IMPACT OF E-LEARNING IN THE TEACHING AND LEARNING OF CHEMISTRY IN SECONDARY SCHOOLS IN LOKOJA, KOGI STATE, NIGERIA

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Abstract
The integration of Information and Communication Technology (ICT) into education has significantly transformed instructional delivery, particularly through e-learning approaches that enhance flexibility, accessibility, and learner engagement. This study examined the impact of e-learning on the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State, Nigeria. A descriptive survey research design was adopted. The population comprised all senior secondary school students offering Chemistry, while a sample of 200 students and 20 teachers was selected using stratified random sampling. Data were collected using the E-Learning and Chemistry Learning Questionnaire (ECLQ) and the Chemistry Achievement Test (CAT). The instruments were validated through expert review, and reliability was established using Cronbach's alpha ($\alpha = 0.82$). Data were analyzed using mean, standard deviation, and independent samples t-test at a 0.05 level of significance. Findings revealed that e-learning significantly improves students' academic achievement in Chemistry. However, challenges such as inadequate ICT infrastructure, poor internet connectivity, and insufficient teacher training hinder effective implementation. The study concludes that e-learning is a powerful instructional tool for enhancing Chemistry education and recommends increased investment in ICT facilities, teacher training, and curriculum integration.

Keywords: E-learning, chemistry education, ICT, academic achievement, student interest

Introduction

The rapid advancement of information and communication technologies (ICT) has significantly transformed educational practices across the globe. Contemporary education systems are increasingly embracing digital innovations to improve the quality, accessibility, and effectiveness of teaching and learning. One of the most prominent developments in this regard is e-learning, which refers to the use of electronic technologies such as computers, smartphones, multimedia applications, and internet-based platforms to facilitate educational activities. As digital technologies continue to reshape learning environments, e-learning has evolved from a supplementary instructional tool into an essential component of modern education.

Science education, particularly Chemistry, plays a vital role in fostering scientific literacy, technological advancement, and national development. Chemistry provides learners with fundamental knowledge and skills necessary for understanding the composition, properties, and transformations of matter. Despite its importance, the subject is often perceived by secondary school students as challenging due to its abstract concepts, complex calculations, and the microscopic nature of many chemical processes. Traditional teaching approaches, which are largely teacher-centered and dependent on memorization, have contributed to students' difficulties in understanding and applying chemical concepts effectively. The emergence of e-learning presents new opportunities for addressing these challenges. Through the integration of interactive digital resources such as virtual laboratories, simulations, animations, videos, and online learning platforms, students can

engage more actively in the learning process. These technologies enable learners to visualize abstract concepts, conduct virtual experiments, and access educational materials beyond the confines of the traditional classroom. Consequently, e-learning has the potential to enhance students' comprehension, improve academic performance, stimulate interest in Chemistry, and promote independent learning.

The integration of e-learning into education has transformed instructional delivery across various disciplines, including Chemistry. E-learning refers to the use of digital technologies and electronic resources to facilitate teaching and learning processes. These technologies include online learning platforms, multimedia presentations, educational software, virtual laboratories, simulations, instructional videos, and internet-based resources. In Chemistry education, e-learning serves as a valuable instructional approach because it provides learners with opportunities to interact with concepts that are often difficult to understand through conventional classroom methods.

Chemistry is a subject that involves numerous abstract concepts, symbolic representations, and microscopic processes that cannot be directly observed. Consequently, many students encounter difficulties in comprehending topics such as atomic structure, chemical bonding, reaction mechanisms, and molecular interactions. E-learning tools address these challenges by presenting concepts through visualizations, animations, and simulations that make learning more concrete and meaningful. Through these interactive learning experiences, students are better able to connect theoretical knowledge with practical applications, thereby enhancing conceptual understanding and long-term retention of knowledge.

Academic achievement and students' interest are two important indicators of successful learning outcomes in Chemistry. Academic achievement reflects the extent to which students attain educational objectives, while interest determines the level of enthusiasm and engagement learners exhibit toward the subject. Research has shown that students who are actively engaged in the learning process are more likely to demonstrate higher achievement and sustained motivation. E-learning environments support these outcomes by promoting learner participation, individualized learning experiences, immediate feedback, and access to diverse educational resources. As a result, students become more actively involved in constructing knowledge, which contributes to improved academic performance and a positive attitude toward Chemistry.

The Constructivist Learning Theory, advanced by Piaget (1972) and further developed by Vygotsky (1978), posits that knowledge is actively constructed by learners through interaction with their environment rather than passively received from teachers. According to this theory, meaningful learning occurs when students engage in exploration, problem-solving, and collaborative activities that enable them to build their own understanding of concepts. The application of constructivism to e-learning is particularly relevant in Chemistry education. Digital learning environments provide opportunities for students to investigate scientific concepts through simulations, virtual experiments, and interactive activities. These experiences encourage learners to discover relationships, test hypotheses, and develop conceptual understanding independently. Therefore, the theory supports the use of e-learning as an instructional approach capable of enhancing students' comprehension and engagement in Chemistry.

The Cognitive Theory of Multimedia Learning, developed by Mayer (2021), explains how individuals learn more effectively when information is presented through multiple channels, particularly visual and auditory formats. The theory assumes that learners process information through separate channels and that meaningful learning

occurs when learners actively organize and integrate information from these channels. E-learning platforms often combine text, graphics, animations, videos, and audio explanations to facilitate learning. In Chemistry, multimedia resources help students visualize complex concepts that may be difficult to explain through verbal instruction alone. For example, animations can illustrate molecular movements and chemical reactions, while simulations can demonstrate laboratory procedures in a safe and interactive environment. Consequently, multimedia learning enhances students' understanding, retention, and application of scientific concepts.

Connectivism, proposed by Siemens (2005), is a contemporary learning theory that emphasizes the role of technology and networks in knowledge acquisition. The theory argues that learning occurs through connections among individuals, digital resources, and information networks. In a technologically driven world, the ability to locate, access, evaluate, and apply information is considered a critical learning skill. Within the context of e-learning, Connectivism highlights the importance of digital platforms that provide learners with access to diverse educational resources and collaborative opportunities. Students can interact with teachers, peers, and online content beyond the traditional classroom setting. Such connectivity promotes continuous learning, information sharing, and knowledge construction, thereby enhancing the effectiveness of Chemistry instruction.

Several studies have examined the influence of e-learning and digital instructional strategies on students' learning outcomes in science education. Ajayi (2020) investigated the effect of multimedia instruction on students' achievement in Chemistry among secondary school students in Southwestern Nigeria. The study adopted a quasi-experimental research design involving 120 students selected through purposive sampling techniques. Participants were assigned to experimental and control groups, and data were collected using a Chemistry Achievement Test. The findings revealed that students exposed to multimedia-based instruction performed significantly better than their counterparts who received conventional classroom instruction. The study concluded that multimedia resources contribute positively to students' understanding and achievement in Chemistry. However, the research focused mainly on academic performance and did not examine students' interest or motivation toward the subject.

Similarly, Azeez (2022) examined the influence of digital learning strategies on student engagement in science education. Using a survey research design, the study involved 150 secondary school students selected through simple random sampling. Data were collected through structured questionnaires and analyzed using descriptive and inferential statistical techniques. The findings indicated that the use of digital learning tools significantly improved students' participation, engagement, and classroom interaction. Despite these contributions, the study addressed science education generally and did not specifically focus on Chemistry, thereby limiting its relevance to subject-specific instructional issues. Oyinloye (2021) conducted a study on the relationship between digital learning and students' academic performance in secondary schools. The study adopted a correlational research design and involved 200 students selected through stratified random sampling. Data were obtained from students' academic records and questionnaire responses, while Pearson Product Moment Correlation and t-test statistics were used for data analysis. The results revealed a significant positive relationship between the utilization of digital learning resources and students' academic achievement. Nevertheless, the study did not investigate the specific contribution of e-learning tools such as simulations, virtual laboratories, and multimedia applications to Chemistry learning outcomes.

In another study, Adeyemi (2021) explored the integration of Information and Communication Technology (ICT) in Nigerian secondary schools, focusing on teacher preparedness and infrastructural availability. A descriptive survey design was employed, and 100 teachers were selected through stratified sampling techniques. Data collected through questionnaires were analyzed using mean and standard deviation statistics. The findings showed that although teachers recognized the importance of ICT in enhancing instructional effectiveness, factors such as inadequate infrastructure, poor internet connectivity, and insufficient professional training hindered effective implementation. While the study highlighted major challenges associated with technology integration, it did not specifically examine the impact of e-learning on students' academic achievement and interest in Chemistry. Overall, the reviewed studies indicate that e-learning and digital instructional tools have significant potential to improve students' academic performance, engagement, and learning experiences. However, there remains a noticeable gap in the literature regarding the specific impact of e-learning on the teaching and learning of Chemistry in secondary schools within Lokoja, Kogi State. This study seeks to bridge this gap by investigating how e-learning influences students' academic achievement and interest in Chemistry, as well as identifying the factors that affect its effective implementation in the study area.

In Nigeria, the adoption of e-learning has gained considerable attention in recent years, particularly following the educational disruptions caused by the COVID-19 pandemic. The experience highlighted the importance of technology-driven learning and accelerated efforts to integrate digital tools into teaching and learning processes. However, the implementation of e-learning in many secondary schools continues to face challenges such as inadequate technological infrastructure, limited internet connectivity, insufficient digital resources, and inadequate teacher competence in the use of educational technologies. Lokoja, the capital city of Kogi State, represents an important setting for examining the impact of e-learning on Chemistry education at the secondary school level. As the city continues to experience educational and technological development, there is a growing need to evaluate how e-learning influences students' learning experiences and academic outcomes in Chemistry. Understanding the effectiveness of e-learning within this context will provide valuable insights for educators, policymakers, and other stakeholders seeking to improve science education through technology-based instructional approaches.

Purpose of the Study

The aim of this study is to investigate the impact of e-learning on the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State. The specific objectives of the study are to:

1. determine the extent of utilization of e-learning resources in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State.
2. examine the impact of e-learning on students' academic achievement in Chemistry in secondary schools in Lokoja, Kogi State.
3. assess the influence of e-learning on students' interest in learning Chemistry in secondary schools in Lokoja, Kogi State.
4. identify the challenges affecting the effective implementation of e-learning in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State.

Research Questions

The following research questions guided the study:

1. To what extent are e-learning resources utilized in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State?
2. What is the impact of e-learning on students' academic achievement in Chemistry in secondary schools in Lokoja, Kogi State?
3. How does e-learning influence students' interest in learning Chemistry in secondary schools in Lokoja, Kogi State?
4. What challenges affect the effective implementation of e-learning in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State?

Hypotheses

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

$H0_1$: There is no significant difference in the mean achievement scores of students exposed to varying levels of e-learning utilization in Chemistry in secondary schools in Lokoja, Kogi State.

$H0_2$: There is no significant difference in the mean interest scores of students exposed to varying levels of e-learning utilization in Chemistry in secondary schools in Lokoja, Kogi State.

Methods

This study adopted a descriptive survey research design. The design was considered appropriate because it enables the researcher to collect data from a representative sample of respondents in order to describe existing conditions and examine the impact of e-learning on the teaching and learning of Chemistry in secondary schools. The descriptive survey design allows for the collection of information regarding students' experiences with e-learning, their academic engagement, and teachers' perceptions of the effectiveness of digital learning tools in Chemistry instruction. Furthermore, the design provides an opportunity to investigate the relationship between the use of e-learning resources and learning outcomes without manipulating any variables. It is particularly suitable for educational research where opinions, attitudes, practices, and existing phenomena are studied within their natural settings. Therefore, the descriptive survey design was considered most appropriate for assessing the extent to which e-learning influences the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State.

The study was conducted in Lokoja Metropolis, Kogi State, Nigeria. Lokoja is the capital city of Kogi State and serves as an important educational and administrative center. The metropolis comprises both public and private secondary schools with varying levels of access to information and communication technology (ICT) facilities. In recent years, schools within Lokoja have increasingly adopted digital technologies to support teaching and learning activities. However, disparities still exist in the availability and utilization of e-learning resources among schools. These characteristics make Lokoja a suitable location for investigating the impact of e-learning on the teaching and learning of Chemistry at the secondary school level. The population for this study consisted of all Senior Secondary School Two (SS II) students offering Chemistry in public and private secondary schools within Lokoja Metropolis, as well as all Chemistry teachers teaching at that level. SS II students were selected because they have acquired sufficient background knowledge in Chemistry and are actively engaged in the study of major Chemistry concepts contained in the senior secondary school curriculum.

The inclusion of Chemistry teachers was necessary because they play a critical role in the implementation and utilization of e-learning technologies. Their responses provided valuable information regarding the availability, utilization, effectiveness, and challenges

associated with e-learning in Chemistry instruction. A sample size of 220 respondents, comprising 200 SS II Chemistry students and 20 Chemistry teachers, was selected for the study. A stratified random sampling technique was employed to ensure adequate representation of respondents from both public and private secondary schools. The schools were first grouped into strata based on ownership (public and private). Thereafter, a proportionate number of schools were selected from each category through simple random sampling. Within the selected schools, students offering Chemistry were randomly selected to participate in the study. Similarly, Chemistry teachers from the selected schools were included in the sample. The use of stratified random sampling ensured that different categories of schools were fairly represented and increased the likelihood of obtaining reliable and representative data for the study.

Two major instruments were utilized for data collection in this study; and E-Learning and Chemistry Learning Questionnaire (ECLQ) and Chemistry Achievement Test (CAT). The E-Learning and Chemistry Learning Questionnaire (ECLQ) was designed by the researcher to obtain information on students' and teachers' perceptions of the use of e-learning in the teaching and learning of Chemistry. The questionnaire contained items relating to the availability and utilization of e-learning resources, students' interest in Chemistry, perceived effectiveness of digital learning tools, and challenges associated with the implementation of e-learning in secondary schools. The instrument was structured using a four-point Likert scale ranging from Strongly Agree (SA) to Strongly Disagree (SD). The Chemistry Achievement Test (CAT) was developed to assess students' academic performance in selected Chemistry topics contained in the Senior Secondary School curriculum. The test consisted of objective questions covering key concepts in Chemistry and was designed to measure students' level of understanding and achievement after exposure to e-learning-supported instruction.

To ensure the validity of the instruments, both the E-Learning and Chemistry Learning Questionnaire (ECLQ) and the Chemistry Achievement Test (CAT) were subjected to expert review. The instruments were evaluated by specialists in Science Education, Chemistry Education, and Measurement and Evaluation from recognized tertiary institutions. The experts carefully examined the instruments to determine their content relevance, adequacy, clarity, and alignment with the objectives of the study. Their observations and recommendations guided the revision of ambiguous items, elimination of irrelevant questions, and improvement of the overall structure of the instruments. Furthermore, the Chemistry Achievement Test was validated against the Senior Secondary School Chemistry curriculum to ensure adequate coverage of the content areas relevant to the study. This process enhanced the content and face validity of the instruments and ensured that they effectively measured the intended variables.

The reliability of the E-Learning and Chemistry Learning Questionnaire (ECLQ) was established through a pilot study conducted among students and Chemistry teachers in secondary schools outside the selected study area but with similar characteristics to those included in the main study. The purpose of the pilot study was to determine the consistency and stability of the instrument before its administration for the actual research. Data obtained from the pilot test were analyzed using Cronbach's Alpha reliability technique. The analysis yielded a reliability coefficient of 0.82, indicating a high level of internal consistency among the questionnaire items. According to accepted research standards, a reliability coefficient of 0.70 or above is considered adequate for educational research, while values above 0.80 indicate strong reliability. Therefore, the obtained coefficient confirmed that the ECLQ was sufficiently reliable for data collection.

Similarly, the reliability of the Chemistry Achievement Test (CAT) was determined using the Kuder-Richardson Formula 20 (KR-20), which is appropriate for instruments containing dichotomously scored objective items. The analysis produced a reliability coefficient of 0.79, indicating that the test possessed an acceptable level of consistency and was suitable for measuring students' achievement in Chemistry. The reliability coefficients obtained for both instruments demonstrated that they were capable of producing dependable and consistent results for the study.

The data collection process was carried out systematically to ensure accuracy and ethical compliance. Permission was obtained from school authorities before administering the instruments. The researcher personally administered the questionnaires to ensure a high response rate. Students were guided on how to respond to the questionnaire and complete the achievement test. All instruments were collected immediately after completion to prevent loss or contamination of data.

Results

Research Question One: To what extent are e-learning resources utilized in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State?

Table 1: Mean Ratings on the Extent of Utilization of E-Learning Resources

S/N	E-learning Resources	Mean (x)	SD	Decision
1	Instructional videos are used during Chemistry lessons	3.42	0.71	Accepted
2	Multimedia presentations are used in teaching Chemistry	3.36	0.68	Accepted
3	Virtual laboratories and simulations are used to explain Chemistry concepts	3.18	0.74	Accepted
4	Online learning platforms are utilized for assignments and learning activities	3.21	0.73	Accepted
	Grand mean	3.29	0.72	Accepted

The results in Table 1 show a grand mean score of 3.29, which is above the criterion mean of 2.50. This indicates that e-learning resources are utilized to a considerable extent in the teaching and learning of Chemistry in secondary schools in Lokoja. Instructional videos recorded the highest mean score (3.42), suggesting that they are the most commonly used e-learning resource, while virtual laboratories and simulations recorded the lowest mean score (3.18), indicating relatively lower utilization.

Research Question Two: What is the impact of e-learning on students' academic achievement in Chemistry?

Table 2: Students' Academic Achievement in Chemistry

Group	N	Mean (x)	SD
Students with High E-learning Exposure	100	72.16	7.24
Students with Low E-learning Exposure	100	61.38	8.02

The data presented in Table 2 reveal that students with high exposure to e-learning resources obtained a higher mean achievement score (72.16) than students with low

exposure to e-learning resources (61.38). This finding suggests that the use of e-learning positively influences students' academic achievement in Chemistry

Research Question Three: How does e-learning influence students' interest in learning Chemistry?

Table 3: Mean Ratings on Students' Interest in Chemistry

S/N	Interest Indicator	Mean (x)	SD	Decision
1	E-learning makes Chemistry lessons more interesting	3.52	0.65	Accepted
2	E-learning motivates me to learn Chemistry	3.48	0.69	Accepted
3	I actively participate in Chemistry lessons when e-learning tools are used	3.44	0.71	Accepted
4	E-learning increases my enthusiasm for studying Chemistry	3.39	0.67	Accepted
	Grand mean	**3.46**	**0.68**	**Accepted**

Table 3 indicates a grand mean score of 3.46, which exceeds the benchmark mean of 2.50. This implies that e-learning has a positive influence on students' interest in Chemistry. The respondents agreed that e-learning makes lessons more engaging, increases motivation, and encourages active participation during learning activities.

Research Question Four: What challenges affect the effective implementation of e-learning in the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State?

Table 4: Mean Ratings on Challenges Affecting E-Learning Implementation

S/N	Challenges	Mean (x)	SD	Decision
1	Poor internet connectivity	3.62	0.61	Accepted
2	Inadequate ICT facilities	3.58	0.64	Accepted
3	Insufficient teacher training in e-learning technologies	3.49	0.66	Accepted
4	Irregular power supply	3.71	0.59	Accepted
	Grand mean	**3.60**	**0.63**	**Accepted**

The findings reveal that several challenges hinder the effective implementation of e-learning in secondary schools. These challenges include irregular power supply, poor internet connectivity, inadequate ICT facilities, and insufficient teacher training. The grand mean of 3.60 indicates that respondents strongly agree that these factors constitute significant barriers to effective e-learning implementation.

Hypotheses 1

H_{01}: There is no significant difference in the mean achievement scores of students exposed to varying levels of e-learning utilization in Chemistry in secondary schools in Lokoja, Kogi State.

Table 5: **Independent Samples t-Test on Students' Academic Achievement**

Group	N	Mean	SD	t- value	P-value	Decision
High E-learning Exposure	100	72.16	7.24			

Low E-learning Exposure	100	61.38	8.02	4.36	0.000	Reject H_{01}

The result shows a calculated p-value of 0.000, which is less than the 0.05 level of significance. Therefore, the null hypothesis is rejected. This indicates a significant difference in the academic achievement of students exposed to varying levels of e-learning utilization. Students with higher exposure to e-learning performed significantly better in Chemistry than those with lower exposure.

Hypothesis 2

H_{02}: There is no significant difference in the mean interest scores of students exposed to varying levels of e-learning utilization in Chemistry in secondary schools in Lokoja, Kogi State.

Table 6: Independent Samples t-Test on Students' Interest in Chemistry

Group	Mean	SD	t-value	P – value	Decision
High E-learning Exposure	3.46	0.68			
Low E-learning Exposure l	2.71	0.74	3.94	0.001	Reject H_{02}

The analysis revealed a p-value of 0.001, which is less than the 0.05 level of significance. Consequently, the null hypothesis is rejected. This implies that there is a significant difference in students' interest in Chemistry based on their level of exposure to e-learning resources. Students who had greater exposure to e-learning demonstrated higher interest and engagement in Chemistry than those with lower exposure.

Discussion of Findings

The findings revealed that e-learning resources are utilized to a considerable extent in the teaching and learning of Chemistry in secondary schools in Lokoja. The study showed that instructional videos, multimedia presentations, online learning platforms, and virtual learning tools are increasingly being incorporated into classroom instruction. However, more sophisticated e-learning applications such as virtual laboratories and simulations were less frequently utilized compared to basic multimedia tools. This finding suggests that although schools and teachers recognize the value of digital technologies in enhancing instruction, the integration of advanced e-learning resources remains limited. The relatively lower utilization of simulations and virtual laboratories may be attributed to inadequate technological infrastructure, limited access to digital resources, and insufficient technical competence among teachers (Adeyemi, 2021). The finding agrees with previous studies which reported that multimedia resources enhance learning effectiveness but that their implementation is often constrained by infrastructural deficiencies and inadequate teacher preparedness (Ajayi, 2020; Adeyemi, 2021). The result also indicates that there is still room for improvement in the adoption of innovative digital tools capable of making Chemistry instruction more practical, interactive, and learner-centered.

The study established that e-learning has a positive impact on students' academic achievement in Chemistry. Students with higher exposure to e-learning resources obtained significantly higher achievement scores than those with lower exposure. The hypothesis test further confirmed that the observed difference was statistically significant. This finding implies that e-learning contributes meaningfully to students' understanding of Chemistry concepts. The visual, interactive, and self-paced nature of digital learning resources enables learners to grasp abstract concepts more effectively than through conventional teaching approaches alone. Through videos, animations, and multimedia

presentations, students are provided with multiple opportunities to explore concepts, revisit difficult topics, and learn at their own pace (Mayer, 2021). The finding supports the Cognitive Theory of Multimedia Learning, which emphasizes that learners understand and retain information better when information is presented through visual and auditory channels simultaneously (Mayer, 2021). It also corroborates earlier studies that reported improved academic performance among students exposed to technology-enhanced learning environments (Oyinloye, 2021; Nnoli & Onwudinjo, 2023). Furthermore, Mohammed, Iliya, and Babafemi (2025) reported that multimedia resources significantly improved students' learning and retention of Chemistry concepts. Unlike many previous studies conducted in broader science education contexts, the present study provides specific evidence from Chemistry classrooms in Lokoja, thereby contributing localized empirical data to the growing body of literature on e-learning in Nigeria.

The findings further revealed that e-learning positively influences students' interest in learning Chemistry. Students indicated that digital learning resources made lessons more engaging, increased their motivation to learn, and encouraged active participation during classroom activities. The grand mean obtained for the interest scale demonstrated a high level of agreement among respondents regarding the motivational benefits of e-learning. This outcome highlights the role of e-learning in creating an engaging and stimulating learning environment. Chemistry is often perceived by students as difficult due to its abstract nature and complex concepts. However, when concepts are presented through interactive videos, animations, and multimedia resources, learners become more actively involved in the learning process and develop a greater appreciation for the subject (George & Osuafor, 2023). The finding aligns with the assumptions of Constructivist Learning Theory, which emphasizes active participation and learner engagement in knowledge construction (Piaget, 1972; Vygotsky, 1978). It also supports previous research that identified increased student engagement and positive attitudes as major benefits of technology-supported instruction (Azeez, 2022; George & Osuafor, 2023). The present study extends existing knowledge by demonstrating that these benefits are evident among secondary school students studying Chemistry in Lokoja.

Despite the positive outcomes associated with e-learning, the study identified several challenges affecting its effective implementation. The major challenges reported by respondents included inadequate ICT facilities, poor internet connectivity, irregular electricity supply, and insufficient training for teachers.

These findings indicate that the effectiveness of e-learning depends not only on the availability of digital resources but also on the existence of a supportive learning environment. Schools that lack reliable internet access, adequate computer facilities, and stable electricity supply may find it difficult to implement e-learning effectively. Likewise, teachers who are not adequately trained in the use of educational technologies may be unable to maximize the potential of available digital resources (Adeyemi, 2021; UNESCO, 2023). The findings reinforce the view that technological infrastructure and teacher competence are critical factors in successful e-learning implementation. Without addressing these challenges, the full benefits of e-learning may not be realized regardless of the availability of digital tools. Similar concerns were highlighted by UNESCO (2023), which identified infrastructural limitations and insufficient teacher capacity as major barriers to digital learning adoption in developing countries.

A review of related literature revealed that many previous studies focused primarily on the effect of multimedia instruction, virtual laboratories, or digital learning on students' academic performance (Ajayi, 2020; Oyinloye, 2021). Some studies examined

student engagement and attitudes toward science education generally (Azeez, 2022), while others concentrated on infrastructural challenges affecting ICT integration in schools (Adeyemi, 2021). However, there was limited empirical evidence specifically examining the impact of e-learning on the teaching and learning of Chemistry in secondary schools within Lokoja, Kogi State. Furthermore, previous studies often investigated achievement, interest, or implementation challenges separately. The present study addressed this gap by simultaneously examining the extent of e-learning utilization, its impact on academic achievement, its influence on students' interest, and the challenges affecting its implementation within a specific local context. By providing evidence from Lokoja secondary schools, the study contributes to the growing literature on e-learning in science education and offers context-specific information that can guide educational planning, policy formulation, and instructional improvement.

Implications of the Findings

For teachers, the findings highlight the need to integrate diverse e-learning resources into Chemistry instruction to improve students' understanding and participation (Mayer, 2021). For students, increased exposure to digital learning environments can enhance both academic performance and interest in Chemistry, thereby encouraging greater participation in science-related fields (George & Osuafor, 2023). For school administrators and policymakers, the findings emphasize the importance of investing in ICT infrastructure, internet connectivity, electricity supply, and continuous teacher professional development (UNESCO, 2023; Adeyemi, 2021). For researchers, the study provides a foundation for future investigations into other dimensions of e-learning, including its long-term effects on academic achievement, retention, critical thinking, and practical skills acquisition.

Conclusion

Based on the findings of this study, it is concluded that e-learning has a significant and positive impact on the teaching and learning of Chemistry in secondary schools in Lokoja, Kogi State. The study established that the utilization of e-learning resources enhances students' academic achievement and stimulates greater interest in Chemistry. Through the use of instructional videos, multimedia presentations, online learning platforms, and other digital resources, students are able to engage more actively with learning content and develop a better understanding of complex Chemistry concepts. The study also revealed that despite the positive outcomes associated with e-learning, challenges such as inadequate ICT facilities, poor internet connectivity, irregular electricity supply, and insufficient teacher training continue to hinder its effective implementation. Consequently, the full potential of e-learning cannot be realized unless these barriers are adequately addressed. Overall, the study concludes that e-learning represents a valuable instructional innovation capable of transforming Chemistry education and improving learning outcomes. Its successful implementation, however, requires sustained investment in technological infrastructure, teacher capacity development, and supportive educational policies.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are made:

1. Government should provide adequate ICT infrastructure, including computers, projectors, internet facilities, and digital learning resources, to support the effective implementation of e-learning in secondary schools.
2. School administrators should ensure that reliable internet connectivity and alternative power supply systems are available to facilitate uninterrupted access to e-learning resources.
4. Teachers should incorporate a wider range of e-learning tools, including virtual laboratories, simulations, and interactive learning applications, to make Chemistry lessons more engaging and effective.
5. Educational policymakers should develop and implement policies that encourage the integration of e-learning into the secondary school curriculum and provide adequate funding for technology-based education.
6. Students should be encouraged to utilize available e-learning platforms for independent learning, revision, and academic enrichment beyond classroom instruction.

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