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EFFECT OF INQUIRY- BASED LEARNING STRATEGIES ON STUDENTS' PROBLEM-SOLVING SKILLS AND ACADEMIC ACHIEVEMENTS IN MATHEMATICS IN PUBLIC SECONDARY SCHOOLS IN AGUATA EDUCATION ZONE

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Abstract

This study investigated the effect of inquiry-based learning strategies on students' problem-solving skills and academic achievement in Mathematics in public secondary schools in Aguata Education Zone, Anambra State. The study was guided by three research questions and three null hypotheses tested at the 0.05 level of significance. A quasi-experimental research design involving a pre-test and post-test non-equivalent control group was adopted. The population comprised 2893 Senior Secondary School Two (SS2) students in public secondary schools in Aguata Education Zone. A sample of 127 students was selected using a multi-stage sampling procedure. The instrument for data collection was the Mathematics Achievement Test (MAT) and Problem-Solving Inventory (PSI), which was validated by two experts in Science Education and one from Measurement and Evaluation unit of Educational Foundation Department, Faculty of Education UNIZIK, Awka. The reliability of the instrument was established using kuder Richardson and Cronbach Alpha which yielded coefficient of internal consistency of .90 and .73. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the null hypotheses at the 0.05 level of significance. The findings revealed that students exposed to inquiry-based learning strategies achieved significantly higher mean gain scores in academic achievement and problem-solving skills than those taught using the conventional lecture method. The results also showed no statistically significant difference in the academic achievement and problem-solving skills of male and female students. Furthermore, the interaction effect of teaching method and gender on students' academic achievement and problem-solving skills was not statistically significant. The study concluded that inquiry-based learning strategies are more effective than the conventional lecture method in improving students' academic achievement and problem-solving skills in Mathematics. It was recommended that Government and educational stakeholders should provide continuous professional development programmes for Mathematics teachers on innovative learner-centered instructional strategies.

Keywords: Inquiry- Based Learning Strategies, Problem-Solving Skills, Academic Achievements

Introduction

Education has been widely recognized as a deliberate and systematic process aimed at developing the intellectual, social, and practical capacities of individuals for personal and societal advancement. It is a conscious effort to develop human potential and equip individuals with the knowledge, skills, competencies, and values necessary for meaningful participation in society. In the contemporary world, education plays a vital role in preparing individuals to cope with rapid technological advancements and socio-economic changes. The demands of the twenty-first century require education to produce individuals who possess essential life skills such as critical thinking, effective communication, creativity, collaboration, and technological competence (Suto, 2013). These skills are cultivated through the learning process and are often reflected in the academic performance and learning outcomes of students. Within the broad field of education, science education occupies a strategic position because it provides learners with the ability to think critically, solve problems, and apply knowledge to real-life situations.

According to Ihejiamaizu, Neji and Agiande (2020), science education contributes significantly to the empowerment of citizens and national growth. Science education is a fusion of science and education that produces a simplified and comprehensible concept of science for individuals who are not traditionally part of the scientific community (Ayeni, 2021). One of the foundational pillars of science education is Mathematics.

Mathematics is widely regarded as the foundation of science and technology because of its extensive application in various fields of human endeavor. It plays a crucial role

in scientific discoveries, technological innovations and economic advancement. Okereke (2016) described Mathematics as the science of patterns, logical order and the exploration of relationships among quantities and structures. Mathematics is primarily based on deductive reasoning, through which conclusions are drawn logically from established principles (Noer, 2017). Most primary and secondary schools use Mathematics results as a determining factor when promoting students to the next higher class (Anigbo, 2016). In response to the critical role of Mathematics, the Federal Republic of Nigeria (2024), in the National Policy on Education, emphasizes that Mathematics must be taught to all students because of its importance to scientific and technological development. It is also a prerequisite for admission into most tertiary institutions, regardless of the chosen course of study.

Despite the indispensable role of Mathematics in scientific advancement, technological innovation, and national development, students' academic achievement in the subject has remained a major concern across the world.

Academic achievement refers to the extent to which learners attain the intended learning outcomes after a period of instruction and is commonly measured through classroom tests, continuous assessment, and standardized examinations (Bahago, 2021). In the context of Mathematics education, academic achievement reflects students' understanding and application of mathematical concepts, reasoning, and problem-solving abilities. In this study, academic achievement refers specifically to students' performance in Mathematics.

Globally, the challenge of low Mathematics achievement has continued to attract the attention of educational researchers and policymakers. The Trends in International

Mathematics and Science Study (TIMSS) 2023 reported that a substantial proportion of students in many developing countries performed below the international benchmark in Mathematics, indicating persistent weaknesses in Mathematical understanding and reasoning (Mullis, Martin, Foy, Kelly and Fishbein, 2024). These reports suggest that poor Mathematics achievement is not limited to one nation but represents a global educational challenge.

The situation in Nigeria is equally concerning. Mathematics remains one of the compulsory subjects for certification at the senior secondary school level and a prerequisite for admission into most tertiary programs. However, national examination evidence indicates persistent challenges in students' achievement in Mathematics. The West African Examination Council (WAEC) Chief Examiners' reports from 2020 to 2024 showed fluctuations in the proportions of candidates obtaining credit-level passes in Mathematics over the years. Similarly, the National Examinations Council (NECO) reports have consistently highlighted weaknesses in students' analytical reasoning, conceptual understanding, and application of mathematical procedures during examinations (NECO, 2024). These patterns suggest that poor achievement in Mathematics remains a significant concern within the Nigerian secondary school system. Although academic achievement is an important indicator of successful learning in Mathematics, meaningful achievement cannot be attained without the ability to solve mathematical problems. Consequently, the development of students' problem-solving skills has become one of the major goals of Mathematics education.

Problem-solving skill refers to the ability to identify and analyse a problem, select and apply appropriate solution strategies and evaluate the effectiveness of the solutions using logical and mathematical reasoning (OECD, 2023). In Mathematics, it involves

applying conceptual understanding, reasoning and critical thinking to solve both routine and non-routine problems rather than merely recalling formulas or procedures. Students with effective problem-solving skills demonstrate conceptual understanding, flexibility in thinking and the capacity to transfer knowledge to unfamiliar situations.One instructional approach that has consistently been recommended for improving both academic achievement and problem-solving skills is Inquiry-Based Learning (IBL).

Inquiry-Based Learning is a learner-centered instructional strategy that engages students in questioning, investigating, exploring evidence, constructing explanations, and communicating findings through active participation in the learning process (Ali, 2024). Rather than receiving information passively from the teacher, learners become active participants who generate ideas, investigate problems, test hypotheses, collaborate with peers, and reflect on their learning experiences. Through these activities, students construct deeper conceptual understanding and develop higher-order thinking skills essential for meaningful Mathematics learning.

Empirical studies examining the simultaneous influence of Inquiry-Based Learning on both academic achievement and problem-solving skills among secondary school students in Aguata Education Zone are scarce. This gap in the literature provides the justification for investigating the effect of Inquiry-Based Learning strategies on students' academic achievement and problem-solving skills in Mathematics in public secondary schools in Aguata Education Zone, Anambra State.

However, in examining the effectiveness of an instructional strategy, it is also important to consider whether students’ gender influences their response to the instructional

approach and their learning outcomes. Gender therefore represents another important factor that requires consideration in Mathematics education.

It is against this background that this study investigates the effect of inquiry-based learning strategies on students' problem-solving skills and academic achievement in Mathematics in public secondary schools in Aguata Education Zone, Anambra State.

Purpose of the Study

The main purpose of the study was to investigate the effects of Inquiry-Based Learning strategies on students' problem-solving skills and academic achievement in Mathematics in public secondary schools in Aguata Education Zone. Specifically, the study sought to determine;

1. The problem-solving skill mean scores of students taught Mathematics using Inquiry-Based Learning strategies and those taught using the conventional lecture method.
2. The mean problem-solving skill mean scores of male and female students taught Mathematics using Inquiry-Based Learning strategies.
3. The interaction effect of gender and teaching method (IBL and CLM) on students' problem-solving skills.

Research Questions

The study was guided by the following research questions;

1. What are the problem-solving skill mean scores of students taught Mathematics using Inquiry-Based Learning strategies and those taught using the conventional lecture method?
2. What are the problem-solving skill mean scores of male and female students taught Mathematics using Inquiry-Based Learning strategies?
3. What is the mean interaction effect of gender and teaching method (IBL & CLM) on students problem solving skills

Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance;

1. There is no significant difference in the problem-solving skill mean scores of students taught Mathematics using Inquiry-Based Learning strategies and those taught using the conventional lecture method.
2. There is no significant difference in the problem-solving skill mean scores of male and female students taught Mathematics using Inquiry-Based Learning strategies.
3. There is no significant interaction effect of gender and teaching method (IBL & CLM) on students' problem-solving skills

Methodology

The researcher adopted a quasi-experimental research design, employing a non-randomized pre-test–post-test control-group design. Consequently, intact groups were assigned to the experimental and control conditions. The design was chosen because schools might not permit the disruption and manipulation of their conventional class structures required for a true experimental design, in which students would be randomly, assigned to either the experimental or control group. The study was conducted in public secondary schools in Aguata Education Zone, Anambra State.The population of the study comprised 2,893 Senior Secondary School Two (SS2) Mathematics students, consisting of 1,332 males and 1,561 females in 52 government-owned public secondary schools in Aguata Education Zone, Anambra State. The sample for the study comprised 127 SS2 Mathematics students drawn from the two public co-educational secondary schools in Aguata local Government Area within the Aguata Education Zone of Anambra State. A multistage sampling procedure was adopted where Purposive sampling was used to select only public co-educational (mixed –sex) secondary schools in Aguata local Government Area, Simple random sampling technique (balloting) was used to select two co-educational schools from the qualified schools in Aguata LGA. Two instruments were used for data collection in the study namely: The Mathematics Achievement Test (MAT) and the Problem-Solving Inventory (PSI), developed by Heppner, P.P and Petersen, C.H (1982). The MAT consists of 50 multiple-choice questions, developed by the researcher, aimed at assessing students' academic achievement in Mathematics. The questions were adapted from WAEC past question papers from the last six years (WAEC 2020 -2024). Each item in the MAT offers four alternative answers (A-D), and the questions are designed

to cover all six levels of Bloom's Taxonomy of Educational Objectives. The Problem-Solving Inventory (PSI), was adapted from Journal of Counseling Psychology developed by Heppner, P.P and Petersen, C.H (1982). The adapted instrument consists of 35 items and was used to measure students' problem-solving skills. The instrument employed six-point Likert response format of Strongly Agree (SA), Moderately Agree (MA), Slightly Agree (SLA), Slightly Disagree (SLD), Moderately Disagree (MD), and Strongly Disagree (SD). The instruments, scope, research questions, hypotheses and lesson plans were submitted to three experts for validation: two from the Department of Science Education and one from the Measurement and Evaluation Unit of the Department of Educational Foundations, all at Nnamdi Azikiwe University, Awka. The reliability test for data collection was conducted to determine the internal consistency of the instruments. The reliability of Mathematics Achievement Test (MAT) was established using the Kuder-Richardson 20(KR-20), while the reliability of the Problem-Solving Inventory (PSI) was determined using Cronbach's Alpha method, the both gave a coefficient of internal consistency of .90 and 0.73. The study lasted for six weeks, first week was for pretests while the actual treatment for both experimental and control group lasted for four weeks, the last week was for the administration of post-test.

Mean and standard deviation were used in answering research questions and analysis of covariance (ANCOVA) was used in testing the hypothesis at alpha level of 0.05.

Results

Research Question 1: What are the mean problem-solving skill scores of students taught Mathematics using Inquiry-Based Learning strategies and those taught using the conventional lecture method?

Table 1: Mean Scores and Standard Deviations for the Problem-Solving Skills of Students Taught Mathematics Using IBL and CLM

Teaching method	N	Pre-test		Post-test		Mean Gain
		Mean (PSS)	SD	Mean (PSS)	SD	
IBL	68	69.99	9.07	84.88	7.40	14.89
CLM	59	57.73	9.43	69.56	7.90	11.83
Mean Difference		12.26		15.32		3.06

Table 1 indicates that students taught Mathematics using Inquiry-Based Learning (IBL) strategies had a pre-test mean score of 69.99 and a post-test mean score of 84.88, with a mean gain score of 14.89. In contrast, students taught using the Conventional Lecture Method (CLM) had a pre-test mean score of 57.73 and a post-test mean score of 69.56, with a mean gain of 11.83. These results suggest that both methods are effective in enhancing students' problem-solving scores. However, compared to CLM, IBL is more effective, with a mean gain difference of 3.06. This implies that IBL was more effective in improving students' problem-solving scores in Mathematics.

$H0_1$: There is no significant difference in the mean problem-solving skill scores of students taught Mathematics using Inquiry-Based Learning strategies and those taught using the conventional lecture method.

Table 2: Summary of the Analysis of Covariance for Students' Problem-Solving Skills After They Were Taught Mathematics Using IBL and CLM

Sources	Sum of Squares	df	Mean Square	*F*	*p*-value	Decision
Corrected Model	9455.700a	4	2363.925	54.879	.000	
Intercept	6091.307	1	6091.307	141.410	.000	
Pre-PSS	1905.816	1	1905.816	44.244	.000	
Teaching Methods	2437.031	1	2437.031	56.576	.000	Sig.
Gender	247.689	1	247.689	5.750	.018	Sig.
TM * gender	111.422	1	111.422	2.587	.110	Not Sig.
Error	5255.214	122	43.076			
Total	782706.000	127				
Corrected Total	14710.913	126				

R Squared =.643 (Adjusted R Squared =.631)

The findings in Table 2 reveal a statistically significant mean difference in problem-solving skills between students taught Mathematics using inquiry-based learning (IBL) and those taught using the conventional lecture method (CLM), after adjusting for pre-test problem-solving skill scores, $F(1,126) = 56.58$, $p < 0.001$. Since $p < 0.05$, the null hypothesis stating "there is no significant mean difference in the problem-solving scores of students who were taught Mathematics using Inquiry-Based Learning strategies and conventional lecture method" is rejected.

Research Question 2: What are the mean problem-solving skill scores of male and female students taught Mathematics using Inquiry-Based Learning strategies?

Table 3: Mean Scores and Standard Deviations for the Problem-Solving Skills of Male and Female Students Taught Mathematics Using IBL

Teaching method	Gender	N	Pre-test		Post-test		Mean gain
			Mean (PSS)	SD	Mean (PSS)	SD	
IBL	Male	30	68.60	10.788	84.83	7.733	16.23
	Female	38	71.08	7.419	84.92	7.235	13.84
Mean Difference				-2.48		-0.09	2.39

Table 3 indicates that for students taught using Inquiry-Based Learning (IBL), male students had a pre-test mean score of 68.60 and a post-test mean score of 84.83, with a mean gain of 16.23, while female students had a pre-test mean score of 71.08 and a post-test mean score of 84.92, with a mean gain of 13.84. The mean gain difference between male and female students in the IBL group was 2.39 in favor of males, suggesting that male students showed a higher improvement in problem-solving skills than their female counterparts when taught using IBL.

$H0_2$: There is no significant difference in the mean problem-solving skill scores of male and female students taught Mathematics using Inquiry-Based Learning strategies.

The findings in Table 2 show a statistically significant difference in the problem-solving skill scores of male and female students after controlling for pre-test scores, $F(1, 122) = 5.75$, $p = 0.018$. Since $p < 0.05$, the null hypothesis stating that there is no significant difference in the mean problem-solving skill scores of male and female students taught Mathematics using Inquiry-Based Learning strategies was rejected.

$H0_3$: There is no significant interaction effect of gender and teaching method (IBL and CLM) on students' problem-solving skills.

The results in Table 2 show that the interaction effect between gender and teaching method was not statistically significant, F(1, 122) = 2.59, p = 0.110. Therefore, the null hypothesis stating that there is no significant interaction effect of gender and teaching method (IBL and CLM) on students' problem-solving skills was not rejected.

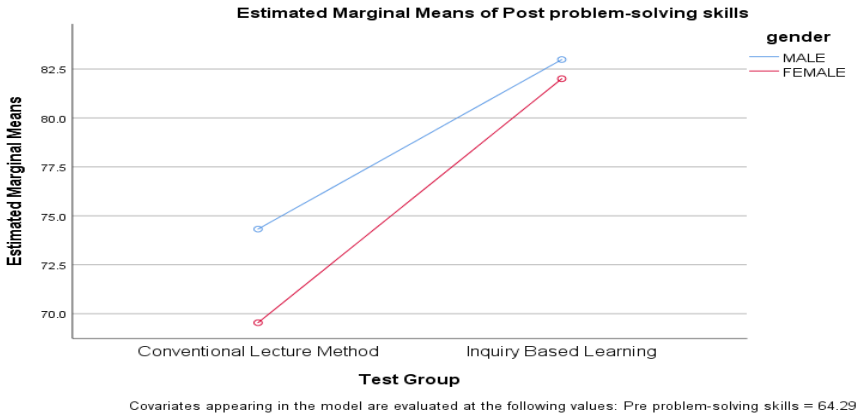


Figure 1: Profile Plot of the Interaction Effect of Gender and Teaching Method (IBL and CLM) on Problem-Solving Skills

Discussion

The findings of this study revealed that students taught Mathematics using Inquiry-Based Learning (IBL) strategies achieved significantly higher problem-solving skills than those taught using the Conventional Lecture Method (CLM). Students in the IBL group obtained a higher mean gain score (14.89) than those in the CLM group (11.83).

Furthermore, the Analysis of Covariance (ANCOVA) showed a statistically significant difference between the two groups after controlling for pre-test scores, $F(1,122) = 56.576$, $p < .05$. This indicates that inquiry-based learning was more effective than the conventional lecture method in improving students' mathematical problem-solving skills.

The finding is not surprising because inquiry-based learning actively engages students in exploring mathematical concepts, formulating questions, testing ideas, discussing alternative solutions, and reflecting on their reasoning. These learning experiences promote critical thinking, logical reasoning, and independent problem-solving, which are essential components of mathematics learning.

This finding agrees with the study of Ahmad, Liman, and Shehu (2023), who reported that students taught Mathematics using inquiry-based learning significantly outperformed those taught using the conventional lecture method in problem-solving and conceptual understanding. Similarly, Ke, Dai, West, Pan, and Xu (2024) found that inquiry-oriented mathematical activities significantly improved students' applied mathematical problem-solving skills because learners actively constructed knowledge rather than relying on teacher explanations. The result further supports the Constructivist Theory, which posits that learners construct knowledge more effectively when they actively participate in learning activities.

The result of Table 2 revealed that students taught Mathematics using inquiry-based learning strategies obtained significantly higher academic achievement scores than those taught using the conventional lecture method. Students in the inquiry-based learning group recorded a mean gain of 27.21 compared with 24.36 for students in the

conventional lecture group. The ANCOVA result further confirmed a statistically significant difference between the two teaching methods, $F(1,122) = 11.921$, $p = .001$.

This finding suggests that inquiry-based learning enhances students' understanding of mathematical concepts by encouraging active participation, collaboration, investigation, and reflective thinking. Students taught through inquiry-based learning are more likely to develop conceptual understanding than those taught through teacher-centered instruction, which often emphasizes memorization of formulas and procedures.

The present finding is consistent with Ahmad, Liman, and Shehu (2023), who reported that inquiry-based learning significantly improved students' achievement in Mathematics compared with the conventional lecture method. Similarly, Oduwole, Anaduaka, and Orji (2025) found that students exposed to inquiry-based instruction achieved significantly higher scores than those taught using traditional teaching methods. Likewise, Rahmadaniet, Syafrijon, Jalinus, Ridwan, Abdullah, and Syah (2024), in a meta-analysis of inquiry-based learning studies, concluded that inquiry-based instruction has a substantial positive effect on students' academic achievement across different educational settings. These findings support the view that active learner engagement promotes meaningful learning and improved academic performance.

Data presented in Table 3 on problem-solving skills, of Male and Female Students taught Mathematics Using IBL revealed that IBL significantly enhanced students' ability to solve mathematical problems. However, a statistically significant difference was found between the problem-solving skills of male and female students, $F(1,122) = 5.750$, $p = .018$, with male students recording slightly higher mean gain scores than

female students. Despite this difference, the interaction effect between teaching method and gender was not statistically significant, $F(1,122) = 2.587$, $p = .110$. This indicates that although male students performed slightly better overall, inquiry-based learning was equally effective in improving the problem-solving skills of both male and female students.

The slight difference in favour of male students may be attributed to individual differences in prior mathematical experiences, confidence levels, or exposure to problem-solving activities rather than the instructional strategy itself. Since the interaction effect was not significant, the findings demonstrate that inquiry-based learning does not favour one gender over the other but rather provides equal opportunities for both male and female students to develop mathematical reasoning and problem-solving competencies.

This finding partly agrees with Di Tommaso, Contini, De Rosa, Ferrara, Piazzalunga, & Robutti (2024), who found that learner-centred instructional strategies reduced gender disparities in mathematics learning. It is also consistent with Rocha, Viseu, and Matos (2024), who reported that inquiry-oriented mathematical activities improved students' reasoning and problem-solving abilities irrespective of gender. The finding further supports Vygotsky's Social Constructivist Theory, which emphasizes collaborative learning, dialogue, and scaffolding in promoting higher-order thinking among learners. Through group discussions, guided inquiry, and collaborative investigations, both male and female students are provided with similar opportunities to develop effective mathematical problem-solving skills.

Overall, the findings of this study provide strong empirical evidence that inquiry-based learning strategies are more effective than the conventional lecture method in improving students' academic achievement and problem-solving skills in Mathematics. The study further demonstrates that inquiry-based learning promotes gender equity in mathematics education, as its effectiveness does not depend on students' gender. Although a slight gender difference was observed in problem-solving skills, the absence of significant interaction effects indicates that both male and female students benefit similarly from inquiry-based learning. Therefore, the adoption of inquiry-based learning strategies in secondary school mathematics classrooms is recommended as an effective instructional approach for improving learning outcomes, fostering critical thinking and problem-solving skills, and promoting inclusive and equitable mathematics education.

Conclusion

Based on the findings of the study, it was concluded that Inquiry-Based Learning strategies are more effective than the Conventional Lecture Method in improving students' problem-solving skills and academic achievement in Mathematics among Senior Secondary School students in Aguata Education Zone of Anambra State. The learner-centered nature of Inquiry-Based Learning encourages students to participate actively in learning, investigate mathematical concepts, collaborate with peers, and develop logical reasoning required for solving mathematical problems.

Recommendations

Based on the findings of the study, the following recommendations are made;

1. Government and educational stakeholders should provide continuous professional development programmes for Mathematics teachers on innovative learner-centered instructional strategies.
2. Teachers should encourage collaborative learning, classroom discussion and problem-solving activities that actively involve students during Mathematics lessons.
3. School principals should organize regular workshops, seminars and conferences to train teachers on the effective implementation of Inquiry-Based Learning strategies.

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