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Effects Of Integrating ICT in Teaching Electrochemistry Concepts on Student's Attitude and Mastery of Content

By

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Abstract
The purpose of this study was to investigate effects of integrating Information and Communication Technology (ICT) in teaching concepts on student's attitude and mastery of content. The contention of this article is that poor performance in high school chemistry leads to limited understanding of essential scientific principles, hampering students' readiness for advanced STEM courses, reducing future career opportunities in science-related fields, and contributing to overall low academic achievement in sciences. Electrochemistry as a topic is regarded as one of the most difficult chemistry topics in which both pre-service teachers and students had learning difficulties. The abstract nature of chemistry that makes it highly amenable to ICT integration. The difficult concepts can be animated and made to appear simple. The study found that integrating ICT in teaching significantly improved students' mastery of electrochemistry concepts and improved student's attitude. This approach enhanced understanding and engagement, aligning with research emphasizing hands-on, interactive learning with technology. In conclusion the ministry of education through curriculum developers should enhancing ICT integration in science education by providing professional training to teachers and ensuring adequate ICT infrastructure for integrating ICT into curriculum.

Key words: ICT integration, Teaching methodologies, Electrochemistry education, Secondary education, Educational technology

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Introduction

In recent years, there has been a significant global push towards integrating Information and Communication Technology (ICT) in education, particularly in developed nations. This integration has influenced curriculum development and instructional methodologies, making ICT an integral part of educational strategies (Li & Ma, 2019). The transformative power of ICT is evident in its ability to revolutionize pedagogical approaches, using tools like multimedia resources and interactive platforms to cater to diverse learning styles and promote active engagement among students (Voogt et al., 2013).

Information and Communication Technology (ICT) not only enhances teaching and learning practices but also offers opportunities to broaden access to quality education, especially in remote or underserved areas (World Bank, 2019). It helps overcome barriers like geographical distance and socioeconomic disparities by providing online resources and virtual classrooms. Moreover, ICT plays a crucial role in improving the management of education systems, streamlining administrative tasks, data analysis, and communication within educational institutions (Mulkeen et al., 2015). In Nigeria, there's a growing recognition of the urgent need to equip educators with ICT skills to modernize the educational system (Ogunsola, 2013). This aligns with the global trend where technology has become a knowledge transfer highway, transforming societies and changing the way people think, work, and live (Ghavifekr et al., 2015). As part of preparing students for the digital era, schools need to consider integrating ICT into their curriculum.

Information and Communication Technology (ICT) integration in education refers to incorporating computer-based communication into daily instructional processes, with teachers playing a crucial role in utilizing ICT for creating dynamic and proactive teaching-learning environments (Arnseth & Hatlevik, 2012). The primary goal is to enhance the quality, accessibility, and cost-efficiency of instruction delivery, leveraging networking opportunities to address the challenges of globalization (Gravifark & Rosdy, 2015). Technology use in education enhances learning effectiveness across various subjects and offers valuable assistance and support for both teachers and students without replacing the role of quality teachers (Jamieson-Procter et al., 2013). This is crucial as it facilitates learning beyond traditional boundaries, enabling teaching and learning to occur remotely.

Despite the importance of ICT integration, its implementation has faced challenges, including the lengthy and complex process of formulating ICT policies (Farrell & Isaacs, 2007). In Kenya, for instance, the national ICT policy took several years to finalize, emphasizing access to ICT tools and internet connectivity (Nduati & Bowman, 2005). However, the policy also outlined strategies for enhancing the quality of teaching and learning through ICT in educational institutions (Kenya. MoEST, 2005).

The integration of Information and Communication Technology (ICT) in education, particularly in Migori County, Kenya, aims to improve the teaching and learning of sciences, specifically chemistry. Despite annual Science Mathematics and Technology Education (SMASSE) workshops to enhance science teaching with ICT integration, chemistry

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performance in Migori County has stagnated below a mean grade of D+ for more than five years, as observed in Kenya Certificate of Secondary Education (KCSE) results between 2018 and 2023 (Ministry of Education, Kenya). One challenging topic is electrochemistry, identified as difficult for both teachers and students (Nakhleh, 1992; Oguda, 1994; Ozkaya, 2002).

The abstract nature of chemistry, particularly topics like electrochemistry, makes it suitable for ICT integration. ICT can animate and simplify complex concepts, aiding student understanding. However, despite efforts by the Kenyan government to train teachers in ICT integration and improve infrastructure, KCSE chemistry performance remains low in Migori County (Ministry of Education, Kenya, 2011). The foregoing raises concerns as poor chemistry performance can limit students' opportunities in related fields such as medicine and industry.

The study's purpose was to investigate the impact of integrating ICT in teaching electrochemistry in Migori County secondary schools. The objectives were to determine the impact of integrating ICT on students' mastery of electrochemistry concepts and to investigate the effects of integrating ICT on students' attitude towards learning electrochemistry. The study's significance lies in potentially improving students' mastery of electrochemistry, enhancing teachers' pedagogic skills, and influencing science curriculum development.

The study was based on the constructivist theory of learning, which emphasizes that learners actively construct knowledge through experiences. It draws on the works of Piaget and Vygotsky, highlighting the role of social interaction and language in learning. In constructivist classrooms, learning is seen as a cycle of questioning, interpreting, and analyzing information to develop understanding. In conclusion, the study addresses a crucial gap in literature regarding the impact of ICT integration on teaching electrochemistry concepts in Migori County secondary schools. By understanding these effects, educational policies and practices can be improved to enhance students' learning outcomes. The findings may also inform the integration of ICT in other subjects and regions, contributing to the broader field of educational research.

Research Methods

Research design

The research design aimed to efficiently serve the research purpose by adopting a Solomon Four Group quasi-experimental design. This design allowed the researcher to examine the effects of ICT integration on teaching electrochemistry in Migori County secondary schools. The experimental groups were taught using ICT tools such as computers with internet connectivity and chemistry software, while control groups were taught using conventional materials like chalkboards. Randomization ensured fairness in group assignment, and pretests and post-tests were conducted to assess student outcomes. The design was structured to avoid bias and confounding variables, as noted by Orodho (2009), and to facilitate efficient data collection and analysis. The Solomon Four Group model provides strong evidence for intervention and allows for the assessment of testing effects and confounding variables, which is not possible in other models. The quasi-experimental design was chosen due to the inability to assign individual participants to groups randomly, with efforts made to include groups of students with similar characteristics to minimize threats to internal validity.

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Study Area

Migori County, located in southwestern Kenya, is known for its pleasant climate due to its high altitude and proximity to Lake Victoria. It borders Homa Bay, Kisii, and Narok counties, as well as Tanzania and Lake Victoria. Chemistry as a subject is chosen purposively for the study in Migori County because of its poor performance compared to other subject Map of Migori County in kenya ts. There is little study on ICT integration in chemistry in schools within Migori County. Figure 1 below shows a Map of Migori County.

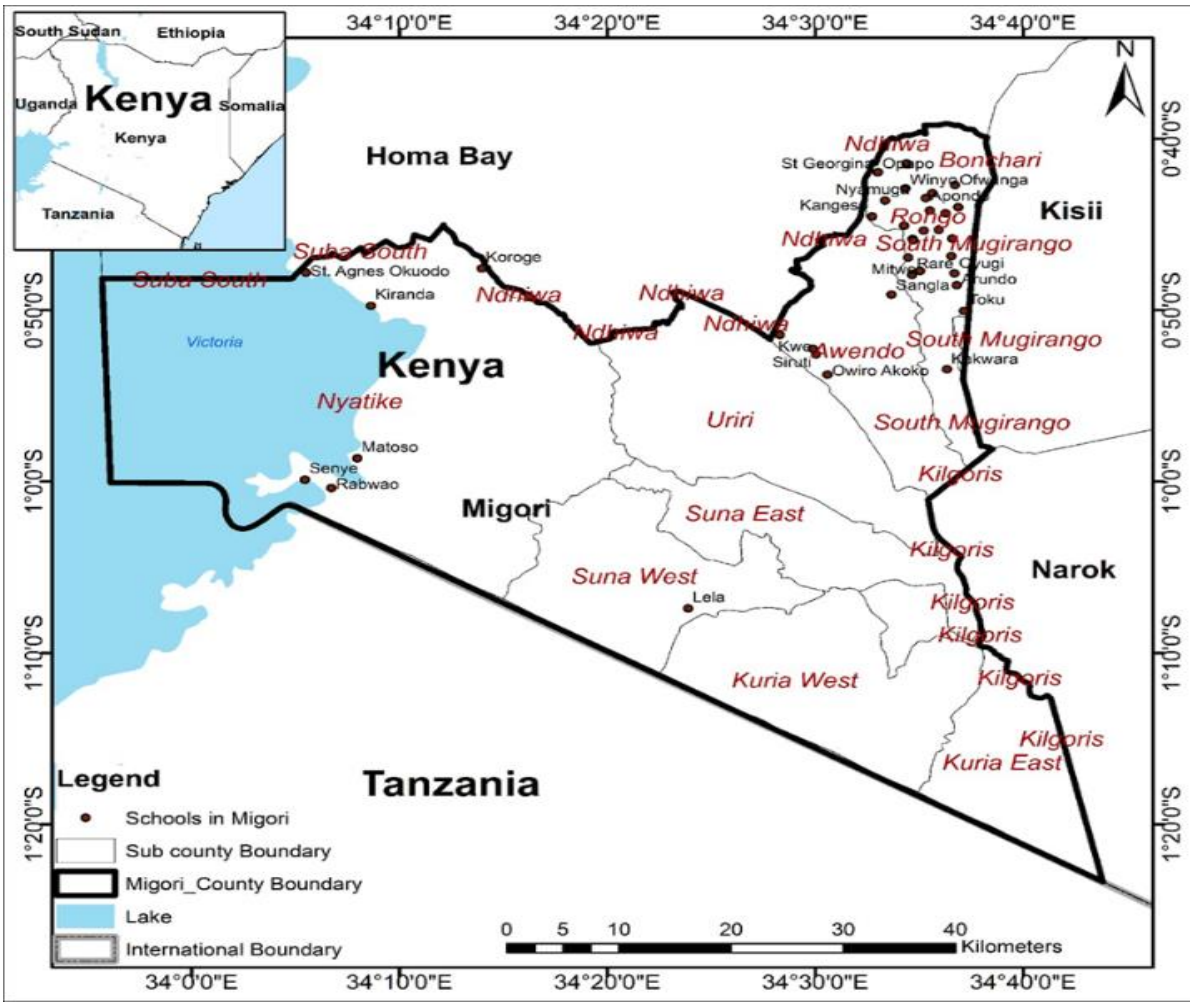

Figure 1: Map of Migori County in Kenya
Source: County Director of MOE Migori County

Target population, sampling procedure and sample size

The research targeted secondary schools in Migori County, including both private and public schools, with a focus on sub-county schools with ICT infrastructure. These schools were chosen because they represented the majority of schools in Migori County, accounting for 76.95% of all schools. The study specifically involved form two students since it was the form where the introductory to electrochemistry, specifically the 'Effect of electric current on substances,' was being taught according to the chemistry syllabus. Respondents included

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principals, Heads of Department (HOD) of science, chemistry teachers, and form two students from these schools, selected for their comparative entry behavior at the Kenya Certificate of Primary Education (KCPE). Probability sampling was used to ensure representativeness of the wider population, with stratified sampling at the sub-county level followed by systematic sampling to select four sub-counties out of the ten in Migori County. The study's Solomon four group design: 4 sub-counties, 4 sub-county schools with ICT, 280 students (assumed 70 per stream), 4 principals, 4 HODs, and 12 teachers as outlined in the sampling grid (Table 1).

Table 1: The Sampling Grid.

	Target population					Sampled population				
	strata	Subcounty schools	students	Principals	Chem teachers	strata	Sub county schools	Students	principals	Chem teachers
TOTAL NO:	10	227	80,644	227	300	4	4	280	4	12

Source: Field Data 2025

Data Collection Instruments

The study used a combination of questionnaires, interviews, and tests to gather data. Questionnaires were used for principals, teachers, and students due to their ability to reach a large number of respondents and their cost-effectiveness. Interviews were conducted with teachers and principals to gather more in-depth information. Pre-test and post-test exams were given to students to assess their entry behavior and the effects of ICT integration on learning. The research instruments were validated through a pilot study, ensuring their reliability and appropriateness. Data analysis involved descriptive and inferential statistics, with T-tests and ANOVA used for comparison. Ethical considerations included informed consent, anonymity, and confidentiality. Logistic considerations involved obtaining consent from relevant authorities and conducting the research over a maximum period of one year.

Data Collection Procedure

First the researcher obtained authority to conduct research from National Commission for Science, Technology and Innovation (NACOSTI), ministry of education through County director of education from the county of study and the principles of sampled schools. The researcher visited the sampled schools and organized with their administrations on when it was convenient and the time limit to collect the data and to train the chemistry teachers on what was expected of them; how to use the data collection instruments such as questionnaires for students and how to use the experimental method. Also appropriate time for administering pre and posttest exams were noted during the visit.

Experimental groups in this study were taught using ICT tools such as computers with internet connectivity and available chemistry software, alongside projectors for accessibility. Various animations on electrochemistry and some online electrochemistry classes were projected on white boards for students to watch so as to improve their attitude and understanding on the topic electrochemistry. In contrast, control groups were taught using

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conventional materials like chalkboards and chalk, excluding these ICT tools for the same topic. Randomization was employed to assign participants to these groups, ensuring fairness. Pretests were administered to determine students' entry behavior, followed by post-tests after class to assess outcomes. The same teaching methods and skills were employed to deliver content consistently.

The study sampled was divided into four groups, with two experimental and two control groups. The first experimental group underwent testing both before and after treatment, while the second (first control group) was also tested before and after without treatment. The third group (another experimental group) underwent testing only after treatment, while the fourth group, another control group, was tested only once, without treatment or a pretest. This configuration adhered to Solomon's Four Group model, ensuring a comprehensive examination of the effects of the treatment on student outcomes as illustrated in Table 2 below.

Table 2: Research Fabric Solomon Four Group

Group	Pre-Test	Treatment	Post-Test
E1	X	T	X
C1	X	N	X
E2		T	X
C2		N	X

KEY; **E**: *Experimental,* **C**: *Control*, **X**: *test*, **T**: *Treatment*, **N**: *No treatment*
Source: Field Data 2025

Results and discussion

Two hundred and eighty learners and sixteen teachers participated in the study, including four head of departments. Gender distribution among learners was nearly equal, with 144 males (51.4%) and 136 females (48.6%). Among teachers, 58.3% were female and 41.7% were male as illustrated in Figure 2.

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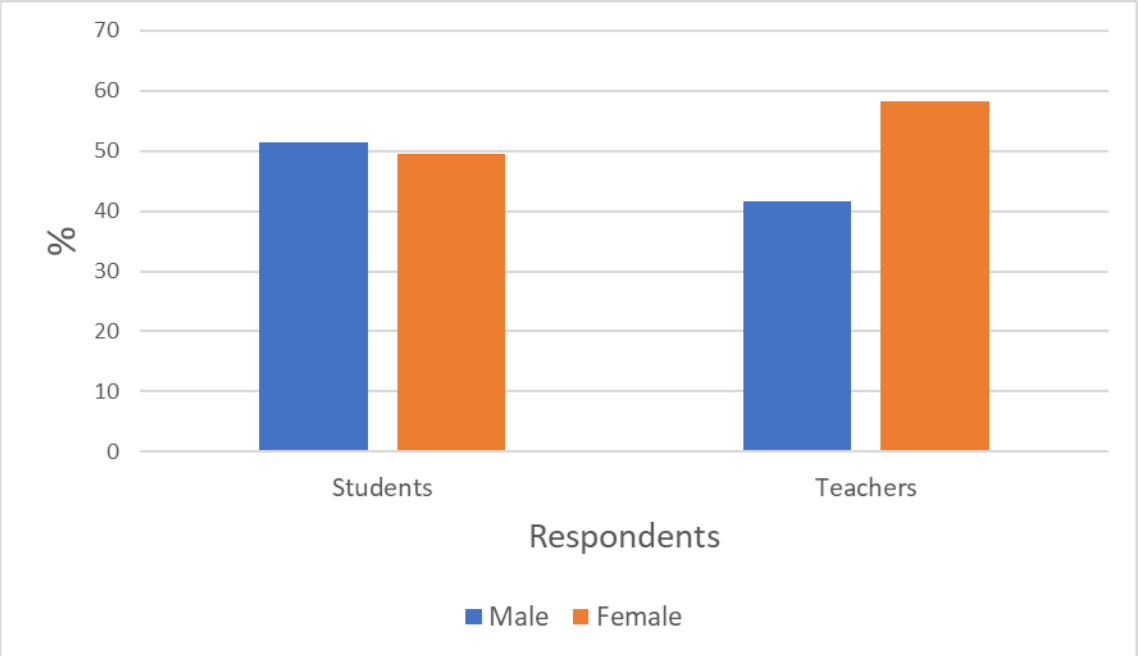

Figure 2: Gender of the respondents
Source: Field Data 2025

Impact of integrating ICT on students' mastery of electrochemistry concepts

The pre-test scores of the control and experimental groups were assessed at the beginning of the study using the Standardized Chemistry Achievement Test. The control group, taught through lectures, had a mean score of 8.22%, while the experimental group, taught using an alternative method, had a mean score of 9.27%. The difference in means was 1.05%. However, a t-test showed no significant difference between the two groups ($t=2.44$, $df=279$, $p=0.2475$), indicating similar abilities at the start of the study, ensuring that any differences in post-test results were not due to initial disparities in student abilities. Post-test results indicated a mean score of 13.43% (SD=2.45) for the control group and 17.59% (SD=3.33) for the experimental group, with a significant difference between the two ($t=-28.18$, $df=279$, $p=0.0037$). The null hypothesis, that ICT has no impact on students' mastery of electrochemistry, was rejected ($t=28.18$, $df=279$, $p<0.0001$), confirming ICT's positive influence on performance in Migori County's public secondary schools.

Table 3: Mean Pre-Test Scores for the School

	Type of group	Mean	SD	t-test
Pretest score	Control group	8.22	2.44	t=2.44, df=279, p=0.2478
	Experimental group	9.27	3.20	
Post-test score	Control group	13.43	2.45	t=-28.18, df=279, p=0.0037
	Experimental group	17.59	3.33	

Source: Field Data 2025

The study's experimental approach, combining practical methods and ICT integration, significantly improved students' understanding of electrochemistry. This aligns with previous research emphasizing hands-on, interactive learning facilitated by ICT in enhancing science

achievement (Khalili & Shashaani, 1994; Schecker et al., 2014). ICT use also boosts student motivation and interest in science (Kay, 2006; Teo et al., 2011), as seen in the higher engagement and better post-test results of the experimental group. Practical activities, known for promoting conceptual understanding and retention (Kirschner et al., 2006; Mayer, 2004), contributed to improved performance. Active learning, facilitated by manipulation of materials and discussions, enhances comprehension and retention (Bonwell & Eison, 1991; Prince, 2004). These results are consistent with meta-analyses highlighting active learning's effectiveness in science education (Freeman et al., 2014; Prince, 2004), supporting the adoption of innovative teaching methods to enhance student engagement and understanding in science.

Effects of integrating ICT on students' attitude towards learning electrochemistry

In the survey to establish the availability of the ICT facilities in teaching and learning chemistry, majority of the learners indicated they had used both computers and smart phones (36.0%). Similarly, more than half of the teachers (50.0%) as well as head of departments acknowledge use of the same. A large proportion of leaners indicated that they were allowed to access school computers or any other ICT (59.3%) and indicated that they perceived ICT as useful to their learning of chemistry in the topic (95.0%). Learners indicated that they were allowed to access school computers or any other ICT (59.3%) and felt it was useful to their learning of chemistry in the topic (95.0%). Learners indicated that majority of their teachers used smart phones in teaching chemistry concepts 145 (51.8%). Learners also indicated that they felt motivated while using ICT in chemistry lessons 273(97.5%). Majority also acknowledge having an ICT technician in their school 211 (75.4%) as illustrated in Table 4.

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Table 4: Learners' Response on The Effects Of Integrating ICT On Students' Attitude Towards Learning Electrochemistry In Migori County Secondary Schools

Question	attribute	frequency	percent	Chi square
Have you ever used any of the following ICT facilities in learning chemistry?	Computer	132	22.6	$\chi^2 = 24.2538$
	smart phone	210	36.0	d.f =3
	projector	32	5.5	$p < 0.0001$
	Both Smart phones and computers	210	36.0	
	total	584	100.0	
Are you allowed to access school computers or any other ICT	No	114	40.7	$\chi^2 = 3.24$
	Yes	166	59.3	with 1 d.f.
	total	280	100.0	p = 0.0719
Do you think ICT is useful to your learning of chemistry in the topic; Effect of electric current on substances	Yes	266	95.0	$\chi^2 = 81.0$
	No	14	5.0	d.f.=1
	total	280	100.0	p = 0.0000
Which of the following does your chemistry teacher use to teach in class	Computer	58	20.7	$\chi^2 = 44.4615$
	smart phone	145	51.8	d.f.=3
	projector	16	5.7	p = 0.0000
	Both Smart phones and computers	62	22.1	
	total	280	100.0	
Do you feel motivated using ICT in chemistry lessons	Yes	273	97.5	$\chi^2 = 90.26$
	No	7	2.5	d.f.=1
	total	280	100.0	p = 0.0000
Does your school have an ICT laboratory technician to help you study difficult chemistry concepts in absent of chemistry teacher	Yes	211	75.4	$\chi^2 = 25.0$
	No	69	24.6	d.f.=1
	total	280	100.0	p = 0.0000

Source: Field Data 2025

For teachers, majority of the (5.0% indicated they were competent in ICT integration and felt well prepared (50.0%) to use ICT in teaching at form two difficult concepts in electrochemistry as illustrated in Table 4.4. When asked whether they had integrated ICT in teaching concepts in electrochemistry at form two level, majority indicated yes (83.3%) and confirmed that the effect was positive. Half of the teachers believed that their schools were supportive of using ICT integration through offering of computer packages even though not quite often as illustrated in Table 5.

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Table 5: Teachers' Response on The Effects Of Integrating ICT On Students' Attitude Towards Learning Electrochemistry In Migori County Secondary Schools

Question	attribute	frequency	percent	Chi square
Have you been trained to use computer to teach?	Yes	10	83.3	$\chi^2 = 61.4122$
	No	1	8.3	d.f.=1
	Total	12	100.0	p=0.0000
Rate your competence in ICT integration	Fair	2	16.7	$\chi^2 = 16.34$
	Good	4	33.3	d.f.=2
	Excellent	6	50.0	p=0.0003
	Total	12	100.0	
Do you feel well prepared to use ICT in teaching at form two difficult concepts in electrochemistry at	Yes	6	50.0	$\chi^2 = 0$
	No	6	50.0	d.f.=1
	Total	12	100.0	p=1.0000
Have you integrated ICT in teaching concepts in electrochemistry at form two level	Yes	10	83.3	$\chi^2 = 43.56$
	No	2	16.7	d.f.=1
	Total	12	100.0	p=0.0000
Do you think your school is supportive of using ICT integration?	Yes	6	50.0	$\chi^2 = 0$
	No	6	50.0	d.f.=1
		12	100.0	p=1.0000
How often do you integrate ICT in teaching chemistry?	often	6	50.0	$\chi^2 = 0$
	not often	6	50.0	d.f.=1
	Total	12	100.0	p=1.0000

Source: Field Data 2025

For the HODs, majority (50.0%) acknowledges having ICT facilities to aid teaching Chemistry in their school and that the chemistry teachers regularly attend ICT related workshops (50.0%). They also added that their Chemistry teachers integrate ICT in teaching difficult concepts (75.0%) which has proved successful, are well prepared with ICT expertise, there are available ICT facilities accessible to teachers and students (75.0%), school administration support integration of ICT (100%) as illustrated in Table 6.

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Table 6: Hods Response on the Effects of Integrating ICT on Students' Attitude towards Learning Electrochemistry in Migori County Secondary Schools

Question	attribute	frequency	percent	Chi square
Does your school have ICT facilities to aid teaching Chemistry?	Yes	2	50.0	$\chi^2 = 0$
	No	2	50.0	d.f.=1
	Total	4	100.0	p=0.0000
Do Chemistry teachers integrate ICT in teaching difficult concepts?	Yes	3	75.0	$\chi^2 = 25.0$
	No	1	25.0	d.f.=1
	Total	4	100.0	p=0.0000
Are the available ICT facilities accessible to teachers and students?	Yes	3	75.0	$\chi^2 = 25.0$
	No	1	25.0	d.f.=1
	Total	4	100.0	p=0.0000

Source: Field Data 2025

The survey findings highlighted the widespread availability and use of ICT facilities among both students and teachers in the teaching and learning of chemistry. A significant proportion of learners reported having access to computers and smartphones, and the majority perceived ICT as useful in their chemistry learning. This aligned with previous research indicating that students are increasingly using ICT tools such as computers and smartphones for educational purposes (Gikandi et al., 2011; Khaddage et al., 2016). The high level of motivation reported by students when using ICT in chemistry lessons further underscores the positive impact of technology on student engagement and learning outcome (Kay, 2006).

Teachers also demonstrated a high level of ICT competency and integration in their teaching practices, particularly in teaching difficult concepts in electrochemistry. This reflected a growing trend in education where teachers are leveraging ICT tools to enhance their teaching methods and improve student understanding (Ertmer, 2005; Teo et al., 2011). The positive perception of the effectiveness of ICT integration by both teachers and head of departments highlights the recognition of ICT as a valuable tool in enhancing teaching and learning experiences in chemistry education (Balanskat et al., 2006; Voogt & Pelgrum, 2005). The supportive environment for ICT integration in schools, as indicated by the availability of ICT facilities, regular ICT workshops for teachers and school administration support, is crucial in facilitating the effective use of technology in education (UNESCO, 2017; Voogt et al., 2013). This finding underscores the importance of school leadership and infrastructure in promoting the successful integration of ICT in teaching and learning.

Conclusion

The study revealed that integrating ICT in teaching significantly improved students' mastery of electrochemistry concepts in Migori County's public secondary schools. The experimental approach, combining practical methods and ICT, enhanced students' understanding and engagement, aligning with previous research emphasizing the effectiveness of hands-on, interactive learning facilitated by technology. The findings also highlighted the widespread availability and positive perception of ICT among both students and teachers, indicating its importance in enhancing teaching and learning experiences. The high level of ICT competency among teachers and the supportive environment in schools further emphasized the value of technology in education. Overall, the study underscores the positive impact of

ICT integration on student achievement and the importance of continued support for innovative teaching methods in science education.

Recommendation

The study recommends enhancing ICT integration in teaching science, especially chemistry, by providing professional development for teachers, ensuring adequate ICT infrastructure, integrating ICT into the curriculum, encouraging student engagement with ICT tools, establishing monitoring mechanisms, implementing supportive policies, and promoting research and development in ICT in education to create innovative tools and strategies.

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