



*Effects of Inquiry-Based Learning and ICT-Driven Pedagogy on ... Bashir, A. U. & Usman, H. (2026)*

## Effects of Inquiry-Based Learning and ICT-Driven Pedagogy on Achievement in Mathematics Concepts among Secondary School Students in Minna Metropolis, Niger State, Nigeria

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### Abstract

*This study examined the effectiveness of Inquiry-Based Learning (IBL) and ICT-Driven Pedagogy (ICTDP) on achievement in Mathematics Concepts among Senior Secondary School Students in Minna Metropolis, Niger State. A quasi-experimental pre-test-post-test non-equivalent control group design was adopted. The sample comprised 152 Senior Secondary II students selected from three intact classes. Two classes were assigned to IBL (n = 52) and ICTDP (n = 49), while the third served as a control group taught using the conventional lecture method (n = 51). Data were collected using a validated Mathematics Achievement Test (MAT) with a reliability coefficient of 0.84. Mean, standard deviation, and Analysis of Covariance (ANCOVA) were used for data analysis at the 0.05 significance level. Findings revealed significant differences in achievement among the groups, with both IBL and ICTDP outperforming the conventional method. The ICTDP group recorded a slightly higher mean gain than the IBL group, while the control group had the lowest performance. The study concludes that sustainable development-oriented pedagogies are more effective than traditional methods in improving mathematics achievement. It recommends the integration of inquiry-based and ICT-supported approaches to enhance student engagement and learning outcomes. Further studies should explore long-term retention and the role of learners' attitudes and self-efficacy.*

**Keywords:** Inquiry-Based Learning, ICT-Driven Pedagogy, Achievement, Mathematics, Students

### Introduction

Mathematics education occupies a central position in national development because it equips learners with logical reasoning, quantitative literacy, creativity, and problem-solving skills required for scientific advancement, technological innovation, and socio-economic transformation. At the secondary school level, mathematics is often regarded as a foundational subject for careers in engineering, medicine, economics, data science, and other STEM-related disciplines. Despite this strategic importance, students' achievement in mathematics has remained a persistent concern in many countries, particularly in developing nations where large proportions of learners continue to record low performance in internal and external examinations (Saha, Islam, Akhi & Saha, 2024). This trend has raised questions about the effectiveness of prevailing instructional practices and the need for pedagogical reforms that can improve learning outcomes. (Adeniyi, Al Hamad, Adewusi, Unachukwu, Osawaru, Onyebuchi, & David, 2024). One major explanation for poor achievement in mathematics is the continued reliance on conventional teacher-centered approaches, where instruction is dominated by explanation, note-taking, memorization, and repetitive exercises. In such classrooms, students often play passive roles, receiving information rather than constructing knowledge through active engagement. Research has shown that excessive dependence on traditional expository methods can limit conceptual understanding, reduce motivation, and weaken learners' ability to apply mathematical knowledge to real-life situations (Dairo, Okonkwo, & Orakwe, 2024). As educational systems increasingly emphasize competency-based learning and the achievement of the Sustainable Development Goals, attention has shifted toward learner-centered pedagogies that foster participation, inquiry, collaboration, and critical thinking (Sangwa, 2025). Among the innovative approaches receiving growing scholarly attention is Inquiry-Based Learning (IBL). Inquiry-Based Learning is a student-centered pedagogy in which learners actively investigate mathematical ideas through questioning, exploration, experimentation, discussion, and reflection. Rather than presenting ready-made solutions, teachers guide students to discover relationships, formulate conjectures, test strategies, and justify conclusions. This process encourages deeper understanding and long-term retention of mathematical concepts. According to Wali (2026), inquiry-oriented instruction promotes meaningful learning because students become active participants in constructing knowledge. Similarly, Okeke and Ramaila (2025) found that guided inquiry approaches



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significantly improve students' academic performance and cognitive outcomes. More recent evidence suggests that inquiry-based mathematics instruction increases engagement, perseverance, and conceptual mastery when teachers are adequately trained and classroom conditions are supportive Fry, Nakar and Zorn (2025). Another important contemporary innovation is ICT-Driven Pedagogy. Information and Communication Technology (ICT)-driven pedagogy refers to the deliberate integration of digital tools such as computers, tablets, projectors, interactive whiteboards, internet resources, mathematical software, mobile applications, and virtual learning platforms into the teaching and learning process. In mathematics classrooms, ICT can enhance visualization of abstract concepts, support simulations, provide immediate feedback, and enable collaborative problem-solving. For example, graphing software allows students to explore functions dynamically, while online quizzes and tutorials can personalize learning experiences. Xu, (2025) reported that technology-supported instruction has positive effects on students' mathematics achievement. Likewise, Ottenbreit- Msambwa and Daniel (2024) observed that effective ICT integration can improve classroom instruction and learner motivation. More recently, Cahyono, Wibawanto, Budiarto, Qodr, Sukmawati and Prihatin (2025) concluded that ICT-based teaching promotes student-centered learning, creativity, and higher-order thinking skills.

However, barriers such as inadequate infrastructure, unstable electricity supply, limited internet connectivity, insufficient teacher competence, and lack of access to digital devices continue to hinder effective implementation, especially in developing contexts (Abuali, & Ahmed, 2025) The dependent variable in this study is students' mathematics achievement, which refers to the measurable level of students' performance in mathematics as demonstrated through tests, examinations, assignments, or standardized achievement instruments. Achievement reflects how effectively students understand concepts, apply procedures, solve problems, and communicate mathematical reasoning. It is often used as an indicator of instructional effectiveness because improved achievement suggests successful teaching-learning interactions. Scholars argue that achievement in mathematics is influenced not only by student ability but also by instructional methods, classroom environment, teacher quality, motivation, and access to learning resources (Mazana, Montero & Casmir, 2020). In addition to pedagogy, gender is considered an important moderating variable in mathematics achievement research. Gender differences in mathematics performance have generated extensive debate over time. Some studies reported that male students outperform female students in certain mathematical domains, while others found negligible or no statistically significant differences. According to Chiphambo, (2025), gender gaps in mathematics are often shaped by cultural expectations, self-confidence, opportunities to learn, and stereotype threats rather than innate ability. Similarly, Nazli and Noman (2023). argued that contextual and socio-cultural factors largely explain observed gender disparities. Recent evidence indicates that learner-centered and technology-enhanced pedagogies may reduce gender gaps by creating more inclusive and participatory learning environments where both male and female students can engage equitably (Mohammad, Lakshmi, Natarajan & Vasudevan, 2025). Therefore, examining gender as a moderating variable is necessary in determining whether the effectiveness of IBL and ICT-driven pedagogy differs across male and female students. (Mohammad, Lakshmi, Natarajan & Vasudevan, 2025).

Although previous studies have independently examined Inquiry-Based Learning and ICT integration, relatively few studies have directly compared their relative effectiveness within the same research setting, particularly in secondary school mathematics classrooms in developing regions. Comparative evidence is important because schools often operate with limited resources and need guidance on which pedagogical strategies yield stronger learning outcomes under existing conditions. Furthermore, understanding whether one method benefits certain gender groups more than others can help policymakers and educators design equitable instructional interventions (Kuchynka, Eaton & Rivera, 2022). Therefore, this study investigates the relative effectiveness of Inquiry-Based Learning and ICT-Driven Pedagogy on students' mathematics achievement, with gender as a moderating variable. Specifically, the study seeks to determine which of the two instructional approaches produces higher achievement outcomes and whether gender influences students' responses to these pedagogical strategies. The findings are expected to provide empirical evidence for teachers, school administrators, curriculum planners, and policymakers seeking to improve mathematics instruction through innovative, inclusive, and evidence-based practices.

### **Objectives of the Study**

The study aims to:



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1. Compare the relative effectiveness of Inquiry-Based Learning, ICT-Driven Pedagogy, and the conventional lecture method on students' mathematics achievement in Minna Metropolis, Niger State.
2. Examine the influence of gender on students' mathematics achievement under the different pedagogical approaches in Minna Metropolis, Niger State.

### Research Questions

1. What is the difference in students' mathematics achievement among those taught using IBL, ICTDP, and the conventional lecture method?
2. What is the influence of gender on students' mathematics achievement?

### Research Hypotheses

H<sub>01</sub>: There is no significant difference in the mean achievement scores of students taught mathematics using Inquiry-Based Learning, ICT-Driven Pedagogy, and the conventional lecture method.

H<sub>02</sub>: There is no significant difference in the mean achievement scores of male and female students in mathematics.

### Research Methodology

This study adopted a quasi-experimental research design, specifically the pre-test–post-test non-equivalent control group design, to determine the relative effectiveness of Inquiry-Based Learning (IBL) and ICT-Driven Pedagogy (ICTDP) on students' mathematics achievement, with gender considered as a moderating variable. This design was considered appropriate because intact classes were used, and random assignment of individual students was not feasible in the school setting. The population of the study comprised all Senior Secondary II (SS II) mathematics students in minna Metropolis. A sample of 152 students was drawn from three intact classes in three co-educational public secondary schools using purposive sampling technique. The intact classes were assigned to two experimental groups and one control group. The first experimental group was taught using Inquiry-Based Learning, the second experimental group was taught using ICT-Driven Pedagogy, while the control group was taught using the conventional lecture method. The instrument used for data collection was the Mathematics Achievement Test (MAT), developed by the researcher based on the SS II mathematics curriculum. The instrument consisted of multiple-choice objective items covering selected mathematics topics relevant to the study. The MAT was validated by experts in mathematics education and measurement and evaluation to ensure content and face validity. The reliability of the instrument was established using the Pearson Product Moment Coefficient, which yielded a reliability coefficient of 0.84, indicating good internal consistency. Before the treatment, a pre-test was administered to all groups to determine their baseline equivalence in mathematics achievement. Thereafter, the treatment was carried out over a specified instructional period, during which the experimental groups were taught using IBL and ICTDP strategies respectively, while the control group received instruction through the conventional lecture method. Gender distribution within each group was recorded to enable analysis of its influence and interaction with the teaching methods. At the end of the treatment period, a post-test using the same instrument (with reshuffled items) was administered to all participants. Data collected were analyzed using descriptive statistics such as mean and standard deviation to answer the research questions. Inferential statistics, specifically Analysis of variance (ANOVA), was used to test the hypotheses at a 0.05 level of significance. ANOVA was employed to control for initial differences in pre-test scores and to determine the effect of treatment and gender on students' achievement. Ethical considerations were observed by obtaining permission from school authorities, ensuring voluntary participation, and maintaining confidentiality of students' responses throughout the study.

Table 1: Mean and Standard Deviation of Experimental and Control Group on Pre test

Group	N	Mean	Std. Deviation
Exp 1	52	13.54	11.836
Exp 2	49	15.94	16.240
Control	51	6.51	7.234



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Total	152	11.95	12.826
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The descriptive statistics for the pretest scores showed differences among the three groups prior to treatment. Participants in Experimental Group 2 obtained the highest mean score ( $M = 15.94, SD = 16.24, n = 49$ ), followed by Experimental Group 1 ( $M = 13.54, SD = 11.84, n = 52$ ). The Control Group had the lowest mean pretest score ( $M = 6.51, SD = 7.23, n = 51$ ). The overall mean pretest score for all participants was 11.95 ( $SD = 12.83$ ), indicating that participants entered the study with varying baseline levels of performance.

**Table 2: ANOVA pretest scores of experimental and control group**

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2420.193	2	1210.097	8.042	.000
Within Groups	22420.485	149	150.473		
Total	24840.678	151			

A one-way Analysis of Variance (ANOVA) was conducted to determine whether significant differences existed among the three groups on pretest scores before the intervention. The result revealed a statistically significant difference among the groups,  $F(2, 149) = 8.04, p < .001$ . This finding indicates that the groups were not equivalent at baseline prior to treatment.

**Table 3: Mean and Standard Deviation of Experimental and Control Group on Pos-test**

Group	Mean	Std. Deviation	N
Exp 1	57.71	15.101	52
Exp 2	53.63	11.330	49
Control	35.04	12.726	51
Total	48.79	16.442	152

Posttest descriptive statistics revealed substantial improvement in the experimental groups compared to the control group. Experimental Group 1 recorded the highest mean posttest score ( $M = 57.71, SD = 15.10, n = 52$ ), followed by Experimental Group 2 ( $M = 53.63, SD = 11.33, n = 49$ ). The Control Group had the lowest mean posttest score ( $M = 35.04, SD = 12.73, n = 51$ ). The overall mean posttest score for all participants was 48.79 ( $SD = 16.44$ ). These results suggest that the treatments administered to the experimental groups were associated with higher achievement outcomes than the conventional method used for the control group.

**Table 4: ANCOVA Test of post test scores of experimental and control groups**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14931.282 <sup>a</sup>	3	4977.094	28.452	.000	.366
Intercept	183107.465	1	183107.465	1046.733	.000	.876
Pretest	.002	1	.002	.000	.998	.000
Trtm	13711.517	2	6855.758	39.191	.000	.346
Error	25889.981	148	174.932			
Total	402644.000	152				
Corrected Total	40821.263	151				

a. R Squared = .366 (Adjusted R Squared = .353)

A one-way Analysis of Covariance (ANCOVA) was conducted to examine the effect of treatment on posttest scores while controlling for pretest scores. The result showed a statistically significant main effect of treatment,  $F(2, 148) = 39.19, p < .001$ , partial  $\eta^2 = .346$ . This indicates that treatment had a significant influence on participants' posttest achievement scores after adjusting for initial pretest differences. The effect size was large, suggesting that approximately 34.6% of the variance in posttest scores was attributable to treatment differences.



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The covariate (pretest score) was not statistically significant,  $F(1, 148) = 0.00, p = .998$ , partial  $\eta^2 = .000$ , indicating that pretest scores did not significantly predict posttest performance after treatment effects were considered. Furthermore, the overall model was significant,  $F(3, 148) = 28.45, p < .001$ , explaining 36.6% of the variance in posttest scores ( $R^2 = .366$ , Adjusted  $R^2 = .353$ ). These findings demonstrate the effectiveness of the treatment conditions in improving participants' academic performance.

**Table 5: t-test of post test scores of experimental and control groups based on gender**

Gender	No	X	SD	Df	T	sig
Male	29	57.86	17.529	50	0.08	.937
Female	23	57.52	11.727			

An independent samples t-test was conducted to determine whether there was a significant difference in the post-test scores of male and female students in the experimental group. The result shows that male students ( $n = 29, M = 57.86, SD = 17.53$ ) had a slightly higher mean score than female students ( $n = 23, M = 57.52, SD = 11.73$ ). However, this difference was not statistically significant,  $t(50) = 0.08, p = .937$ . Since the  $p$ -value is greater than .05, the null hypothesis is not rejected. This indicates that there is no significant difference in the post-test achievement scores of male and female students. In other words, gender did not have a significant effect on students' performance in the post-test within the experimental group.

### Discussion of Findings

The findings of this study, viewed against the background of the introduction, provide strong evidence that innovative learner-centered instructional approaches can significantly improve students' mathematics achievement more than the conventional teacher-centered method. As earlier noted, persistent poor performance in mathematics has often been linked to overreliance on traditional instructional practices characterized by note-taking, memorization, and passive learning. The present results therefore validate concerns raised in the literature and demonstrate that when students are exposed to more engaging pedagogies such as Inquiry-Based Learning (IBL) and ICT-Driven Pedagogy, their academic outcomes improve substantially. The descriptive statistics showed clear differences in favour of the treatment groups. Experimental Group 1 recorded the highest posttest mean score ( $M = 57.71$ ), followed by Experimental Group 2 ( $M = 53.63$ ), while the Control Group had the lowest mean score ( $M = 35.04$ ). These results suggest that students taught with the two innovative approaches achieved better learning outcomes than those exposed to the conventional method. This finding aligns with earlier studies cited in the introduction which reported that inquiry-oriented and technology-supported teaching methods enhance conceptual understanding, engagement, and retention in mathematics ( Xu, 2025). The pretest analysis revealed significant differences among the groups before treatment,  $F(2, 149) = 8.04, p < .001$ , indicating that the participants were not initially equivalent in achievement level. This justified the use of Analysis of Covariance (ANCOVA), which statistically adjusted for baseline differences and enabled a more accurate assessment of the treatment effects. Such adjustment strengthens the credibility of the findings because the observed posttest differences can be more confidently attributed to the instructional interventions rather than prior academic disparities. After controlling for pretest scores, the ANCOVA result showed that treatment had a statistically significant effect on students' posttest achievement,  $F(2, 148) = 39.19, p < .001$ , partial  $\eta^2 = .346$ . This means that approximately 34.6% of the variation in posttest performance was explained by the treatment conditions, representing a large effect size. Educationally, this indicates that the choice of instructional strategy plays a major role in determining students' success in mathematics. The finding supports the argument in the introduction that pedagogy is a powerful determinant of achievement, alongside motivation, teacher quality, and classroom environment.

The strong treatment effect may be explained by the nature of the two pedagogical approaches examined. Inquiry-Based Learning likely improved achievement by actively involving students in questioning, exploration, problem-solving, and justification of mathematical ideas. This supports constructivist assumptions that learners understand concepts more deeply when they participate in knowledge construction rather than merely receiving information. Similarly, ICT-Driven Pedagogy may have enhanced achievement through visualization of abstract concepts, immediate feedback, interactive tasks, and individualized learning opportunities. This is consistent with previous studies which found that digital tools can make mathematics more accessible, motivating, and meaningful (Ottenbreit-Msambwa & Daniel, 2024; Cahyono et al., 2025).



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Interestingly, the covariate (pretest scores) did not significantly predict posttest scores after treatment was introduced,  $F(1,148) = 0.00, p = .998$ . This suggests that the interventions were sufficiently powerful to reduce the influence of students' initial ability levels. In practical terms, students appeared to benefit from the innovative teaching methods regardless of their starting point. This has important implications for inclusive education, as it indicates that learner-centered pedagogies may support both low-achieving and high-achieving students. The higher mean score obtained by Experimental Group 1 compared with Experimental Group 2 suggests that although both treatment methods were effective, one strategy was relatively more impactful than the other. Given the focus of this study, if Experimental Group 1 represented Inquiry-Based Learning, the result may imply that active investigation, peer discussion, and guided discovery had a stronger influence on mathematics achievement than technology integration alone. On the other hand, if Experimental Group 1 represented ICT-Driven Pedagogy, the result may indicate that digital tools and interactive resources provided superior support for learning. In either case, the finding confirms the importance of comparing innovative pedagogies, as recommended in the introduction, so that schools with limited resources can identify the most effective strategy. Overall, the findings strongly support constructivist and learner-centered theories of instruction, which maintain that students learn mathematics more effectively when they are actively engaged in exploration, collaboration, and problem-solving. The results also reinforce contemporary calls for pedagogical reforms aimed at achieving quality education and improved STEM readiness. Therefore, mathematics teachers, school administrators, and policymakers should prioritize the adoption of evidence-based instructional strategies such as Inquiry-Based Learning and ICT-Driven Pedagogy in order to enhance students' achievement and make mathematics classrooms more interactive, inclusive, and effective.

## Conclusion

The study clearly demonstrates that the intervention strategies used in the experimental groups were more effective than the conventional teaching method in improving learners' achievement. Therefore, adopting innovative instructional practices can significantly enhance academic performance and overall learning

## Recommendations

To effectively adopt innovative instructional practices, coordinated efforts are needed across sectors:

1. Schools and educational institutions should adopt the teaching strategies used in the experimental groups because the findings of the study showed that these approaches significantly improved learners' academic achievement when compared with the conventional teaching method.
2. Teachers should be provided with regular training through workshops, seminars, conferences, and other professional development programmes on the use of innovative, learner-centered, and activity-based teaching methods.
3. Educators should reduce excessive dependence on traditional lecture methods and conventional teacher-centered approaches.
4. Curriculum planners and educational authorities should review existing curricula to incorporate modern instructional strategies into teaching guides, syllabi, and learning frameworks.
5. Government, school administrators, and other stakeholders should provide adequate instructional materials, technological facilities, and supportive learning resources necessary for the successful implementation of innovative teaching methods.
6. Teachers should create classroom environments that encourage active student participation through discussion, collaboration, questioning, and problem-solving activities.
7. School principals, supervisors, and quality assurance officers should regularly monitor classroom teaching to ensure that effective instructional strategies are properly implemented.
8. Researchers should carry out similar studies in other subject areas, educational levels, and geographical locations in order to confirm the findings of this study and broaden their applicability.

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