Chemistry Teachers' Awareness and Utilization of Information Communication Technology Tools for Addressing Difficult Chemistry Concepts

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Abstract

This study investigated the awareness and utilization level of chemistry teachers, regarding the use of Information and Communication Technology (ICT) to address difficult chemistry concepts. Three research questions guided the study A survey design was employed, with data collected from 33 chemistry teachers using a validated, 3-clustered, self-developed structured questionnaire named Addressing Chemistry Difficult Concepts Using ICT Tools (ACDCICT). The Cronbach's Alpha reliability indices for the three clusters of the RCDCICT are 0.84, 0.88, and 0.86 respectively. Descriptive statistics specifically, mean and standard deviation were used to answer the research questions. Results revealed that teachers identified electrolysis, energy and chemical reactions, orbitals and electronic structure of atoms, nuclear chemistry, and chemical bonding as the most difficult topics for students. The study found a low level of awareness among teachers regarding ICT tools such as Chemsketch, Microsoft PowerPoint, and YouTube for addressing difficult chemistry concepts. Chemistry teachers do not frequently utilize ICT tools for the addressing of difficult chemistry concepts. The study recommended, among others, chemistry teachers should make effort to present chemistry contents in a simplified manner through leveraging both general ICT and subject specific tools such as ChemDraw, ChemSketch.

Keywords: Chemistry education, ICT, difficult concepts, teacher awareness, Utilization

Introduction

` In modern chemistry education, integrating Information and Communication Technology (ICT) tools is necessary. This is done to reform and reshape chemistry education and to reduce the abstractness of some chemistry concepts. Furthermore, ICT is a key components of pedagogy (Bekbenova et al., 2026) and represent one of the 21st century skills that every chemistry teacher should possess. This is because ICT tools promote student's engagement, help reduce the abstractness of some difficult chemistry concepts, and enable chemistry teachers to create and deliver more effective, interactive lesson plans and learning experiences (Umate et al, 2025; Umate et al, 2022)

The recent advances in technological resources such as computers, online instructional resources, virtual learning environments, virtual laboratories, and multimedia tools have made tremendous influence on the teaching and learning of science subjects particularly chemistry. Chemistry is a foundational science subject with significant implications for technological and industrial development (Chinda et al., 2025). However, it is perceived by both students and teachers as difficult and abstract. Some of these perceived difficult topics include: electrolysis, energy and chemical reactions, orbitals and electronic structure of atoms, nuclear chemistry and chemical bonding, and chemical equilibrium, among others (Babafemi et al., 2025; Oladejo et al., 2023; Kyado et al. ,2021). This is why students in Nigeria consistently perform poorly in chemistry examinations, as evidenced by the WAEC Chief Examiner Reports (2020–2025). A major contributing factor is the abstract nature of many chemistry concepts, which poses challenges for both teaching and learning (Woldie et al., 2019) As a result of the abstractness and difficulty of some of these concepts, chemistry education immensely benefits from integrating ICT tools.

The use ICT tools such as virtual laboratories, multimedia tools, simulation software, online instructional resources can help enhance learning, making it enjoyable, concrete and interesting for students. As a result, ICT awareness and utilization among chemistry teachers is paramount to improving students' conceptual understanding of the subject. It also enhances chemistry teacher's ability to develop an interactive and enjoyable learning experience. This, in turns, makes the teaching and learning of chemistry easy and fascinating.

Batamuliza et al (2024) found that simulations increased students' engagement and comprehension of complex chemistry topics. Many studies have reported numerous benefits of ICT tools in chemistry teaching. For instance, ICT tools improve chemistry students' conceptual understanding (Gupta, 2023), and reduce the abstractness of some difficult chemistry concepts (Ameyaw, 2020; Abdulrahaman et al., 2020; Igboanugo et al., 2020). Byusa et al. (2022) found that chemistry students exposed to ICT-integrated instructional strategies achieved a deeper conceptual understanding, thereby reducing the abstractness and

difficulty of these concepts. Specifically, ICT tools simplify difficult chemistry concepts and reduce abstractness by visualizing the chemical structures in 3D, and using animations to show the movement of electrons and ions during electrolysis (Abdulrahaman et al., 2020; Igboanugo et al., 2020). Furthermore, Umate et al. (2018) argued that integrating ICT tools in the chemistry classroom enables teachers to become conversant with the latest innovative teaching methods, and assessment tools. This, in turn, makes learning experiences dynamic and effective.

Studies show mixed ICT utilization among teachers. Nonyeka and Okigbo (2023) report high awareness and use among Anambra secondary teachers, while Ameen et al. (2019) confirm similar findings for mathematics teachers. However, several studies report very low use of ICT tools especially subject specific software among chemistry teachers across various Nigerian states and Ghana (Aliyu, 2024; Hamza et al., 2024; Tijani, 2022; Umate et al., 2022). Ahmad et al. (2026) and Dudek (2025) note that teachers use simple ICT tools proficiently but rarely adopt complex ones due to competency gaps. In contrast, Neupane (2023) reports widespread use of common digital tools among Nepalese teachers.

In Enugu State, Nigeria, the Ministry of Education, in partnership with international organizations like the World Bank and the United Nations International Children's Emergency Fund (UNICEF) supplied adequate ICT tools to the secondary schools. This initiative aims to encourage teachers to integrate these tools in their daily instructional activities, thereby enhancing student's academic performance and fostering essential 21st century skills such as collaboration, critical thinking, problem solving, and entrepreneurship, among others.

However, students consistently perform poorly in chemistry examinations, as evidenced by the WAEC Chief Examiners' Reports (2020–2025). A major contributing factor is the abstract nature of many chemistry concepts, which poses challenges for both teaching and learning (Woldie et al., 2019). While researchers have proposed various solutions, including teacher training and multimedia-aided instruction (Gupta,2023; Winter et al., 2022), the persistent poor performance suggests gaps in ICT tools awareness and utilization by the teachers.

What has not yet been ascertained is whether chemistry teachers' awareness and utilization of ICT tools for addressing difficult topics have been fully explored. This is because these tools could be used to reduce the abstractness, and difficulty of some chemistry concepts. Therefore, this study focuses on the role of ICT in addressing difficult chemistry concepts. ICT tools, such as simulations and interactive software, can concretize abstract concepts and improve comprehension (Dudek, 2025; Umate et al., 2025). However, the extent to which chemistry teachers are aware of and utilize these tools remains understudied, particularly in Nigeria. The presence of this gap in the literature necessitated this study.

Statement of the Problem

Integrating Information and Communication Technology (ICT) tools into chemistry classrooms is essential for the reducing difficulty and the abstractness of difficult chemistry concepts and developing 21st century skills. Recognizing this, the Enugu State Government, in partnership with the international organizations such as UNICEF and the world Bank, has supplied adequate ICT tools to secondary schools. This was done to enable chemistry teachers to leverage these resources to enhance instructional delivery, concretize abstract topics and improve academic performance.

Despite the provision of these ICT resources, secondary school students consistently underperform in chemistry examination as highlighted in the WAEC Chiefs' Examiners Reports (2020-2025), largely due to the abstract nature of the subject. While empirical evidence reveals that ICT integration in the chemistry classroom enhances conceptual understanding, chemistry teachers in Nigeria often rely on basic digital tools, neglecting subject specific tools that could address difficult and abstract concepts due to persistent competency gaps.

If this problem persists, investments in ICT tools in secondary schools across Enugu State will remain underutilized, instruction will remain heavily abstract and students' performance will continue to decline. Therefore, the problem of this study is the persistent underperformance of students in chemistry, despite available ICT infrastructure as well as lack of empirical evidence regarding chemistry teachers' awareness and utilization of ICT tools specifically focused on addressing difficult and abstract chemistry concepts.

Purpose of the Study

The purpose of this study is to ascertain chemistry teachers' awareness and utilization of information and communication technology tools for addressing difficult concepts in teaching and learning of chemistry. Specifically, the study seeks to determine:

1. The chemistry concepts identified by teachers as difficult for students.
2. awareness level of chemistry teachers regarding the use ICTs for addressing difficult concepts in chemistry
3. the extent of chemistry teachers' utilization of ICT tools for addressing difficult concepts in chemistry

Research Questions

1. What chemistry concepts identified by teachers as difficult for students?

2. What is the awareness level of chemistry teachers regarding the use ICTs for addressing difficult concepts in chemistry?
3. What is the extent of chemistry teachers' utilization of ICT tools for addressing difficult concepts in chemistry?

Theoretical framework

Cognitive Flexibility Theory (CFT) is a constructivist approach arguing that complex, and abstract subjects require instruction that presents information through multiple, varied contexts rather than oversimplified, linear formats. Its core principles are: multi-perspective representation, avoidance of oversimplification, active knowledge-construction by learners, and interconnected conceptual understanding. The theory holds that non-linear, multidimensional hypertext systems are uniquely capable of conveying this complexity and fostering cognitive flexibility.

This study applies CFT to chemistry education by using a cognitive flexibility hyperlink (ICT tools). This hyperlink, supported by teacher guidance, gives students access to diverse digital resources (e.g., videos), transforming abstract chemistry concepts into more tangible, comprehensible material.

Method

A Survey research design was employed in this study. This research design involves data collection from a large sample using a questionnaire or checklist (Creswell, & Guetterman, 2019). The design was used because it provides a more reliable means of extracting data from population under study. The sample of this investigation involved all 33 chemistry teachers in Nsukka Local Government Area (9 males, 24 females).

A Researcher developed questionnaire named "Addressing Chemistry Difficult Concepts Using ICT Tools (ACDCICT)" was used for data collection. It is made of two sections (Section A and B). Section A elicits the respondents' personal information, while section B is divided into three clusters. Cluster one contains 27 chemistry items on a 3-Point Likert Scale: VD=Very Difficult (3), D=Difficult (2) and ND=Not Difficult (1). Cluster two contains 12 items on a 4-Point Likert Scale: HA = Highly Aware (4), SA=Somehow Aware (3), Rarely Aware = (2) and NA= Not Aware (1). Cluster three contains 12 items on a 4-Point Likert Scale: HU = Highly Utilized (4), U=Utilized (3), SU= Somehow Utilized (2) and NU= Not Utilized (1).

The ACDCICT was validated by a panel of three experts: two from the Chemistry Education Unit and one from the Measurement and Evaluation Unit of the Department of Science Education, University of

Nigeria, Nsukka. The reliability coefficients of the three clusters of the RCDCICT are 0.84, 0.88 and 0.86 ascertained using Cronbach Alpha Method, because the items were scored polytomously. Descriptive statistics (mean and standard deviation) were used to answer the research questions. A mean threshold of 2.0 and above was set for identifying difficult topics, while 2.5 and above was used to ascertain the chemistry teachers' awareness and utilizations of ICT tools for addressing difficult chemistry concepts.

Results

Research One: What chemistry concepts do teachers identify as difficult for students?

Table 1: Mean Rating Scores of Chemistry Teachers on Concepts Identified as Difficult for Students

S/N	Item Statement	Mean	SD	Remark
1	Nature of matter and Separation Technique	1.24	0.66	Not difficult
2	Particulate nature of matter	1.09	0.29	Not difficult
3	Symbols formula and equations	1.27	0.54	Not difficult
4	Chemical combination	1.33	0.67	Not difficult
5	Kinetic theory of matter and gas laws	1.42	0.71	Not difficult
6	Acids, bases and salts	1.94	0.66	Not difficult
7	Carbon and it compounds	1.21	0.49	Not difficult
8	Hydrocarbons and crude oil	1.8	0.51	Not Difficult
9	Electrolysis	2.4	0.79	Difficult
10	Energy and chemical reactions	2.0	0.79	Difficult
11	Chemical equilibrium	1.7	0.69	Not difficult
12	Air and air pollution	1.12	0.42	Not difficult
13	Water, solution and solubility	1.15	0.51	Not difficult
14	Classification of organic compounds: Alkanes, Alkenes, Alkynes and Alkanols	1.36	0.49	Not difficult
15	Aromatic compounds	1.75	0.66	Not difficult
16	Orbitals and electronic structure of atoms	2.36	0.70	Difficult
17	Nuclear chemistry	2.90	0.17	Difficult
18	Chemical bonding	2.09	0.58	Difficult
19	Metals and their compounds	1.61	0.70	Not difficult
20	Alkanoic acids	1.54	0.71	Not difficult
21	Alkanoates	1.70	0.85	Not difficult
22	Fats and oils	1.55	0.66	Not difficult
23	Alkanals and Alkanones	1.36	0.65	Not difficult
24	Amines	1.30	0.53	Not difficult
25	Amides	1.58	0.79	Not difficult
26	Amino acids	1.54	0.71	Not difficult
27	Carbohydrates	1.58	0.61	Not difficult

Table 1 displays the results of chemistry teachers' ratings on topics in which chemistry students encountered difficulties. The results indicate that the chemistry students encountered difficulties in the following topics: electrolysis, energy and chemical reactions, orbitals and electronic structure of atoms, nuclear chemistry and chemical bonding. The mean rating scores of these difficult topics were 2.40, 2.0,

2.36, 2.90, and 2.09, respectively. Since the mean rating scores for these topics were 2.0 and above, they were classified as difficult.

Research Question Two: What are the mean awareness rating scores of chemistry teachers regarding the use ICTs for addressing difficult concepts in chemistry?

Table 2: Chemistry Teachers' Awareness of the Use of ICT Tools for Addressing Difficult Concepts

S/N	Item Statement	Mean	SD	Remark
1	Molecular model buliders e.g Chemsketch, ChemDoodle, ChemWindow, Chemdraw, ChemWriter	1.42	0.56	Low Awareness
2	Chemistry Tutorial Videos e.g Youtibes, Khan Academy	1.34	0.54	Low Awareness
3	Interactive Periodic Tables e,g Ptable, webelements	1.97	0.43	Low Awareness
4	Virtual Lab Platforms e.g chemcollectives, Phet	1.70	0.40	Low Awareness
5	Online Whiteboard e.g Limnu, miru	1.06	0.36	Low Awareness
6	Virtual Learning Environment platforms e,g Google classroom, Moodle, Blackboard	1.72	0.32	Low Awareness
7	Online Quizzing and Assessment Tools e.g Quizlet, Kahoot, Socrative	1.32	0.40	Low Awareness
8	Presentation Software e.g powerpoint, google slides	2.55	0.30	High Awareness
9	Chemistry online calculators e.g WolframeAlpha	2.60	0.61	High Awareness
10	Video conferencing tools e.g Zoom, Google Meet , Microsoft Team	2.64	0.49	High Awareness
11	Animation and Gamifications tools e,g 3D Role Playing game, chemical nomenclature, Organic reaction games	2.56	0.63	High Awareness
12	Online chemistry Resources e.g ChemGuide, Libretext chemistry	2.52	0.57	High Awareness
	Cluster Mean	**1.95**	**0.468**	**Low Awareness**

Table 2 shows the chemistry teachers' awareness regarding the use of ICTs for addressing difficult concepts. The mean rating scores for items 1-7 are less than 2.5, indicating that chemistry teachers have low awareness regarding these ICT tools for addressing difficult chemistry concepts. Whereas items 8- 12 have mean rating scores greater than 2.5, implying that chemistry teachers have high awareness of these ICT tools for addressing difficult chemistry concepts. The cluster mean is 1.95, which indicates that the respondents have a low awareness of the use of ICT tools in addressing difficult concepts in chemistry.

RQ3: What is the extent of chemistry teachers' utilization of ICT tools for addressing difficult concepts in chemistry

Table 3: Chemistry Teachers Utilization of ICT Tools for Addressing Difficult Chemistry Concepts

S/N	Item Statement	Mean	SD	Remark
1	Molecular model buliders e.g Chemsketch, ChemDoodle, ChemWindow, Chemdraw, ChemWriter	1.60	0.56	Not Utilized
2	Chemistry Tutorial Videos e.g Youtibes, Khan Academy	1.88	0.99	Not Utilized
3	Interactive Periodic Tables e,g Ptable, webelements	2.30	0.69	Not Utilized
4	Virtual Lab Platforms e.g chemcollectives, Phet	1.15	0.54	Not Utilized
5	Online Whiteboard e.g Limnu, miru	2.06	1.12	Not Utilized
6	Virtual Learning Environment platforms e,g Google classroom, Moodle, Blackboard	1.36	0.83	Not Utilized
7	Online Quizzing and Assessment Tools e.g Quizlet, Kahoot, Socrative	2.05	0.60	Not Utilized
8	Presentation Software e.g powerpoint, google slides	2.57	0.62	Utilized
9	Spreadsheets software e.g MS Excel	2.62	0.61	Utilized
10	Video conferencing tools e.g Zoom, Google Meet , Microsoft Team	2.13	0.49	Not Utilized
11	Animation and Gamifications tools e,g 3D Role Playing game, chemical nomenclature, Organic reaction games	2.35	0.71	Not Utilized
12	Online chemistry Resources e.g ChemGuide, Libretext chemistry	1.89	0.57	Not Utilized
	Cluster Mean	**1.99**	**0.694**	**Not Utilized**

Table 3 shows the chemistry teachers' utilization of ICT tools for addressing difficult chemistry concepts. The mean rating scores for all items are less than 2.5 with exception of items 8 and 9. This indicates that chemistry teachers are not utilizing these ICT tools for addressing difficult chemistry concepts except for presentation software and spreadsheet packages. The cluster mean is 1.99, which indicates that chemistry teachers do not generally utilize these ICT tools to address difficult concepts in chemistry.

Discussion

The findings of this study reveal that students find the following chemistry topics difficult: electrolysis, energy and chemical reactions, orbitals and electronic structure of atoms, nuclear chemistry, and chemical bonding. This may be because these topics are not taught using instructional materials that can help concretize learning. In other words, these topics cannot be fully understood through the presentation of mere theoretical facts; rather, they require a combination of both theoretical explanations and visual representations of the processes leading to the establishment of those facts. This aligns with the studies carried out by Babafemi et al. (2025), Oladejo et al. (2023) and Kyado et al. (2021) and Etokere and Ikwut (2020), all of whom found that energy and chemical reactions, chemical equilibrium, nuclear chemistry, and chemical bonding, among others, are topics that students find difficult in chemistry.

One of the findings of this study reveals that chemistry teachers in the Nsukka local government area have a low level of awareness regarding the use of ICT tools for addressing difficult concepts in chemistry. This may be due to their inability to access online information that could inform them of the necessary ICT tools for addressing these concepts. This could also due to teachers' ICT phobia, resistance to change, or reluctance to acquire ICT skills, which consequently leads to their inability to use ICT tools effectively and efficiently. This aligns with the studies carried out by Naomi and Chigozie (2020), Tijani (2022), Umate et al. (2022), Aliyu (2024), and Hamza et al. (2024), who revealed that science (chemistry) teachers have low awareness of the use of ICT tools for effective teaching and learning of science. However, this finding contrast with that of Nonyeka and Okigbo (2023) who reported that the overall level of ICT awareness amongst teachers was high.

Another finding of this study reveals that chemistry teachers do not frequently use ICT tools particularly subject specific ICT tools for addressing difficult chemistry concepts. They primarily use PowerPoint and Spreadsheet packages for teaching and learning. However, these tools are often used for static content delivery rather than interactive or process-oriented addressing difficult concepts. Hence, it may be difficult to use them to reduce the abstractness and difficulty of some chemistry concepts. This finding aligns with the results of studies carried out by Ahmad et al. (2026) and Dudek (2025) who reported that most teachers only use simple ICT tools for teaching and learning.

Conclusion

The study identified some topics that students find difficult in chemistry which, consequently contribute to their poor academic achievement in both internal and external examinations. Furthermore, the findings indicate that chemistry teachers in the Nsukka Local Government Area have low awareness of the use of ICT tools for addressing difficult concepts in chemistry and do not frequently use Subject specific ICT tools for teaching and addressing these concepts.

Therefore, to improve chemistry students' learning experiences and subsequently their academic achievement, educational stakeholders such as the Government, science educators, and curriculum planners should work towards updating teachers' ICT skills set and teaching methodologies through the organization of workshops and seminars to align with students' changing academic needs. In addition, they should ensure the continual availability of these ICT tools for the ongoing addressing difficult concepts of difficult topics in chemistry

Recommendation

1. Chemistry teachers should make an effort to present chemistry content in a simplified manner through leveraging both general ICT and subject specific ICT tools
2. The Government and other relevant agencies should make efforts to enhance chemistry teachers' awareness by sensitizing them through conferences, workshops, and seminars, among others.
3. The government and other relevant agencies should make efforts to improve chemistry teachers' ICT technical know-how through workshops, hand-on training and seminars. This, in turns, may increase their frequency of ICT tool use in chemistry classroom.

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