Availability and Accessibility of Computers and ICT Resources in Teaching and Learning Chemistry in Secondary Schools in Nyamira County, Kenya

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ABSTRACT

This study investigated the availability and accessibility of computers and ICT resources for teaching and learning Chemistry in public secondary schools in Nyamira County, Kenya. The study adopted a descriptive survey design involving 404 Form Three students, 21 Chemistry teachers, and 15 school principals selected through stratified, purposive, and simple random sampling techniques. Data were collected using questionnaires, interviews, and observation schedules, and analyzed using descriptive statistics and thematic analysis. Findings revealed that most schools had inadequate ICT infrastructure, including limited numbers of functional computers, insufficient internet connectivity, lack of subject-specific software, and constrained access to computer laboratories. Students and teachers reported limited opportunities to use ICT during Chemistry lessons due to lab congestion, inadequate technical support, and competing departmental demand for the same ICT facilities. The study concludes that availability and accessibility of ICT resources remain significantly below the level required for effective computer-integrated Chemistry instruction. The study recommends increased ICT investments, targeted allocation for technological based instruction in science subjects, and enhanced support systems to expand access and promote meaningful technology use in Chemistry teaching.

Key words: ICT Integration, Computer Access, Chemistry Education, ICT Resources, Digital Learning.

INTRODUCTION

The integration of Information and Communication Technologies (ICT) into science education has become a central focus of contemporary pedagogical reform aimed at improving learning outcomes and fostering digital competence among learners (Muriithi, 2019). ICT-supported instruction enhances conceptual understanding by enabling students to visualize complex and abstract scientific phenomena that are often difficult to convey through traditional teaching methods (Mwendwa, 2020). In Chemistry education, ICT provides unique instructional advantages through simulations, animations, digital models, interactive diagrams, and virtual laboratories. These tools support learners in bridging the micro–macro–symbolic divide, which encompasses particle-level representations of matter, observable chemical phenomena, and symbolic equations (Hsu, 2021). By enabling dynamic interactions with chemical concepts, ICT promotes inquiry-based learning, problem solving, and scientific reasoning, explaining why many global education systems have adopted digital pedagogies to improve science learning.

International experiences demonstrate that effective ICT integration in science education enhances learner engagement, motivation, and academic performance. Digital resources allow teachers to demonstrate chemical processes that may be hazardous, costly, or impractical to conduct in a physical laboratory (Hsu, 2021). Virtual laboratories and chemistry simulations provide safe and cost-effective environments for experimentation, enabling learners to manipulate variables, observe outcomes, and repeat experiments without risk. Such experiential learning opportunities are vital given the conceptual difficulties inherent in Chemistry, which remains one of the most challenging subjects in secondary education (Mwangi, 2024).

In Kenya, significant efforts have been made to promote ICT integration in teaching and learning through initiatives such as the National ICT Strategy for Education and Training (2006), the Digital Literacy Programme (DLP), and the Competency-Based Curriculum (CBC), which emphasizes digital literacy across all subjects (Rotich, et al., 2025). These initiatives have facilitated the establishment of computer laboratories, investment in ICT infrastructure, teacher capacity-building programmes, and distribution of digital devices to schools. However, despite these national interventions, ICT uptake remains uneven (Gillet, et al., 2019). While well-resourced urban schools have made substantial progress, many rural schools such as those in Nyamira County continue to face persistent ICT-related challenges.

Most Kenyan institutions experience notable disparities in ICT availability, including limited numbers of functional computers, unreliable electricity, inadequate bandwidth, and shortages of Chemistry-specific digital resources (Shisakha, et al., 2024). High maintenance costs, lack of technical expertise, and insufficient institutional support further restrict effective ICT utilization. These constraints hinder teachers' ability to integrate digital tools into Chemistry instruction and limit students' opportunities to interact with technology that enhances their understanding of complex concepts.

Consequently, the availability and accessibility of ICT resources emerge as critical determinants of successful ICT integration in Chemistry classrooms (Rotich, et al., 2025). Availability refers to the presence, adequacy, and functionality of the ICT infrastructure, while accessibility concerns the ease with which teachers and learners can use the available technologies. When ICT resources are inadequate, poorly maintained, or inaccessible, teachers are unable to incorporate digital simulations, demonstrations, or virtual experiments, denying learners valuable opportunities for enhanced scientific visualization (Dele, et al., 2021). Given these persistent challenges, this study investigates the availability and accessibility of computers and ICT resources for teaching and learning Chemistry in secondary schools in Nyamira County. The findings aim to inform policy, guide resource allocation, and support targeted interventions for improving ICT integration in rural science education.

Statement Of The Problem

Although Chemistry is conceptually demanding, modern technological tools have the potential to simplify complex scientific ideas and improve learner understanding. However, in many Kenyan secondary schools, Chemistry lessons continue to rely heavily on traditional teacher-centred methods due to limited ICT resources. School reports and government audits have noted disparities in ICT provision, particularly in rural counties where budgetary limitations, infrastructure gaps, and inadequate ICT support persist. Preliminary observations in Nyamira County revealed overcrowded computer laboratories, shared ICT facilities, and minimal digital materials tailored to Chemistry instruction. Many teachers reportedly lack regular access to computers or projectors for classroom use, while students rarely interact with digital tools to support their learning. These shortcomings undermine efforts to promote digital literacy and limit the potential of ICT to enhance Chemistry pedagogical practices. Despite national investment in ICT, empirical evidence on actual on-ground availability and accessibility of computers for Chemistry-specific learning remains scarce. This study therefore sought to provide data-driven insights into the accessibility challenges and availability gaps affecting ICT-supported Chemistry education in Nyamira County.

Objective of the Study

- To Determine the availability and accessibility of computers and ICT resources in teaching and learning Chemistry in public secondary schools in Nyamira County, Kenya.

Theoretical Framework

This study is anchored in constructivist learning theory, initially articulated by Jean Piaget, who contended that learners actively construct knowledge by integrating new experiences with prior understanding, rather than assimilating information passively. Constructivism conceptualizes learning as an adaptive, meaning-making process in which individuals organize and interpret their experiential world (Almulla, 2023). Within ICT-mediated environments, computer technologies enhance opportunities for exploration, hypothesis testing, and interactive engagement, positioning the teacher as a facilitator. Empirical evidence, such as Colella (2000) simulation-based "virus game," demonstrates that technology-enriched constructivist activities improve collaboration, engagement, and conceptual understanding. Nonetheless, barriers including limited access to ICT and insufficient technical support remain significant (Manyasa, 2022). Constructivism therefore provides a robust theoretical lens for examining ICT-supported Chemistry learning.

LITERATURE REVIEW

Availability of ICT Resources in Schools

The availability of ICT resources constitutes the foundational prerequisite for any meaningful integration of technology in teaching and learning. Scholars argue that instructional innovation in science education is dependent on the presence of adequate ICT infrastructure including computers, projectors, multimedia devices, internet connectivity, and discipline-specific digital tools without which teachers are unable to leverage technology to enhance pedagogy (Tondeur, 2018). Existing literature across sub-Saharan Africa demonstrates that public secondary schools generally exhibit low penetration of ICT infrastructure due to budgetary constraints, uneven policy implementation, and persistent disparities between urban and rural regions. Empirical studies conducted in Kenya, Uganda, Tanzania, and Ghana consistently indicate that most schools possess between 5 and 20 computers regardless of school size, despite having enrolments running into several hundreds of students (Faustino, et al., 2024). These limited numbers constrain opportunities for instructional integration, particularly when all computers are housed in a single laboratory.

A significant proportion of computers available in rural public schools are outdated, poorly functioning, or entirely non-operational due to irregular maintenance, limited access to spare parts, and exposure to environmental factors such as dust and humidity. This greatly diminishes their capacity to run modern educational applications. The shortage of Chemistry-specific digital resources further compounds this challenge. International literature highlights the importance of virtual laboratories, molecular modelling tools, animations, and simulations in supporting the visualization of abstract concepts such as atomic structure, chemical bonding, and reaction mechanisms (Chan et al. 2021). However, studies in Kenyan secondary schools show that these resources are largely absent, forcing teachers to rely on general-purpose applications such as Microsoft Office that lack the interactivity required for effective Chemistry instruction (Ntorukiri, 2020).

Moreover, many schools lack essential supporting devices such as LCD projectors, digital whiteboards, dashboards, or functional audio-visual equipment. Even where such devices exist, they are frequently shared across departments, locked away for security purposes, or rendered unusable due to missing accessories such as power cables or connectors (Bowers, 2021). Collectively, these limitations suggest that while some ICT infrastructure may be nominally present, its quantity, functionality, and subject relevance are insufficient to support high-quality, technology-enhanced Chemistry education. The literature therefore underscores that true availability must be assessed not only in terms of presence but also adequacy, operational status, and alignment with curricular needs.

Accessibility of ICT Resources for Teachers and Students

Accessibility refers to the degree to which teachers and students can utilize available ICT resources when needed for instructional purposes. Research indicates that even when schools possess ICT infrastructure, multiple structural and institutional factors constrain practical access. A common challenge across African educational contexts is the centralization of ICT resources within a single computer laboratory that is physically distant from most classrooms (Wamusi & Habibu, 2024). This arrangement often forces teachers to move entire classes to the laboratorya logistical challenge that discourages routine use during Chemistry lessons. Overcrowding of computer laboratories further complicates access because the facilities serve multiple functions, including Computer Studies lessons, administrative work, examinations, and staff training. As a result, Chemistry teachers struggle to book the laboratory, especially when priority is accorded to subjects requiring ICT for national assessments.

Competition among departments for limited ICT resources has been widely documented. Departments such as Mathematics, Business Studies, and Computer Studies often dominate laboratory schedules, leaving little or no

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time for Chemistry (Nsabayezu, et al., 2022). Even when Chemistry teachers secure access, the time allocated is often irregular and inconsistent with the curriculum, reducing opportunities for planned ICT-enhanced instruction. Students face similar accessibility challenges. School policies frequently restrict unsupervised use of computer laboratories for security reasons. In addition, concerns about equipment damage or virus infections lead some schools to prohibit students from operating laboratory computers independently, limiting their ability to undertake Chemistry-related digital exploration, virtual experiments, or multimedia-based revision.

Accessibility is also shaped by infrastructural and socio-economic constraints. Many rural schools experience unreliable electricity supply, frequent blackouts, and voltage fluctuations, which undermine the stability required for ICT-based instruction (Mckay, 2019). Internet connectivity, where available, is often limited to administrative blocks, or too expensive for sustained classroom use. This digital isolation prevents teachers from accessing online Chemistry resources, simulations, or instructional videos. Further, the absence of dedicated ICT technicians means that malfunctioning equipment remains out of service for prolonged periods, discouraging the use of technology due to fear of inevitable disruptions (Kiptalam & Rodrigues, 2019). Budget constraints exacerbate these challenges, forcing rural schools to prioritize essential expenditures over ICT repairs and upgrades. Collectively, literature demonstrates that while ICT hardware may be present in schools, accessibility is hindered by scheduling conflicts, infrastructural deficiencies, technical failures, and socio-economic disparities. These factors severely limit teachers' capacity to integrate ICT into daily Chemistry instruction and restrict students' opportunities to engage in meaningful, technology-enabled learning activities.

The reviewed literature highlights the importance of ICT availability and accessibility in enhancing Chemistry teaching, particularly through tools that support visualization and virtual laboratory experiences. However, several gaps persist. Most studies examine ICT integration broadly across subjects rather than focusing on Chemistry, which has unique pedagogical demands. Existing research also concentrates on urban or well-resourced schools, leaving limited understanding of ICT challenges in rural counties such as Nyamira. Although some studies note the presence of ICT devices, few investigate their actual usability, despite evidence that available hardware may remain inaccessible due to administrative restrictions, overcrowded laboratories, or competing departmental priorities. There is also insufficient empirical data on Chemistry-specific digital resources, including simulations and virtual labs. Furthermore, many studies rely on self-reported data without incorporating observational evidence to verify the true condition and distribution of ICT facilities. This study addresses these gaps by examining both availability and accessibility of ICT resources for Chemistry education in rural Nyamira County.

RESEARCH METHODOLOGY

This study employed a descriptive survey research design, which was appropriate for assessing the existing status of ICT availability and accessibility in the teaching and learning of Chemistry without manipulating any variables (Kothari, 2010). The target population consisted of 2820 Form Three Chemistry students, 59 Chemistry teachers, and 33 school principals in secondary schools in Nyamira County, selected because of their direct involvement in oversight of Chemistry instruction and ICT usage. A multi-stage sampling strategy was used to draw respondents from this population: simple random sampling was applied to select Form Three students to ensure equal representation, purposive sampling was used to identify Chemistry teachers due to their specialized knowledge and experience with ICT integration, and stratified random sampling was employed for principals to capture all institutional perspectives from the selected schools. Data were collected using three main instruments: student questionnaires to obtain learners' perceptions of ICT access and use during Chemistry lessons; teacher questionnaires and structured interview schedules to gather detailed information on resource availability, usability, and the challenges experienced in employing ICT for instruction; and observation schedules to verify physical ICT infrastructure, including the number and functionality of computers, laboratory layout, connectivity, and availability of Chemistry-specific digital tools. To ensure validity, the instruments were reviewed by experts in educational technology and refined based on their feedback, while reliability was tested through a pilot study, yielding acceptable Cronbach's alpha values above 0.70. Data collection procedures involved obtaining official permissions, administering questionnaires in controlled environments to minimize bias, conducting teacher interviews privately to encourage openness, and observing ICT facilities on-site to confirm their actual condition. Quantitative data were analyzed using descriptive statistics such as frequencies, percentages, and means through SPSS, while qualitative responses from interviews and open-ended items were thematically analyzed and triangulated with observational findings to enhance credibility. Throughout the study, ethical considerations were carefully observed, including informed consent, confidentiality, and voluntary participation, ensuring that all data were collected responsibly and used solely for academic purposes.

FINDINGS AND DISCUSSION

Availability of ICT Resources

To assess the extent to which schools possessed the ICT infrastructure necessary for effective integration of technology into Chemistry instruction, the study examined the availability of essential digital resources across the participating institutions. This analysis focused on critical components such as computer laboratories, Chemistry-specific software, projectors, and reliable internet connectivity. The distribution of these resources is summarized in Table 1.

Table 1: Availability of ICT Resources

Accessibility	**Frequency (n)**	**Percentage (%)**
Schools with Computer Laboratories	4	27
Schools with Chemistry Teaching Software	5	33
Schools with Projectors	6	40
Schools with Reliable Internet Connectivity	1	7

The results presented in Table 1 demonstrate that the overall availability of ICT resources in the surveyed schools is considerably limited, thereby constraining meaningful ICT integration in Chemistry instruction. Only 27% of schools had established computer laboratories, while 33% possessed Chemistry teaching software, indicating a widespread shortage of subject-specific digital tools. Projectors were available in 40% of schools, offering moderate but insufficient support for multimedia-based pedagogy. Notably, only 7% reported reliable internet connectivitya critical limitation given the importance of online simulations, virtual labs, and digital learning platforms for contemporary Chemistry education. Collectively, these findings reveal substantial gaps in the ICT infrastructure required to enhance teaching and learning in Chemistry.

Further analysis showed that although some schools had computer laboratories, the overall quantity and functionality of available ICT devices remained inadequate. Most schools reported having between 5 and 20 functional computers, resulting in student–computer ratios often exceeding 50:1, far above what is pedagogically desirable. A significant proportion of existing computers were outdated, slow, or partially dysfunctional due to irregular maintenance and the absence of technical support staff. Only a small number of schools were equipped with additional instructional technologies such as LCD projectors, digital whiteboards, or document cameras, further limiting teachers' ability to incorporate ICT during Chemistry lessons.

Availability of Chemistry-related digital content was particularly deficient. Observations revealed an almost complete absence of interactive Chemistry simulations, molecular modelling tools, animations, or virtual laboratory platforms. Teachers therefore relied primarily on general applications such as Microsoft Office, which although useful for basic tasks lack the capacity to support visualization of abstract chemical processes and inquiry-based learning. The scarcity of discipline-specific digital resources significantly restricted teachers' ability to enhance learners' conceptual understanding through ICT. Overall, despite the presence of some ICT infrastructure, the quantity, relevance, and functionality of available resources were inadequate to support robust and sustained ICT-enhanced Chemistry education.

Accessibility of ICT Resources

To evaluate teachers' actual access to ICT resources, respondents were asked to indicate the degree to which computers were available for their instructional and professional use. Their perceptions offer important insight into the operational accessibility of ICT infrastructure, which is crucial for effective integration of technology into Chemistry teaching. Table 2 presents teachers' responses regarding ICT accessibility.

Table 2: Accessibility of ICT Resources

Accessibility Indicator	Frequency (n)	Percentage (%)
Highly Accessible	5	23.8
Accessible	6	28.6
Undecided on Accessibility	3	14.3
Inaccessibility	7	33.3

The findings in Table 2 indicate that teachers generally experienced substantial access to ICT resources. Five respondents (23.8%) reported that computers were highly accessible, suggesting that ICT facilities were readily available for lesson preparation and instructional activities. An additional 28.6% described these resources as "accessible", reinforcing the perception of relatively fair access among teachers. However, 14.3% remained undecided, which may reflect inconsistent use, insufficient familiarity with ICT systems, or unclear protocols governing access. Of the teachers sampled 33.3% reported ICT resources as inaccessible for utilization in teaching Chemistry. While this suggests broadly favourable access conditions, the high number of respondents that reported inaccessibility and undecided on access indicates a need for improved ICT orientation and clearer access guidelines to ensure more consistent utilization of available technologies.

Despite these perceptions, the study found that practical accessibility of ICT resources for teaching Chemistry remained considerably constrained. Computer laboratories although present in some schools were shared across multiple departments, with priority consistently given to Computer Studies, administrative tasks, and examinations. Consequently, Chemistry teachers faced difficulty booking laboratory spaces, resulting in infrequent and irregular opportunities to integrate ICT into scheduled lessons. Students similarly reported limited exposure to computers for Chemistry-related tasks, including digital revision, simulations, and assignments. In several schools, computer laboratories were kept locked outside designated ICT periods, further restricting student access.

Infrastructure-related challenges further limited accessibility. Unstable or low-bandwidth internet connectivity was common, and in many cases restricted to staffrooms and administrative offices rather than classrooms or laboratories. Frequent power interruptions, especially in rural schools lacking backup systems, also disrupted ICT use during lessons. These factors collectively reduced the reliability and consistency of ICT-supported instruction.

The absence of technical support staff emerged as a major constraint. Most schools lacked dedicated ICT technicians, resulting in slow repairs and prolonged equipment downtime. Teachers reported avoiding ICT-based lessons due to fears of encountering unresolved technical glitches. Overall, both teachers and students described ICT accessibility as low, with significant logistic, infrastructural, and technical barriers limiting effective use of digital tools in Chemistry classes. These findings underscore the need for systemic improvements to ensure that available ICT resources translate into meaningful, sustained educational use.

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CONCLUSION

The study concluded that availability and accessibility of computers and ICT resources for teaching and learning Chemistry in Nyamira County secondary schools is substantially inadequate. Limited numbers of functional computers, lack of subject-specific digital tools, congested laboratories, unstable internet, and insufficient technical support restrict both teachers' and students' opportunities to utilize ICT for Chemistry instruction. Without improved accessibility and targeted resource allocation, Chemistry education in the county is unlikely to benefit fully from ICT-supported pedagogies.

RECOMMENDATIONS

Based on the findings, the study recommends that schools and education stakeholders prioritize the expansion of ICT infrastructure by increasing the number of functional computers, enlarging computer laboratories, and acquiring essential devices such as projectors and Chemistry-specific software to support digital instruction. To enhance accessibility, schools should develop ICT timetables that allocate dedicated slots for Chemistry lessons and encourage open access to computer laboratories during non-class hours, thereby enabling both teachers and students to interact more frequently with digital tools. Reliable internet connectivity and consistent power supply should be strengthened through investment in high-bandwidth internet, stabilizers, and backup power solutions such as generators or solar systems to ensure uninterrupted ICT use. Additionally, schools should employ qualified ICT technicians to provide regular maintenance, troubleshoot technical issues, and minimize equipment downtime that often discourages teachers from planning ICT-based lessons. Finally, Boards of Management and county governments should allocate targeted budgets for the acquisition of digital Chemistry resources, including simulations, virtual laboratories, and interactive multimedia tools, to enrich instructional delivery and enhance students' conceptual understanding of scientific phenomena.

Ethical and Logistical Considerations

"Before commencing the research, the researcher obtained approval from the graduate school at Kenyatta University. Following this, clearance was sought from the National Council for Science and Technology (NACOSTI) to conduct the study. Additionally, the researcher requested permission from the Nyamira County Commissioner, County Director of Education, and the school administration where the research took place. The researcher also sought consent from all participants, ensuring that the information provided was kept confidential and used solely for the purposes of the study. All sources from which data was gathered have been appropriately acknowledged.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this article. All data were collected and analyzed objectively, and no external party influenced the study design, interpretation of findings, or preparation of the manuscript. The research was conducted solely for academic purposes, and the author does not have any financial, institutional, or personal relationships that could have inappropriately affected or biased the work.

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