning strategy and those taught using a lecture method; in favor of students' in Inquiry teaching and learning strategy. The finding of the study is in consonance with Dushimimana and Mugabo, (2022) who observed that inquiry based teaching approach had a significant effect on students' performance in the selected Chemistry concepts. It was also discovered that inquiry method was more effective than the lecture method of teaching science in terms of students' overall performance in Chemistry concepts and other science related subjects. The finding was in agreement with Piaget (1976), who demonstrated the efficacy of students' active participation in lessons through construction of their knowledge. The study's findings revealed that there is no significant difference in the mean achievement scores of male and female students taught Chemistry concept of stereochemistry using inquiry based learning strategy among Senior Secondary School students Chemistry 2 in Enugu Education Zone of Enugu State. The finding of the study is in agreement with Onah (2022), Onah and Achufusi (2022), who noted that gender, is not factor with teaching approach in physics. Meanwhile the find does not agree with Ezeugo and Agwagah (2018) who revealed that the male students taught with inquiry based learning performed significantly better than their female counterparts taught with concept mapping. The study also showed that there is no discernible relationship between gender and instructional strategy and students' academic achievement scores in chemistry. This finding concurred with Onah (2022), which found no evidence of a significant interaction between gender and instructional strategy on students' physics conceptual understanding of waves. Onah and Nnadi (2022), on the other hand, observed a noteworthy interaction on students' academic progress in current electricity between gender and instructional treatment. It is clear that the scientific community cannot agree on how gender and instructional practices interact to affect students' conceptual grasp of science, particularly physics ideas. There is therefore a great need to embark on more studies in order to shed further light on this issue.

Conclusion/ Recommendations

Students' academic progress in stereochemistry is increased when the inquiry based teaching approach is used in instruction. This is because students' active involvement in constructing their knowledge through guided inquiry helped them to grasp the concept of stereochemistry and as such outperformed those who were taught the identical concept through lecture in terms of posttest results. Nonetheless, the results indicated that there is no discernible gender gap in students' academic achievement levels. Based on the findings of the study, the following recommendations were made:

1) The primary goal of teacher educators in universities and colleges of education should be to provide chemistry instructors with the knowledge and abilities necessary to implement the inquiry based teaching technique in secondary school stereochemistry.
2) The Federal Ministry of Education through seminar and workshop should encourage chemistry teachers to use inquiry based teaching as a teaching strategy as it improves students' achievement and not a gender biased strategy.
3) The curriculum of teacher-training programs should include a course on the inquiry based teaching strategy, through seminars, workshops, and other opportunities for working teachers to get refresher training on the method.
4) Curriculum should be reviewed by curriculum planners to reflect the strategy of inquiry based learning while textbook authors should be encouraged to incorporate the strategy in Chemistry textbooks to foster more achievement and gender equality.

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