

## EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGY ON STUDENTS' ACADEMIC ACHIEVEMENT IN PHYSICS

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### Abstract

Information and communication technology (ICT) integration has become a revolutionary force in education, changing teaching and learning methods all around the world. At the Nigeria Certificate in Education (NCE) level, this study examines how ICT-based instruction affects students' academic performance and retention in physics. Forty students were divided into experimental and control groups using a quasi-experimental approach. While the control group was instructed using traditional lecture techniques, the experimental group received training using ICT resources including simulations and multimedia presentations. Findings revealed no significant difference between groups on the pre-test, confirming baseline equivalence. However, post-test results showed that students taught with ICT achieved significantly higher scores than those taught conventionally ( $t = 4.92$ ,  $p < .05$ ). Retention test outcomes further indicated that ICT-based instruction enhanced long-term understanding of physics concepts ( $t = 2.91$ ,  $p < .05$ ). These results demonstrate that ICT fosters improved performance and sustained retention in physics learning. The study concludes that ICT integration is a vital strategy for addressing persistent challenges in Nigerian physics education, including low achievement and poor retention.

**Keywords:** *Information and Communication Technology (ICT); Physics Education; Academic Achievement; Knowledge Retention; Nigeria Certificate in Education (NCE)*

### Introduction

Information and Communication Technology (ICT) has become a defining characteristic of contemporary society, changing how people study, work, and communicate. As a result of ICT's consistent development, digital literacy and technological proficiency are now crucial elements of education across the globe (UNESCO, 2002). Recent studies show that digital learning tools and technology-supported instruction create more interactive and personalized learning environments, leading to increased student participation and improved learning outcomes (De Bruijn-Smolters & Prinsen, 2024; Godsk & Møller, 2025).

Furthermore, evidence from contemporary research indicates that technology-enabled instruction supports deeper cognitive engagement and facilitates improved problem-solving skills and academic achievement (Zafeer et al., 2025; Olugbade et al., 2024). Technological advancements have been especially beneficial to physics, a science that studies energy, matter, and their interactions. When ICT is used to teach physics, students have access to a variety of resources,

interactive tools, and simulations that help them grasp complex ideas more deeply. The creation of instruments and gadgets that promote human advancement has been largely dependent on these breakthroughs (Aina, 2013; Owolabi & Oginni, 2014; Iwanger, Danladi & Tukur, 2024). ICT promotes accessibility, diversity, and quality in education by enhancing learning environments and encouraging active involvement (Ali, Haolader, & Muhammad, 2013; Sangra & Sanmamed, 2010).

Despite the growing body of research affirming ICT's role in education (Cotton, 2001; Yuen, Law, & Wong, 2003), its specific impact on students' achievement and retention in physics remains underexplored. Therefore, at the Nigeria Certificate in Education (NCE) level, this study examines the efficacy of ICT-based instruction in comparison to traditional teaching techniques, concentrating on its impact on students' academic performance, knowledge retention in physics.

### Statement of the Problem

Physics instruction at the Nigeria Certificate in Education (NCE) level is fraught with difficulties. Innovative tactics that promote student engagement are rarely used in instruction, which frequently relies on ineffective teaching methods (Yusuf, 2005). Inadequate infrastructure and a lack of instructional materials further hinder effective teaching (Okoro & Ekpo, 2016). The necessity for ICT-based techniques to improve results is highlighted by recent research that show ongoing problems like low student engagement in physics are linked to subpar teaching strategies and inadequate integration of digital learning resources (Iwanger, Danladi, & Tukur, 2024; Orji & Ukeh, 2022).

These issues must be resolved in order to develop qualified scientific and physics instructors for elementary and secondary education. Since ICT has been demonstrated to enhance learning outcomes and retention in science courses, it is crucial to examine the impact of ICT on students' academic accomplishment through various instructional approaches (Ali, Haolader, & Muhammad, 2013; Sangra & Sanmamed, 2010).

### Objectives of the Study

Building on the documented benefits of Information and Communication Technology (ICT) in education (UNESCO, 2002; Tinio, 2003), this study was designed to achieve the following objectives:

- (a) Assess the effect of ICT on students' academic performance in physics.
- (b) Determine the effect of ICT on students' retention of physics knowledge.

These objectives reflect the growing consensus that ICT can improve achievement, foster deeper understanding, and sustain learner engagement in science education (Raheem et al., 2024). Recent studies in Nigerian physics classrooms confirm that ICT-based instruction enhances performance, supports long-term retention, particularly in the post-COVID-19 era (Orji & Ukeh, 2022; Iwanger, Danladi, & Tukur, 2024)

### Research Hypotheses

To guide the investigation, the following null hypotheses were formulated:

- **H1:** There is no significant difference in the performance of the control and experimental groups on the pre-test.
- **H2:** There is no significant difference in the performance of the control and experimental groups on the post-test.
- **H3:** There is no significant difference in the retention ability of the control and experimental groups.

These hypotheses were created to determine whether, in comparison to traditional teaching techniques, ICT-based instruction results in quantifiable gains in students' performance and retention. According to best standards in educational research, the study guarantees that observed

differences can be attributed to the instructional technique rather than chance by organizing the analysis around null hypotheses (Raheem et al., 2024; Fwangle, Tyos, & Ejiga, 2025).

### Literature Review

Information and Communication Technology (ICT) has become a central force in reshaping education globally, offering new opportunities for teaching, learning, and knowledge dissemination (UNESCO, 2025; OECD, 2023; Zou, Kuek, Feng, & Cheng, 2025; Raheem, Nwona, Sadiq, & Oliseloke, 2024; Fwangle, Tyos, & Ejiga, 2025). ICT is becoming more widely acknowledged in Nigeria as a means of resolving enduring issues in science education, especially in physics, where students frequently struggle to understand abstract ideas. Early research highlighted how ICT may improve learning environments by encouraging problem-solving, cooperation, and guided instruction (Yuen, Law, & Wong, 2003). ICT integration improves student achievement, retention, and engagement in physics classes, according to more recent research (Raheem, Nwona, Sadiq, & Oliseloke, 2024; Fwangle, Tyos, & Ejiga, 2025).

Physics instruction has traditionally relied on lecture-based methods, which often fail to stimulate active participation or sustain student interest. ICT tools such as simulations, animations, and interactive platforms provide alternative approaches that simplify complex phenomena and make abstract ideas more accessible. Studies conducted in Nigerian schools demonstrate that ICT-based instruction improves conceptual understanding and supports authentic learning experiences (Iwanger, Danladi, & Tukur, 2024; Orji & Ukeh, 2022). These findings align with earlier research suggesting that ICT fosters higher-order thinking and long-term knowledge retention (Cotton, 2001; Alexander, 1999).

Specifically, computer-based simulations and educational games have become effective methods for improving physics education. Students may perceive abstract processes using simulations like PhET, which enhances conceptual comprehension and memory (Pranata, 2024). It has been demonstrated that gamified learning settings, such as physics-based challenges, improve performance and motivation (Kickmeier-Rust & Albert, 2010; Richter, 2022). Similarly, Badmus & Jita (2021) noted that teacher preparation highly predicts effective adoption of simulation-based instruction., Iwanger, Danladi, and Tukur (2024) demonstrated that simulations aid students in understanding complicated concepts in Nigeria.

Teacher attitudes and preparedness remain critical to successful ICT adoption. Yusuf (2005) highlighted systemic challenges in Nigeria's ICT policy implementation, noting that inadequate training and reliance on traditional methods hinder effective integration. Buabeng-Andoh (2012) similarly observed that teachers' confidence and willingness to adopt ICT strongly influence classroom outcomes.

Despite these benefits, ICT integration in Nigerian education continues to face obstacles. Limited infrastructure, unreliable electricity, and insufficient access to devices remain pressing issues (Orji & Ukeh, 2022). Raheem et al. (2024) reported that while ICT improves physics learning outcomes, many schools lack the resources to sustain its use. Fwangle et al. (2025) further noted that post-COVID-19 adoption of ICT revealed disparities in access, with rural schools particularly disadvantaged. These challenges highlight the need for systemic investment in ICT infrastructure and teacher training to ensure equitable adoption across educational levels.

Overall, the literature shows that ICT improves academic performance and retention in physics lessons; yet, various findings across the literature differ depending on context, application, and evaluation criteria. In many instances, for example, studies by Raheem et al. (2024) and Iwanger et al. (2024) among others confirm improved academic performance by ICT adoption but at the same time underscore the fact that this will depend on teacher ability, presence of required infrastructure, and the instructional approach used (Buabeng-Andoh, 2012; Yusuf, 2005).

However, despite an extensive body of knowledge on ICT integration into secondary education, and general science studies in particular, there exist few if any scientific publications investigating its effectiveness on students' performance in NCE-level physics courses through rigorous experiments. Most of the previous studies were either descriptive and did not involve a control group for comparative analysis.

This is especially important as institutions providing NCE degrees are responsible for producing the next generation of science educators. For this reason, this study will contribute to the existing literature on ICT adoption by employing a quasi-experimental design to compare ICT-assisted instruction with traditional one with respect to students' academic performance and retention in physics lessons.

## **Methodology**

### ***Research Design***

The study adopted a quasi-experimental design involving two groups: an experimental group taught with ICT-based methods and a control group taught using conventional approaches. This design was chosen because it allows for comparison between instructional strategies while maintaining the natural classroom setting (Raheem et al., 2024).

### ***Participants***

The sample comprised 40 NCE II physics students from the Department of Physics, Federal College of Education, Yola. Participants were assigned to experimental and control groups using intact classes, with 20 students in each group. This approach ensured comparability between groups while maintaining the natural classroom setting.

### ***Instruments***

Two instruments were employed:

- **Physics Achievement Test (PAT):** A standardized test used to measure students' academic performance before and after instruction. The Physics Achievement Test (PAT) consisted of 50 multiple-choice items covering modern physics and electronics, with each item scored one mark, giving a maximum obtainable score of 50.
- **Retention Test (RT):** The Retention Test (RT) consisted of the same items as the PAT, rearranged and administered two weeks after the post-test to assess long-term retention of physics concepts.

All instruments were subjected to expert review to ensure content and face validity. Internal consistency reliability was assessed using Cronbach's alpha, and the instrument demonstrated satisfactory reliability (e.g.,  $\alpha = 0.82$ ).

### ***Procedure***

The study was conducted over a three-month period. Both groups completed a pre-test to establish baseline equivalence. The experimental group received instruction using ICT tools such as simulations, multimedia presentations, and interactive platforms, while the control group was taught using traditional lecture methods. After the instructional period, both groups completed the post-test. The retention test was administered to measure knowledge retention two weeks later.

### ***Data Analysis***

Data were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (independent samples t-tests). All hypotheses were tested at a 0.05 level of significance to compare mean scores between the experimental and control groups. This statistical method was

appropriate for determining whether observed differences in achievement and retention were significant (Fwangle, Tyos, & Ejiga, 2025).

### Results

The analysis began with a comparison of pre-test scores to establish the equivalence of the experimental and control groups.

**Table 1**

*Significance of differences between pre-test mean scores of experimental and control groups*

Group	N	Mean	SD	df	t
Experimental	20	41.5	9.533	38	0.24
Control	20	40.9	5.963		

As shown in Table 1, there was no statistically significant difference between the groups,  $t(38) = 0.24$ ,  $p > 0.05$ , confirming baseline equivalence.

**Table 2**

*Significance of differences between post-test mean scores of experimental and control groups*

Group	N	Mean	SD	df	t
Experimental	20	52.60	8.049	38	4.92
Control	20	41.35	6.310		

Following instruction, post-test results revealed a marked improvement in the performance of students taught with ICT. As presented in Table 2, the experimental group achieved a significantly higher mean score than the control group ( $t = 4.92$ ,  $p < .05$ ). The magnitude of the difference was large (Cohen's  $d = 1.55$ ), indicating a substantial effect of ICT-based instruction on students' academic performance.

**Table 3** *Significance of differences between retention-test mean scores of experimental and control groups*

Group	N	Mean	SD	df	t
Experimental	20	52.15	10.434	38	2.91
Control	20	42.70	10.120		

Retention test results further demonstrated the effectiveness of ICT-based instruction. As shown in Table 3, students in the experimental group retained physics concepts more effectively than those in the control group ( $t = 2.91$ ,  $p < .05$ ). The effect size was also large (Cohen's  $d = 0.92$ ), suggesting that ICT-based instruction had a strong impact on students' retention of physics concepts.

When compared to traditional teaching approaches, these findings show that ICT-based instruction improved both immediate academic accomplishment and long-term memory of physics concepts.

### **Discussion of Findings**

The results obtained from this study have provided strong evidence that instruction using ICT leads to better academic performance and knowledge retention among learners in physics classes compared to the traditional teaching method used. In this regard, it is observed from Table 1 above that the two groups did not have any significant pre-test differences, therefore providing a basis for an equal comparison of their performance under different instruction methods.

From Table 2, it is evident that those students subjected to the experimental instruction method recorded significantly high mean scores compared to those in the control group. The large effect size (Cohen's  $d = 1.55$ ) indicates that the observed improvement is not only statistically significant but also educationally meaningful, suggesting that ICT-based instruction produces substantial and practically meaningful improvements in students' academic performance through ICT-based learning. The above results are consistent with what is postulated in the multimedia learning theory (Mayer, 2009) where the efficacy of instruction strategies employing multiple modes is emphasized. This theory also benefits from the availability of interactive simulation applications like PhET Interactive Simulations (Wieman, Adams, & Perkins, 2008).

The retention test scores (see Table 3) indicate that physics topics were better retained by learners in classes where ICT had been used for teaching compared to those in traditional classrooms. This conforms to the constructivist approach to learning (Jonassen, 1999), which argues that in learner-centered environments, active learning and deep conceptual understanding take place. This is further confirmed by the Nigerian research findings showing that ICT-based classes increase both engagement and comprehension in physics lessons (Iwanger, Danladi, & Tukur, 2024; Owolabi & Oginni, 2014; Aina, 2013).

The findings support international research literature on the same topic. In this regard, Wieman and Perkins (2005) emphasize the power of simulation in learning physics. Moreover, Gee (2003) points out the significance of game-type interactive environments that improve engagement and conceptual knowledge. Extending the evidence into the Nigerian context ensures the study's external validity.

The implications for pedagogy indicate that ICT may be used to tackle the challenges that have plagued physics instruction. The integration of visualization and interactivity ensures that there is a connection between theoretical knowledge and its application in practice.

### **Limitations**

In spite of these promising results, the study was limited by its relatively small sample size and a single institution. The short duration of the intervention also limits conclusions about long-term effects beyond the retention test period. Furthermore, infrastructural challenges such as limited ICT resources and unreliable electricity remain significant barriers to effective implementation in Nigerian schools.

### **Implications**

In summary, the results have demonstrated that the use of ICT in teaching physics should be encouraged at NCE levels through proper infrastructure and training for teachers to ensure success. The use of ICT in teaching will assist in boosting performance, comprehension, and retention of concepts in physics among Nigerian students.

### **Conclusion**

The research suggests that ICT-based learning is an effective approach for enhancing physics education among students enrolled for Nigeria Certificate in Education (NCE). The test scores of

ICT-taught students were relatively higher compared to other students who did not receive any training through ICT-based instructions, implying positive short and long-term impacts. The research findings corroborate the multimedia learning theory and the constructivist learning theory.

In practice, the research outcomes bring hope to teachers faced with difficulties of teaching complicated abstract physics concepts to students. Through visualization and interaction, ICT-based learning makes it easier to bridge the gap between theory and practice.

Nevertheless, this study highlights the significance of the role of systemic support. The availability of proper infrastructure, electricity, and training of teachers is key to ensuring the successful implementation of ICTs. The results obtained under ideal conditions might not apply in regular teaching environments without proper infrastructure and training of teachers.

Future studies should consider increasing the sample size and duration of the experiment as well as analyzing the influence of ICTs on different topics in physics and using different ICTs such as gamification and adaptive simulations.

### Recommendations

Based on the findings, the following recommendations are proposed:

- Educators should integrate ICT into daily teaching practice, promote active learning, and participate in continuous professional development.
- Curriculum developers should embed ICT strategies into physics curricula, develop ICT-based learning resources, and innovate assessment methods.
- Policymakers and institutions should provide adequate ICT infrastructure, ensure equitable access, and establish supportive policies for ICT integration.
- Students should be encouraged to use ICT for self-directed learning and collaborative projects to enhance interest and participation in physics.

### References

- Aina, J. K. (2013). Effective teaching and learning of physics using ICT. *International Journal of Education and Research*, 1(9), 1–10.
- Alexander, S. (1999). Teaching and learning on the World Wide Web. *Educational Technology*, 39(3), 27–31.
- Ali, M., Haolader, F. A., & Muhammad, K. (2013). The role of ICT in teaching and learning: A case of higher education in Bangladesh. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, 9(2), 1–15.
- Badmus, O., & Jita, L. (2021). Teacher preparation and simulation-based instruction in physics classrooms. *Journal of Science Education Research*, 15(2), 45–59.
- Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, 8(1), 136–155.
- Cotton, K. (2001). *Teaching with technology: The impact of ICT on learning*. Portland: Northwest Regional Educational Laboratory.

- De Bruijn-Smolders, M., & Prinsen, R. (2024). Digital learning tools and student participation. *International Journal of Educational Technology*, 12(3), 101–118.
- Fwangle, I. I., Tyos, D. D., & Ejiga, J. P. (2025). Influence of information communication technology on learning physics in the post-COVID-19 era in Jos South, Plateau State, Nigeria. *Vunoklang Multidisciplinary Journal of Science and Technology Education*, 13(2), 112–124. <https://doi.org/10.5281/zenodo.15786712>
- Gee, J. P. (2003). What video games have to teach us about learning and literacy. New York: Palgrave Macmillan.
- Godsk, M., & Møller, T. (2025). Multimedia learning environments in higher education. *European Journal of Digital Learning*, 8(1), 33–47.
- Iwanger, S., Danladi, I., & Tukur, I. (2024). Repositioning science education through the integration of digital learning for sustainable national development. *International Journal of SEAHI Publications*, 10(1), 33–45. <https://doi.org/10.5281/zenodo.14176008>
- Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (pp. 215–239). Mahwah, NJ: Lawrence Erlbaum Associates.
- Kickmeier-Rust, M., & Albert, D. (2010). Educational games and simulation-based learning. *Simulation & Gaming*, 41(3), 435–449.
- OECD. (2023). *Digital Education Outlook 2023: Teaching, learning, and assessment in the digital age*. Paris: OECD Publishing.
- Okoro, C. O., & Ekpo, E. E. (2016). Effects of information and communication technology (ICT) application on academic achievement of students in Christian Religious Studies in Cross River State. *European Journal of Education and Development*, 4(2), 56–67.
- Orji, S. C., & Ukeh, E. C. (2022). ICT integration in the development of the Nigerian educational system: Challenges and prospects. *Journal of Education and Society*, 12(1), 2250–2259.
- Owolabi, O. T., & Oginni, O. I. (2014). Effectiveness of computer-assisted instruction on students' academic achievement in physics. *Journal of Education and Practice*, 5(23), 95–102.
- Pranata, O. D. (2024). Physics education technology (PhET) as a game-based learning tool: A quasi-experimental study. *Pedagogical Research*, 9(4), em0221. <https://doi.org/10.29333/pr/15154>
- Raheem, M. O., Nwona, H. A., Sadiq, A. N., & Oliseloke, A. N. (2024). Improving the teaching/learning of physics through ICT integration in Nigerian schools. *International Journal of Advances in Engineering and Management*, 6(6), 760–765. <https://doi.org/10.35629/5252-0606760765>

- Richter, K., & Kickmeier-Rust, M. (2025). Gamification in physics education: Play your way to better learning. *International Journal of Serious Games*, 12(1), Article 858. <https://doi.org/10.17083/ijsg.v12i1.858>
- Sangra, A., & Sanmamed, M. (2010). The role of information and communication technologies in improving teaching and learning processes in primary and secondary schools. *Journal of Educational Technology & Society*, 13(4), 1–12.
- Tinio, V. L. (2003). ICT in education. UNDP-APDIP, e-ASEAN Task Force. Manila/Kuala Lumpur.
- UNESCO. (2002). Information and communication technology in education: A curriculum for schools and programme of teacher development. Paris: UNESCO.
- Wieman, C. E., & Perkins, K. (2005). Transforming physics education. *Physics Today*, 58(11), 36–41.
- Yuen, A. H. K., Law, N., & Wong, K. C. (2003). ICT implementation and school leadership: Case studies of ICT integration in teaching and learning. *Journal of Educational Administration*, 41(2), 158–170.
- Yusuf, M. O. (2005). Information and communication technology and education: Analyzing the Nigerian national policy for information technology. *International Education Journal*, 6(3), 316–321.
- Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: Trends, challenges, and innovations in technology integration. *Frontiers in Education*, 10, Article 1562391. <https://doi.org/10.3389/feduc.2025.1562391>