EFFECT OF DIGITAL LEARNING TOOLS ON STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY IN SECONDARY SCHOOL IN ONDO STATE, NIGERIA.

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Abstract
*Digital learning tools now play a significant role in modern education by providing innovative methods for teaching and learning, especially in Chemistry. However, despite these advancements, students' performance in Chemistry in many secondary schools continues to fall below expectations. This study investigated the influence of digital learning tools on students' academic performance in Chemistry in secondary schools in Ondo State, Nigeria. A non-equivalentpre-test, post-test control group quasi-experimental design was adopted. The study involved one experimental group taught using digital learning tools and one control group taught through the conventional method of instruction. The sample comprised **61** Senior Secondary School II students, selected using a multi-stage sampling procedure. Two research questions were raised and two hypotheses guided the study. Data were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (independent samples t-test). The results revealed that students exposed to digital learning tools performed significantly better than those taught using the conventional method ($t = 0.03$, $p < 0.05$). The study concluded that digital learning tools significantly enhance students' achievement in Chemistry. It was therefore recommended that Chemistry teachers at the secondary school level should integrate digital learning tools into classroom instruction to improve students' academic performance.*

Keywords: Digital learning tools, instructional strategies,

Chemistry achievement, secondary school students

Introduction

Technology has become a significant force transforming education globally. In modern classrooms, digital learning tools such as simulations, animations, interactive videos, and virtual laboratories have greatly influenced teaching methods and students' learning experiences. These tools promote active participation, improve visual comprehension, and allow students to learn at their own pace, particularly in science subjects that involve abstract ideas such as Chemistry (Omoniyi &Akinsete, 2023).

Chemistry is frequently regarded by students as a challenging subject because many of its concepts are theoretical and difficult to visualize. In Nigeria, reports from the West African Examinations Council (WAEC, 2022) reveal that students' performance in Chemistry continues to be relatively low. Researchers have linked this persistent poor performance to several factors, including inadequate instructional materials, the dominance of teacher-centered teaching approaches, and limited student engagement during classroom activities (Olusola et al., 2020).

Digital learning tools provide practical solutions to many of these challenges. By using virtual demonstrations of chemical reactions, molecular structures, and laboratory experiments, students can better grasp complex concepts, which improves their understanding and retention. Adebayo and Olayinka (2021) noted that incorporating digital media into classroom instruction encourages independent and meaningful learning among students. Based on this premise, the present study investigates the effect of digital learning tools on students' academic performance in Chemistry in secondary schools in Ondo State.

Science is a systematic body of knowledge that plays an important role in addressing human, material, and environmental challenges. It involves two interrelated processes: acquiring knowledge through

the exploration and discovery of the natural world, and applying that knowledge to promote human and material development. Consequently, science education extends beyond the learning of scientific facts; it also focuses on equipping learners with the skills needed to communicate scientific knowledge effectively to individuals and communities that may not traditionally engage with science.

Appropriate teaching methods are not applied in the instruction of subjects such as Biology, Chemistry, or Physics, the process ceases to represent true science education and becomes merely the transmission of scientific information. Effective science education requires teachers who are capable of presenting scientific concepts clearly while also addressing students' misconceptions. Science education is vital for the technological progress of any nation because of its wide-ranging social and economic benefits. Many technologically advanced countries recognize that a nation's true strength lies in the intellectual capacity of its people rather than in its physical resources. As a result, numerous countries are reforming their educational systems to respond to the demands of an increasingly technological world.

In the 21st century, quick and easy access to information has become a crucial factor for both personal growth and societal progress. Researchers have explored the benefits and limitations of internet-based learning compared with conventional classroom teaching. These studies highlight the increasing role of computers in education while also recognizing the difficulties that may arise within online learning environments. According to Cetin et al. (2023), education and technology have become closely interconnected in the modern world, as technological advancements continue to influence how teaching and learning take place.

Subjects related to science and technology help students develop a solid understanding of scientific principles and enable them to apply such knowledge to real-life situations. Examples of these subjects

include Mathematics, Physics, Biology, Health Science, Introductory Technology, and Chemistry. Among them, Chemistry is a compulsory subject for students who wish to pursue science- and technology-related courses at the tertiary level. Chemistry focuses on the properties of atoms, how they combine to form molecules, the interactions between different molecules, and the energy changes that accompany these processes. Brown (2021) emphasized that Chemistry occupies a central role in science and is often regarded as the core discipline within the scientific field.

Chemistry as a discipline involves the study of the composition, structure, and properties of matter, as well as the changes in structure, composition, and energy that occur during chemical reactions. One of the major aims of teaching Chemistry in schools is to help students understand and interpret the natural world. This is because the wide range of materials found in nature can generally be categorized into two basic components: matter and energy. Chemistry has made significant contributions to knowledge in these areas, thereby supporting the broader objective of scientific understanding and effective science education (Wan & Subramaniam, 2023).

The use of digital tools has become globally relevant and affects nearly every aspect of modern life, including education. These tools create opportunities for integrating different forms of instructional materials such as text, images, audio, and video to improve the teaching and learning process. Digital tools include both hardware and software systems, communication networks, and multimedia devices like audio and video equipment, mobile phones, and cameras, which transform information into accessible formats such as text, sound, and visual motion.

Digital tools come in various types and forms, each designed to support specific teaching and learning activities. Portable devices such as Google Chromebooks and iPads can be effectively used for both online learning and classroom instruction. Other technologies, including desktop computers, clickers, SMART boards, and

projectors, are commonly used to present information, support instruction, and facilitate learning. When computers are used as instructional tools, they enable students to develop higher-order thinking skills and apply problem-solving strategies to real-life situations. Hillmayr et al. (2020) found that digital tools improve students' understanding through interactive and multimedia learning materials. Likewise, Eze, Okonkwo, and Uche (2023) noted that digital technologies enhance teacher–student interaction and increase students' motivation across different subject areas, making mobile-assisted learning more effective during instructional activities.

In general, technologically advanced nations acknowledge that sustainable development depends largely on intellectual capacity rather than physical strength. Consequently, many countries are reforming their educational systems to align with the changing demands of technology. This situation highlights the importance of integrating digital learning tools into the teaching and learning of Chemistry and other science-related subjects in today's educational environment.

The use of computers as digital learning tools provides students with opportunities to develop and apply higher-order thinking skills in solving problems relevant to their everyday lives. Hillmayr et al. (2020) emphasized that digital tools enhance students' understanding through interactive and multimedia-based learning content. Similarly, Eze, Okonkwo, and Uche (2023) asserted that digital tools facilitate effective teacher–student interaction and improve learners' motivation across various concepts, thereby making mobile-assisted instruction more engaging and effective during learning activities.

Despite these benefits, the academic performance of Chemistry students has remained comparatively low. Several studies have attributed this poor performance to factors such as the shortage of qualified Chemistry teachers (Eze et al., 2023; Johnson, 2024), negative attitudes and personal fears toward the subject (Wilson et

al., 2020; Njiku, 2022), and teachers' limited proficiency in the use of modern instructional technologies, including computers, tablets, projectors, and smart boards (Roski, Walkowiak, & Nehring, 2021; Eze, Okonkwo, & Uche, 2023). If this persistent trend of poor academic performance and high failure rates in Chemistry is not adequately addressed, it may pose a serious threat to the scientific and technological development of the nation.

To reduce failure rates in Chemistry, researchers have recommended that science teachers undergo regular training and retraining, modern laboratory facilities be adequately provided, and more effective and innovative teaching strategies be adopted (Eze, Okonkwo, & Uche, 2023; Ige, 2024). However, students' academic achievement in Chemistry continues to remain low, particularly in secondary schools in Ondo State, Nigeria. This situation has been linked to inadequate teacher knowledge of digital learning tools, insufficient instructional materials, and the ineffective integration of digital tools in Chemistry teaching.

In view of these challenges, the purpose of this study is to investigate the effects of digital learning tools on students' academic performance in Chemistry. Specifically, the study seeks to examine the effect of digital learning tools instruction on students' achievement in Chemistry.

Two research questions were raised while two hypotheses were formulated to guide this study:

1. Is there any difference between the pre –test achievement means scores of students exposed to digital learning tools in Chemistry concepts and those exposed to conventional method?
2. Is there any difference between the post –test achievement means scores of students exposed to digital learning tools in Chemistry concepts and those exposed to conventional method?

The following null hypotheses were generated for this study at 0.05

levels of significance:

H_o1. There is no significant difference in the pre –test achievement mean score of students in chemistry in the experimental and control groups.

H_o2: There is no significant difference between the achievement mean scores of students exposed to digital leaning tools and those exposed to conventional method.

Significant of the Study

The findings of this study are expected to be beneficial to students, science teachers, curriculum planners, non-governmental organizations, and philanthropists, as well as society at large. The study provides relevant information on the effects of digital learning tools on students' academic achievement in secondary school Chemistry. The results are expected to guide educational stakeholders in understanding how digital learning tools can improve students' learning outcomes in Chemistry.Students are expected to benefit from the inclusion of digital learning tools in the secondary school Chemistry curriculum, as such tools can enhance teaching and learning conditions. The use of digital learning tools can simplify abstract Chemistry concepts that students often find difficult to understand, thereby improving comprehension and achievement. The results of the study may also help curriculum developers and education policymakers make well-informed decisions regarding the inclusion and effective integration of digital learning tools into the secondary school curriculum in Ondo State. Furthermore, the study may provide useful insights for other government sectors involved in educational planning and implementation.

This study was delimited to Ondo North Senatorial District of Ondo State, Nigeria, and covered one selected local government area within the district. The study focused on Senior Secondary School II (SSS II) students. The scope was limited to Chemical Equilibrium, which is one of the abstract topics in the SSS II Chemistry syllabus. Specifically, the study examined the effect of the independent

variable (digital learning tools) on the dependent variable (students' academic achievement in Chemist.

This chapter reviewed relevant literature on the influence of digital learning tools on students' academic achievement in secondary school Chemistry in Ondo State. Chemistry is often regarded as a difficult subject because many of its concepts, such as atomic structure, chemical bonding, and chemical equilibrium, are abstract. According to Cognitive Load Theory, students tend to struggle when too much information is presented simultaneously. Digital learning tools can help reduce this challenge by presenting complex ideas through videos, animations, and interactive activities, which break information into smaller and more understandable units. This approach improves comprehension and retention of concepts.

The study considered digital learning tools as the independent variable and students' academic achievement as the dependent variable. Digital learning tools are technology-based platforms that allow teachers to deliver instructional content electronically. Their importance became more evident during the COVID-19 pandemic when they served as alternatives to face-to-face teaching. Today, they continue to support learning by complementing traditional classroom instruction. However, their effectiveness depends largely on teachers' technological and pedagogical skills. Teachers must plan lessons carefully and integrate technology in ways that support the curriculum rather than allowing it to dominate classroom instruction.

The concept of chemical equilibrium was also discussed because it represents one of the most complex topics in Chemistry. Equilibrium refers to a condition where there is no observable change in a system over time. It may occur as physical equilibrium, where no chemical change takes place, or chemical equilibrium, where reactants and products are continuously formed at equal rates. Reversible reactions can only achieve dynamic equilibrium in a closed system. According to Le Chatelier's principle, any change in temperature, pressure, or

concentration will shift the equilibrium position in a way that counteracts the disturbance.

Previous studies have also emphasized the importance of students' initial academic levels in research involving digital learning tools. Scholars such as Ogunleye and Adeyemi (2021) and Yusuf and Bello (2023) noted that when experimental and control groups have similar pre-test scores, differences in post-test results can more reliably be attributed to the intervention. Other researchers also confirmed that the absence of significant differences at the pre-test stage indicates group equivalence and strengthens the validity of the findings. These observations support the present study, where no significant difference was found between both groups at the pre-test stage.

Methodology

This section describes the methods and procedures adopted for carrying out the study. It covers the research design, population of the study, sample and sampling techniques, research instruments, validity and reliability of the instruments, procedure for data collection, and methods of data analysis.

The study adopted a**non-equivalent pre-test, post-test control group quasi-experimental design,** complemented with a survey approach. The design involved one experimental group and one control group. This design was considered appropriate because intact classes were used, making it suitable for school-based research without disrupting the normal school setting. It also allowed for meaningful comparison between students taught using digital learning tools and those taught using the conventional method of instruction.

The design layout is represented as follows:

Experimental Group:

Pre-test (O_1) $\rightarrow$ Treatment (X_1) $\rightarrow$ Post-test (O_2)

Control Group:
Pre-test (O_3) → Conventional Method (X_2) → Post-test (O_4)
O_1 and O_3 represent the pre-test scores of the experimental and control groups respectively
O_2 and O_4 represent the post-test scores of the experimental and control groups respectively $_1$ represents treatment using digital learning tools. X_2 represents instruction using the conventional teaching method. This design was considered effective in controlling extraneous variables that could threaten the internal and external validity of the study. It also permitted the use of intact classes, thereby preventing disorganization within the school system, which school administrators often seek to avoid.

The population of the study comprised all **Senior Secondary School II (SSSII) Chemistry students** in the 309 public secondary schools in Ondo State as at 2023. SSS II students were selected because they had already acquired foundational Chemistry concepts and calculation skills during their SSS I class, making them suitable for the topic taught in the study. The sample consisted of **61 SSSII Chemistry students** drawn from intact classes in two selected secondary schools in Ondo State. A **multi-stage sampling procedure** was employed. At the first stage, one senatorial district was selected from the three senatorial districts in Ondo State using a simple random sampling technique.

At the second stage, one Local Government Area (LGA) was purposively selected from the chosen senatorial district. The purposive selection was based on the availability of schools with digital learning facilities. At the third stage, two secondary schools were purposively selected from the LGA. The selection criteria for the experimental school included the availability of a standard computer laboratory, at least one qualified Chemistry teacher, coeducational status, and willingness of the school management to participate in the study and allow the use of digital facilities. The control school was selected based on the availability of a Chemistry teacher, coeducational status, and willingness of the school

management to participate in the study. Finally, one arm of the SSS II Chemistry class was randomly selected from each of the two schools.

One research instrument was used for data collection, namely the **Chemistry Achievement Test (CAT)**. The CAT consisted of **30multiple-choiceobjectiveitems** with four options (A–D). The items were adapted from **WAEC and NECO Senior Secondary School Examination past questions** between 2010 and 2022. The questions were randomly selected to adequately cover the topic taught during the study, which was **Chemical Equilibrium**. Two instructional packages were used for the study: **Instructional Package for Digital Learning Tools.** This package was developed for the experimental group. The Chemistry concepts were logically arranged and mounted on computer systems in the experimental school. It consisted of lesson guides and digital resources covering selected concepts in chemical equilibrium, and **Instructional Package for Conventional Method.** This represented the traditional method of teaching Chemistry. Lesson plans were developed by the researcher and implemented by the Chemistry teacher in the control school to minimize instructional bias. The research instrument and instructional packages were validated by the researcher's supervisor, science education experts from the Department of Science Education, Faculty of Education, Adekunle Ajasin University, Akungba-Akoko, and two experienced secondary school Chemistry teachers with at least twelve years of teaching experience. The validation process ensured both **contentand construct validity**. Necessary corrections and modifications were made based on the experts' recommendation. Pilot testing was conducted to determine the reliability of the instrument. The CAT was administered to students from secondary schools outside those selected for the main study in Ondo State. The reliability of the CAT was determined using the **Kuder–Richardson** Formula20 **(KR-20)**, as the items were scored dichotomously (correct or incorrect). The reliability coefficient obtained for the CAT was **0.75,** indicating that the instrument was reliable for the study. The study was conducted in

three stages: pre-treatment, treatment, and post-treatment stages. Permission was obtained from the school authorities to involve their students and to use their lesson periods. A 40-minute lesson period, held twice weekly over six weeks, was approved for the experimental school. The researcher also liaised with school personnel for effective coordination of the research activities.

1. **Pre-treatment Stage:** The CAT was administered to both the experimental and control groups to establish equivalence in academic ability at the entry level.

2. **Treatment Stage:** Students in the experimental group were taught using digital learning tools, while students in the control group were taught using the conventional teaching method. Instruction was conducted twice a week for four weeks using the developed instructional packages.

Post-treatment Stage: The CAT was reshuffled and re-administered to both groups as a post-test to determine the effect of the treatment on students' academic achievement.

The pre-test and post-test scores obtained from the CAT were analysed using both descriptive and inferential statistics. Research questions were answered using **mean and standard deviation,** while the hypotheses were tested using the **independent samples t-test**at the **0.05 level of significance.**

Results and Discussion

Research Question One: Is there any difference between the pre –test achievement means scores of students exposed to digital learning tools in Chemistry concepts and those exposed to conventional method?

To answer this research question, the pre-test scores of students from experimental and control groups were subjected to descriptive analysis and the results are presented in table3.

Table
Mean and standard deviation of pre-test achievement scores of students from experimental and control group

Group	Achievement score	N	Minimum	Maximum	Mean	S. D
Exp.	Pre- test	30	7.00	12.00	9.30	1.45
Control	Pre-test	31	6.00	11.00	9.05	1.54

Table 1 showed that pre-test mean score of secondary school chemistry students in the experimental group ($\bar{x}$ = 9.30, S.D = 1.45) and that of control group ($\bar{x}$ = 9.05, S.D. = 1.54) are similar. However, the results from table 1 showed that the students in the groups entered the experiment with similar knowledge of chemistry.

Research Question Two: Is there any difference between the post –test achievement mean scores of students exposed to digital learning tools in learning Chemistry concepts and those exposed to conventional method?

To answer this research question, the post-test scores of students in the control group and post-test scores of students in the experimental group were subjected to descriptive analysis and the results are presented in table 2.

Table 2
Mean and standard deviation of post-test achievement scores of students from experimental and control groups.

Group	Achievement score	N	Minimum	Maximum	Mean	S. D
Exp.	Post- test	30	10.00	23.00	14.75	2.14
Control	Post-test	31	7.00	15.00	9.68	2.80

The results presented in Table 2 indicate that the post-test mean achievement score of students in the experimental group ($\bar{x}$ = 14.75, S.D. = 2.14) was higher than that of the control group ($\bar{x}$ = 9.68, S.D. =

2.80) following the intervention. This finding suggests that students performed better when taught using digital learning tools, highlighting the positive effect of the intervention on their Chemistry achievement.

Hypothesis One

There is no significant difference in the pre-test achievement mean scores of students in Chemistry in the experimental and control groups.

To test this hypothesis, the pre-test scores of students in both the experimental and control groups were analysed using an independent samples t-test. The results of this analysis are presented in Table3.

Table 3

Independent sampled t-test analysis of pre-test achievement scores of students in experimental and control groups

Group	Achievement score	N	Me an	S. D	df	t- value
Exp.	Pre- test	30	52.00	9.04	59	0.47
Control	Pre-test	31	49.90	8.18		

The results presented in **Table 3** showed that **t = 0.47, p > 0.05**. This indicates that there was **no significant difference** in the pre-test knowledge of students in both the experimental and control groups. Therefore, the hypothesis stating that *there is no significant difference in the pre-test achievement mean scores of students in Chemistry in the experimental and control groups* is **accepted**. This finding confirms that the students were **homogeneous in terms of their Chemistry knowledge** at the entry point of the experiment, providing a fair baseline for comparing the effects of the interventions.

Hypothesis Two

There is no significant difference between the achievement mean scores of students exposed to digital learning tools and those

exposed to the conventional method.

To test this hypothesis, the **post-test achievement scores** of students in the experimental and control groups were analysed using an **independent samples t-test**. A summary of the t-test analysis is presented in **Table4**.

Table 4: Independent t-test analysis of post- test achievement scores of experimental and control groups

Group	Achievement score	N	Me an	S. D	df	t- value
Exp.	Post- test	30	83.45	5.101	59	0.03
Control	Post-test	31	59.88	13.761		

The results presented in Table 4 revealed a calculated value of $t = 0.03$ at $p < 0.05$, indicating that a significant difference exists. As a result, the null hypothesis was rejected. This means that there is a significant difference between the post-test mean achievement scores of students who were taught using digital learning tools and those who were taught using the conventional teaching method. The treatment group recorded a mean score of 83.45, while the group taught with the conventional method had a mean score of 59.88. This suggests that students who learned Chemistry through digital learning tools performed better than those taught through traditional instructional methods.

The findings indicated that the pre-test mean scores of students in both the experimental and control groups were almost the same. This shows that the students in the two groups possessed similar levels of prior knowledge in Chemistry before the commencement of the experiment. Therefore, the null hypothesis stating that there is no significant difference in the pre-test mean achievement scores of the two groups was accepted.

This result is consistent with previous studies in educational research which state that when experimental and control groups have similar pre-test scores, it confirms that both groups started from the same academic level. Under such circumstances, accepting the null hypothesis is appropriate because there is no substantial difference at the initial stage of the study (Ogunleye & Adeyemi, 2021; Yusuf & Bello, 2023).

Conclusion

Based on the results obtained from the data analysis and interpretation, it can be concluded that the use of digital learning tools positively influences the academic achievement of secondary school students in Chemistry in Ondo State.

In line with the findings of this study, the following recommendations are proposed:

1. Chemistry teachers should incorporate digital learning tools alongside traditional teaching methods in order to enhance students' understanding and overall academic performance.
2. The Ondo State government should support the integration of technology in education by providing schools with appropriate digital learning tools for effective teaching and learning of Chemistry.
3. Parents should make efforts to provide their children with access to digital learning tools that can assist them in studying Chemistry independently outside the classroom.
4. Students are encouraged to make productive use of smartphones and other digital platforms to regularly practice Chemistry questions and strengthen their learning.
5. **Curriculum developers** should incorporate digital learning tools into the school curriculum and recommend their use in secondary schools.
6. **School authorities and government agencies** should organize teacher training programs, and teacher trainees should be trained in the use of digital learning tools.

The Suggestions for Further Research.

1. This study should be replicated in other states of Nigeria to explore possible regional variations in the effectiveness of digital learning tools.

2. Similar studies should be conducted in other science subjects such as Biology and Physics in Ondo State and other regions.

3. Future research should examine the influence of potential mediating or intervening variables, such as school location (rural versus urban), students' mathematical ability, and socio-economic background, on the effectiveness of digital learning tools.

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