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Optimizing information and communication technology applications in chemistry learning

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Abstract: Information and communication technology (ICT) is crucial to the educational growth of any country and the academic interactions and collaborations of students. The study determined the extent of ICT application in chemistry instruction in Anambra State, Nigeria, secondary schools. This study uses a descriptive survey. A total of 133 students and 12 chemistry teachers as samples. The t-test was used to test the research hypothesis. The study's findings revealed a low extent of ICT application in teaching and learning chemistry in Anambra State, Nigeria. Moreover, both the chemistry teachers and students agree that ICT is applied to a low extent for teaching and learning chemistry in Anambra State, Nigeria. The study also revealed that the use of outdated computers; lack of technical assistance; lack of time; lack of computer hardware/software; lack of electricity; broken down computers; lack of internet or slow connectivity, and high cost of computers are some of the challenges of ICT application while the provision/maintenance of adequate ICT software and hardware, exposure of chemistry teachers to workshops and conferences and provision of uninterrupted internet services and power supply by the government among others were proffered as possible strategies to eliminate these challenges.

Keywords: Application, ICT, teaching and learning, chemistry lesson

Optimalisasi penerapan teknologi informasi dan komunikasi dalam pembelajaran kimia

Abstrak: Teknologi informasi dan komunikasi (TIK) sangat penting untuk pertumbuhan pendidikan di negara mana pun dan interaksi akademik serta kolaborasi siswa. Studi ini menentukan sejauh mana penerapan TIK dalam pengajaran dan pembelajaran kimia di Anambra State, Nigeria, sekolah menengah. Penelitian ini menggunakan survei deskriptif. Total 133 siswa dan 12 guru kimia sebagai sampel. Uji-t digunakan untuk menguji hipotesis penelitian. Temuan penelitian mengungkapkan rendahnya penerapan TIK dalam pengajaran dan pembelajaran kimia di Negara Bagian Anambra, Nigeria. Selain itu, baik guru dan siswa Kimia setuju bahwa TIK diterapkan pada tingkat yang rendah untuk pengajaran dan pembelajaran kimia di Negara Bagian Anambra, Nigeria. Studi ini juga mengungkapkan bahwa penggunaan komputer usang; kurangnya bantuan teknis; kekurangan waktu; kurangnya perangkat keras/lunak komputer; kekurangan listrik; komputer rusak; kurangnya internet atau konektivitas yang lambat, dan biaya komputer yang tinggi adalah beberapa tantangan aplikasi TIK sementara penyediaan/pemeliharaan perangkat lunak dan perangkat keras TIK yang memadai, paparan guru Kimia untuk lokakarya dan konferensi dan penyediaan layanan internet tanpa gangguan dan catu daya oleh pemerintah antara lain ditawarkan sebagai strategi yang mungkin untuk menghilangkan tantangan tersebut..

Kata Kunci: Aplikasi, TIK, belajar mengajar, pelajaran kimia

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INTRODUCTION

Globally, the importance of information and communication technology (ICT) in education has continued to increase. This has called on the different governments of the world to appreciate the application of ICT in education delivery. This is because using ICT in the educational sector could go a long way to achieving the objectives of teaching and learning even outside the physical classroom. The notion of teaching and learning is a process that enables students to attain learning goals by obtaining the information, attitude, and skills essential for personal, community, and national growth via diverse experiences.. Therefore, in teaching and learning, the students are engaged in activities to acquire, understand and apply what is taught or what they have experienced. Hence, for teaching chemistry to be effective, learning must be accomplished through practice, which the use of ICT can enhance (Chittleborough, 2014; Sadykov & Čtrnáctová, 2019).

Chemistry is a natural science subject central to technological breakthroughs and national development. Chemistry studies matter, including its characteristics, structure, and composition; how it develops and interacts with energy (Ellis & Robb, 2021). Chemistry is a science subject that links all other sciences and provides the major workforce needs of a nation. Its applications can be seen daily (Odukwe & Nwafor, 2022). Chemistry as a scientific discipline is essential in the areas of medicine, clothing, housing, oil exploration, food production, and storage. This implies that the knowledge and skills acquired from chemistry help man in exploring their daily life activities solve problems in their natural environment, and contribute to the community and national development. This can be fastened and transmitted to the technological world through ICT. The use of ICT in education (and chemistry in particular) can improve the quality of learning by proving the acquisition of fundamental skills, improving motivation and engagement, and bolstering teachers' continuing education (Bortnik et al., 2017; Chittleborough, 2014; Gambari et al., 2016; Meesuk & Srisawasdi, 2014; Ratamun & Osman, 2018). Therefore, integrating ICT into chemistry learning will promote meaningful learning and enhance teachers' pedagogical activities through collaborative, interactive, and engaging content.

For this reason, ICT in chemistry plays a key role in concretizing learning and invaluably increasing students' achievement in the subject. This is in line with the findings of Olanrewaju et al. (2016) that the use of ICT as an instructional tool significantly improves students' achievement in chemistry. However, a study by Njelita and Emendu (2015) showed that chemistry teachers in Nigeria do not use ICT in teaching the subject. Hence, the need for chemistry teachers to optimize the use of ICT in chemistry curriculum delivery. One of the purposes of the chemistry curriculum is to cultivate a fair degree of competence in ICT applications that will foster entrepreneurial abilities. In addition, globalization, information/communication technology, and entrepreneurship were selected as the three most significant problems impacting the growth of countries throughout the globe and influencing the world of knowledge today (Federal Ministry of Education, 2009). This implies that the government of Nigeria has joined the counties of the world in their quest for an ICT-based education. Correspondingly, the government of Anambra State, Nigeria, in the year 2013, under the leadership of his excellency Mr. Peter Obi, embarked on the distribution of ICT facilities to government-owned secondary schools towards achieving the desire to integrate ICT in teaching and learning. However, successive governments have not

followed up regarding ICT's provision, maintenance, and adequacy in teaching and learning, which could invariably affect its application in chemistry curriculum delivery.

The effective application of ICT in chemistry instruction has the potential to ensure and enhance students' performance, interaction, collaboration, and communication/ sharing of information all over the world. ICT refers to technologies used in gathering, accessing, storing, and communicating information. ICT is the abbreviation for computers, software networks, satellite communications, and associated technologies that enable people to access and exchange information and knowledge in many formats (Ghavifekr & Rosdy, 2015). ICT is a technology used to access, collect, process, modify, display, and transmit information (Ademiluyi, 2019). This suggests that ICT entails the generation, processing, gathering, storage, transmission, presentation, and use of information by humans and machines, a need in the education sector. ICT refers to all digital equipment or tools, contents, forums, resources, and applications that may be utilized to attain teaching and learning objectives, increase access to and reach of resources, develop capabilities, and administer educational systems (Federal Republic of Nigeria, 2012).

Consequently, ICT includes hardware devices and software applications, the internet, communication devices, interactive forums, interactive digital material, and learning management systems, among others. Consequently, the importance of ICT in the education field cannot be emphasized. Therefore, Oke (2013) and Oyebanji (2013) acknowledged the significance of information and communication technologies in the educational sector as it can be used to achieve educational objectives, improve the quality of learning, advance teachers' professional development, and increase students' self-efficacy and their ability to learn independently.

The use of ICT in learning and instruction relies on two factors: students' familiarity with the technology and the teacher's use of it to enhance the quality of education (Oke, 2013). The use of ICT in education can be influenced by both external and internal factors, respectively (Al-Ruz & Khasawneh, 2011; Lin et al., 2012). Insufficient time for course design, access to computers and software, poor technical help, and lack of administrative support are external constraints (Al-Ruz & Khasawneh, 2011). Internal factors influencing the usage of ICT in education include instructors' beliefs, confidence, and attitude toward ICT (Lin et al., 2012). Kwache (2017) argued that ICT might speed up and improve students' writing, basic reading, and comprehension abilities. In addition, Azeez (2018) argued that there is a correlation between students' ICT use and their academic achievement.

Literature beyond the scope of this research has identified various obstacles to the efficient use of ICT in learning and instruction. For instance, according to Ofodu (2017) and Oyebanji (2013), some challenges include irregular power supply, teachers' incompetency, and inadequate funds, among others. Tapera and Kujeke (2019) in their study asserted that extrinsic and intrinsic obstacles/barriers are possible challenges faced by lecturers in teaching chemistry using ICT in higher institutions of learning. Extrinsic hurdles include poor access to ICT resources, time restrictions, insufficient technical assistance, and lack of training, while internal barriers include lack of competence, attitudes toward usage, unwillingness to change, and personal convictions. The use of ICT among students can be seen in all aspects of life and helps to ensure that students work independently and effectively (Aladesusi & Akindiya, 2021; Obielodan et al., 2021; Soltura, 2022).

ICT in education has helped students learn regardless of the environment and situation. Hence, learning can occur not just in the classrooms but online or offline, in moving buses, after school hours, at home, in the playground, in digital libraries, or the football stadium. The adaptation and accessibility of ICT in education have expanded the sources of information for teaching and learning in schools through digital devices (Ahmad et al., 2019; Damopolii et al., 2022; Howlett, 2019; Howlett & Waemusa, 2018; Putiorn et al., 2018). Students' engagement and motivation in class are boosted by the internet's ability to link their various digital devices and make it possible to communicate with each other in real time, wherever they may be located (Aheto & Cronje, 2018; Ewim & Opateye, 2021; McCoy, 2016). When ICT resources are utilized effectively in the classroom, a higher percentage of learning goals are met than when they are not (Nechypurenko & Soloviev, 2018; Ratamun & Osman, 2018). Therefore, it is expected that secondary school students will have access to and use appropriate ICT facilities to instill in themselves the skills necessary for individual survival and reduce the teachers' monopoly on the learning processes.

The use of technology has a positive impact on students' ways of thinking, and there exists a significant relationship between students' use of technology and their performances (Al-Hariri & Al-Hattami, 2017). Similarly, Ghavifekr and Rosdy (2015) showed that the use of ICT enhances students' engagement and their academic performance. According to Kwache (2017), the use of ICT in the field of education strengthens students' abilities, boosts learning engagements and tailored training, and improves teaching and learning via its dynamic, adaptable, interactive, and engaging content. Moreover, according to Ellermeijer and Tran (2019), the use of ICT in chemistry instruction helps to enhance the quality of knowledge, making it more applicable, less difficult, and more connected to real-life issues than the conventional method of teaching. Hence the need for ICT as a tool that can enhance students' knowledge and learning experience and prompt the need for more scientific investigations by both the teachers and the students. This will invariably reduce the abstract nature of most chemistry concepts as ICT is an aspect of instructional material.

Eze (2016) and Osuafor (2018) believe that the appropriate use of ICT for assignment, assessment, and other activities involved in teaching could be exciting to the learner and promote their skill acquisition, interest, and knowledge of the learning contents/objectives. This suggests that the availability, quality, and use of ICT tools for teaching and learning might serve as a foundation for improving the poor performance of students in chemistry, as noted by the WAEC Chief Examiners Report from 2015 to 2018. Also, Igboanugo et al. (2020) stressed the need for chemistry teachers to ensure the integration of ICT in the teaching of chemistry for effective curriculum delivery. Chemistry teachers lack skills involved in the use of ICT and hence, do not use ICT in chemistry curriculum delivery but rather prefer the use of traditional teaching methods (Naah & Mayeem, 2020).

According to Eze and Aja (2014), despite the numerous advantages provided by the use of ICT in teaching and learning, their acceptance is still restricted, especially in secondary schools, where teachers and school administration have yet to truly accept and apply them for instructional purposes. Adelabu (2014) studied the availability and use of ICT in secondary schools in Oyo State, Nigeria, for the effective teaching of life science. They observed that instructors had decreased access to and use of ICT facilities. In addition, the

poll revealed that secondary school biology teachers lack the ICT skills essential for effective subject education.

From the foregoing, it could be deduced that Information and Communication Technologies are necessary for secondary schools in Nigeria and Anambra State, particularly for chemistry curriculum delivery. This could help to ensure better skills acquisition and achievement in the subject for enhanced social change and national development. This is because, without ICT in teaching chemistry at Anambra State, students might lack the needed social empowerment that can make them favorably compete with others, which could affect their opportunities for quality education toward solving community and world problems. Moreover, there exists a dearth of literature on the application of ICT in chemistry lessons, possible challenges, and solutions in Anambra State, Nigeria, hence, the gap the present intends to fill. Examining these variables could go a long way towards providing the needed information to the government, teachers, students, and school administrators on the extent to which ICT is applied in chemistry instruction, challenges encountered, and possible solutions to overcoming the existing challenges. The study determined the extent of ICT application in chemistry instruction in Anambra State, Nigeria, secondary schools.

METHOD

This study uses a descriptive survey as a research strategy. The participants in this study were all students and teachers of SSII chemistry in 14 public secondary schools in the South Orumba Regional Government Area of Anambra State. There are 257 students and 12 chemistry teachers. This study involved 133 chemistry students and 12 chemistry teachers as samples. The researcher used a simple random selection procedure to select six secondary schools out of 14 in the Local Government Area and selected 12 chemistry instructors for this study because the numbers were reasonable. In addition, all chemistry students from the schools in the sample were included.

The questionnaire on the application of information and communication technology (ICT) in chemistry learning at senior secondary school (QAICTTLCSSS), which the researcher developed, was used as a data collection instrument. The instrument consists of two parts. Part A is comprised of student biographies. Part B contains 28 items and is divided into three clusters based on research objectives using a four-point Likert scale (1 point for strongly disagree (SD), 2 points for disagree (D), 3 points for agree (A), and (4 points for strongly agree (SA)

The instrument was validated by three specialists from Nnamdi Azikiwe University in Awka, Anambra State: two from the department of science education (chemistry unit) and one from the department of education foundations (measurement and evaluation unit). The Cronbach Alpha algorithm was also used to get the dependability index of 0.81. The t-test results at the 0.05 level of significance were used to examine the hypothesis. Items receiving an average rating of 2.5 or above represented a favorable reaction or agreement, while those receiving a rating of 2.49 or below represented a less favorable response or disagreement. Anambra State's senior secondary schools employed the real limit of numbers to categorize their usage of ICT in chemistry education into three categories: high extent (3.50 and above), moderate extent (2.50-3.49), and low extent (2.49 and below).

RESULTS

Table 1 presents the mean and standard deviation (SD) ratings for using ICT in chemistry instruction in Anambra State, Nigeria. All the entries in the table were minimal since they were at or below the true limit value of 2.49. In addition, the standard deviation of the items ranged from 0.95 to 1.22, indicating widespread agreement among students and instructors on the limited use of ICT in chemistry instruction in Anambra State, Nigeria. In addition, the total mean and standard deviation scores were 2.02 and 0.72, respectively, indicating the limited use of ICT in teaching and learning chemistry in Nigerian senior secondary schools in the state of Anambra.

Table 1. Mean and SD of responses on the application of ICT in a chemistry lesson

No	Item	Mean	SD	Remark
1.	We use a projector in the classroom and laboratory	1.88	1.04	Low Extent
2.	We use chemistry software to draw molecular structures	1.68	0.95	Low Extent
3.	We have adequate ICT hardware in my school	2.18	1.13	Low Extent
4.	There are interrupted wifi service in my school	2.42	1.21	Low Extent
5.	There is a well-equipped ICT laboratory in my school	2.42	1.22	Low Extent
6.	We have an electronic advanced periodic table in my school	2.10	1.13	Low Extent
7.	We have software for the IUPAC nomenclature of compounds and complexes	1.70	0.95	Low Extent
8.	We used animation in teaching and learning	1.79	0.97	Low Extent
9.	We used molecular modeling and simulation in teaching and learning	2.01	1.09	Low Extent
	Overall mean and Standard Deviation	2.02	0.72	Low Extent

Table 2. The t-test of responses on the application of ICT in chemistry instruction

	N	Mean	SD	Sig.	t	Df	Decision
Students	133	2.04	0.71657	0.767	0.988	143	Not sig.
Teachers	12	1.82	0.75724				
Total	145						

Table 2 reveals the calculated t value is 0.988 and sig. = 0.767. These data imply no significant difference between teachers' and students' responses regarding the application of ICT in chemistry instruction in senior secondary schools in Anambra State, Nigeria. Therefore, both chemistry teachers and students agree with the fact that the application of ICT in chemistry instruction is low.

Table 3 reveals the mean and SD of the challenges in implementing ICT in chemistry instruction. All items are accepted because they are above the 2.50 threshold, which indicates that the item is outdated computer usage; lack of technical assistance; lack of time; lack of computer hardware and software; electricity shortage; broken computer; lack of internet or slow connectivity and expensive computer software and chemistry is a challenge

in the application of ICT in chemistry instruction. In addition, the standard deviation ranging from 0.96 to 1.19 indicates a high degree of closeness between teacher and student responses to the challenges of applying ICT in chemistry instruction.

Table 3. Mean and SD of responses on the challenges in the application of ICT

No	Items	Mean	SD	Remark
10.	Lack of qualified teachers to teach ICT in schools	3.03	1.19	Accepted
11.	Outdated computers lower the morale of both teachers and students	3.19	0.96	Accepted
12.	Lack of technical assistance	3.18	1.09	Accepted
13.	Lack of time	3.19	1.12	Accepted
14.	Lack of computer hardware and software	3.16	1.16	Accepted
15.	Lack of electricity	3.32	1.01	Accepted
16.	Broken down computers	3.12	1.13	Accepted
17.	Lack of internet or slow connectivity	3.23	1.02	Accepted
18.	High cost of computer and chemistry software	3.26	1.11	Accepted
	Overall mean and Standard Deviation	3.19	0.80	Accepted

Table 4. Mean and SD of responses on the strategies that can be employed to improve the application of ICT in chemistry instruction

No	Items	Mean	SD	Remark
19.	There should be the provision of adequate ICT Chemistry software by the government and PTA	3.51	0.71	Accepted
20.	There should be the provision of adequate ICT hardware by the government and PTA	3.50	0.78	Accepted
21.	The appeal can be made to philanthropic individuals for assistance.	3.35	0.95	Accepted
22.	Students should replace any materials damaged by them.	2.99	1.10	Accepted
23.	The appeal can be made to the old boys and girls association (alums) for assistance.	3.36	0.93	Accepted
24.	Regular exposure of teachers and ICT personnel to workshops and conferences.	3.43	0.93	Accepted
25.	Employment of trained teachers and ICT personnel	3.56	0.92	Accepted
26.	Proper usage and maintenance of ICT materials	3.46	0.83	Accepted
27.	Government should provide uninterrupted internet services	3.34	1.03	Accepted
28.	Government should provide an uninterrupted power supply	3.41	0.97	Accepted
	Overall mean and Standard Deviation	3.40	0.70	Accepted

Table 4 presents the mean and SD scores for strategies to enhance the use of ICT in chemistry instruction in senior secondary schools in Anambra State, Nigeria. All the items were accepted since they were above the 2.50 cut-off mark, which shows that the strategies to improve the application of ICT in chemistry instruction, including the provision of

adequate ICT chemistry software and hardware by government, philanthropists, alums and PTA; students' replacement of any ICT materials they damaged; regular exposure of teachers and ICT personnel to workshops and conferences; employment of trained teachers and ICT personnel; proper usage and maintenance ICT materials and provision of uninterrupted internet services and power supply by the government. Moreover, the SD, which ranges from 0.71 to 1.03, shows that the respondents (teachers & students) had similar opinions on each item as the strategies to improve the application of ICT in chemistry instruction.

DISCUSSION

The results showed that items 1-9, including a projector, chemistry software, ICT hardware, wifi service, ICT laboratory, the electronic advanced periodic table, IUPAC nomenclature software, chemistry animation, molecular modeling, and simulation, are not utilized in the teaching and learning of chemistry. As a result, the use of ICT in chemistry instruction in senior secondary schools in the Nigerian state of Anambra is minimal and dismal. Further study revealed that there is no significant difference between instructors' and students' opinions about the use of ICT in chemistry instruction. In Anambra State, Nigeria, chemistry students and teachers agree that ICT is used little in teaching and studying the subject.

The poor use of ICT in chemistry education may be a consequence of the unavailability and inadequacy of ICT resources in secondary schools; one cannot speak about the use of ICT in chemistry instruction without the materials being accessible and sufficient for the students. Thus, the constructivist idea proposed by Vygotsky (1978) that learning should be an active, contextualized process of generating knowledge by permitting peer cooperation among students would be refuted. Ajayi and Ekundayo (2009) noticed that the degree of ICT application in secondary schools in Nigeria is pitiful owing to the lack of ICT infrastructure. In addition, these results complement those of Nwana, Ofoegbu, and Egbe (2017), who determined in research that most instructional materials are not being used.

The study also revealed that the use of outdated computers; lack of technical assistance; lack of time; lack of computer hardware and software; broken down computers; lack of electricity; lack of internet or slow connectivity, and high cost of computer and chemistry software are the challenges that constraint the application of ICT in the teaching and learning of chemistry. This finding is in line with Muhammad et al. (2019), who enumerated some of the problems militating against the use of ICT in teaching and learning, including lack of internet facilities, inadequate and unqualified teachers, as well a lack of well-equipped computer laboratories for practical. The use of ICT in education is hindered by issues such as slow computer speeds, signal problems on the internet, load shedding, poorly performing machines, malware risks, and a lack of access to the internet (Siddiquah & Salim, 2017). The study's results are consistent with those of Ofodu (2017) and Oyebanji (2013), who identified, among other things, a lack of resources, a lack of infrastructure, an unreliable power supply, and instructors' incompetence as obstacles to the effective use of ICT in the classroom.

In addition, the findings indicated that the strategies to unravel the challenges and improve on the application of ICT in chemistry include the provision of adequate ICT chemistry software and hardware by government, philanthropists, alums, and Parents

Teachers Association (PTA); students' replacement of any ICT materials they damaged; regular exposure of teachers and ICT personnel to workshops and conferences; employment of trained teachers and ICT personnel; proper usage and maintenance ICT materials and provision of uninterrupted internet services and power supply by the government. The finding is in agreement with that of Siddiquah and Salim (2017), who stressed the need for teachers and students to acquire the needed ICT skills and suggested that the Government and school administrators should invest more in ICT to reduce the challenges encountered in its application.

CONCLUSION

Information and communication technologies catalyze students' interaction, collaboration, and engagement worldwide. Hence, sustaining the acquisition, understanding, and application of ICT in the instruction of every educational content or objective should be a top priority of the government in Nigeria. Moreover, this study's findings inferred that ICT's application in chemistry instruction in secondary schools in Anambra State, Nigeria is to a low extent and very poor. Some challenges that cause this low extent of ICT application have been highlighted, and possible solutions have been proffered for optimizing the application of ICT in chemistry instruction. Therefore, it is important to equip chemistry educators with ICT resources and offer professional development in ICT usage.

The researchers recommended that ICT be available and adequate for every chemistry student to enhance ICT's application in chemistry instruction in secondary schools. We cannot talk of ICT applications without them being available and adequate for the students. Moreover, funds should be provided by the government for the acquisition and maintenance of ICT facilities. Chemistry teachers and students should be trained and retrained on using ICT in learning and instruction in chemistry. This will ease the integration of ICT as an instructional method. Also, chemistry teachers should be sponsored at national and international conferences, seminars, workshops, etc., to improve their ICT skills and competencies.

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