A Study of the Role of ICT in Quality Learning of Chemistry Education as Perceived by Undergraduate Chemistry Students

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ABSTRACT

ICT has become an essential component of contemporary education, encompassing the discipline of chemistry. This study seeks to investigate the use of tools in ICT to enhance chemistry learning among undergraduate students. The purpose of this study is to analyze the frequency and patterns of usage of ICT tools, assess the level of engagement and collaboration facilitated by these tools, evaluate the effectiveness of ICT tools in aiding the comprehension of chemistry concepts, and identify the challenges associated with their use. A survey was undertaken among 50 undergraduate chemistry students from a Central University in Delhi, employing a questionnaire to gather data on several aspects of ICT utilization in chemistry instruction. These findings emphasize the significance of tackling obstacles and utilizing the advantages of Educators can facilitate more captivating and tailored learning experiences for students by offering more explicit instructions, resolving technical challenges, and improving the availability of educational materials.

Keywords: *ICT, Chemistry, Students, Effectiveness, Engagement, Collaboration, Quality*

INTRODUCTION

One cannot stand still for long or ignore the rapid advancements that are collapsing before our eyes. Information and Communication Technology, or ICT, is no longer something extra – because IT is now a core component of modern education, which is required to uncap an individual’s potential. ICT literacy is as important as reading, writing, and arithmetic in education. It is not just a supporting skill, but a basic skill on which the primary mission of modern education is built. All governments recognize the importance of ICT literacy to social and economic development in interconnected regions and communities. Today, the classroom is a place for students to engage in the process of self-discovery to understand how they use the linguistic and generative power of the binary code of the new information and communication technology (ICT) to create new knowledge and understanding. Here, the two cultures meet naturally and, with a little nudge on each other’s part, create a mutually beneficial connection that drives humanity towards new frontiers of advancement and knowledge.

As per UNESCO's definition in 2002, ICT encompasses the technologies used to transmit, process, store, create, display, share, or exchange information electronically. This includes a diverse range of technologies like radio, television, video, DVD, computers, network hardware and software, as well as associated equipment and services like videoconferencing and email. Furthermore, the National Policy on Information and Technology (2012) promotes ICT as an integral part of educational programmes enriching higher learning that aim to enhance the quality and efficiency of the teaching-learning process. Besides this, it emphasises improving the competitiveness and productivity quality of doctoral and postdoctoral level researchers.

The integration of Information and Communication Technology (ICT) tools in Science Education offers numerous benefits. Firstly, it facilitates access to different contents which supports the so-called information age but also improves learning (Prasad, 2018). Secondly, the science-relay of ICT tools group showed higher motivation and learning gains than the control group after the trial (Palomares-Ruiz et al., 2020). Another benefit of ICT in the field of education is the researcher Savec (2017) claims that ICT enables science educators to build up their Technological Pedagogical Content Knowledge (TPACK) which is a vital ability for the successful integration of technology in science instruction. Incorporating ICT in education can aid students in gaining a deeper understanding of scientific theories, performing research, and developing problem-solving skills in science. Furthermore, the utilization of ICT in the educational process has been proven to enhance learning outcomes and facilitate the integration of technology in science classrooms (Nugultham, 2018).

In India, the government's focus on ICT-enabled teaching-learning involves the utilisation of virtual labs providing lab experiences in virtual learning settings for those who are unable to conduct their lab experiments physically. Furthermore, the such as e-PG Pathshala platform comprises multimedia self-learning modules that enable students to access high-quality and useful resources, which are among the government's initiatives to improve the quality and effectiveness of the learning process (Osborne & Hennesy, 2003). ICT helps students concentrate on higher-level concepts, rather than menial tasks (Levin and Wadmany 2006). A study by McMahon (2009) showed that using ICT had significant correlations with the development of critical thinking skills. The practical component is very essential in science education, particularly chemistry subject. Chemistry focuses on the study of chemicals and their reactions, the majority of which are extremely hazardous to human life if not handled properly. Most chemical reactions are difficult to understand for students without observing them in functioning like the chemistry of atoms, quantum theory, chemical reactions, electrochemistry, and so on. However, teachers typically explain these reactions abstractly and using a molecular diagram. These complex concepts can be presented in a visualised form and 3-D visuals to students and can easily be understood by using ICT in the teaching-learning process (Denby & Campbell, 2005; Dori & Barak, 2001; Rogers, 2006).

Various research indicates that ICT allows students to explore beyond content mechanics and better understand concepts (Reid, 2002). Similarly, studies examining the effects of integrating ICT in science education suggest that it enhances the learning environment by promoting engagement, relevance, self-direction, and reflection, and encourages learners to approach topics in a manner that cultivates a deep and comprehensive understanding of learning objectives (Osborne & Hennesy, 2003). Furthermore, it has been discovered that the utilization of this method increases motivation, interest, and active participation in teaching and learning activities (Denby & Campbell, 2005). According to Hogarth et al. (2006), students who utilized ICT simulations exhibited a greater understanding of scientific concepts compared to those who did not use ICT. Nowadays, teachers are incorporating ICT tools such as ChemDraw, Gaussian, Virtual Chemistry Lab Simulations, Avogadro, YouTube videos, and digital microscopes to make science lessons more practical and engaging (Kurbanoğlu & Akın, 2010; Pyatt, 2014).

India's National Education Policy (NEP) 2020 emphasizes ICT in teaching-learning processes to enable personalized and adaptive learning experiences. Furthermore, the NEP 2020 emphasises the importance of leveraging ICT to address the digital divide and ensure equitable access to quality education for all learners, irrespective of their socio-economic background or geographic location. Initiatives such as digital classrooms, online learning platforms, and open educational resources can help bridge the gap by providing students with access to educational content and resources anytime, anywhere. Furthermore, it fosters holistic development and 21st-century skills such as critical thinking, problem-solving, scientific temper, communication, teamwork, multilingualism, ethics, social responsibility, creativity and digital literacy.

A review of all these studies cleared the fact that rapid developments in hardware and software paved the way for new possibilities. Yet there is a considerable gap between the aspirations of the students and the classroom reality. Various research has been done to analyse the effectiveness of using ICT in science education but countries like India need more research to be conducted to know the undergraduate students in determining the effectiveness of ICT in science education especially in chemistry.

RESEARCH OBJECTIVES

The objectives of this study are:

1. To examine the extent of ICT tool utilization in supplementing chemistry learning among students.
2. To assess the frequency and patterns of ICT tool usage in accessing resources and information for chemistry studies.
3. To explore the engagement and collaboration facilitated by ICT tools in chemistry education.
4. To evaluate the perceived effectiveness of ICT tools in aiding comprehension and understanding of chemistry concepts.
5. To identify the challenges and barriers related to the use of ICT tools for learning chemistry.

RESEARCH METHODOLOGY

In this section, the details of participants of the study, tools and techniques used, procedure and analysis of data collection are mentioned.

Participants

A total of 50 undergraduate chemistry students were selected from a Central University in Delhi. A convenience sampling technique is utilized to select participants from various academic levels and backgrounds.

Tools and Techniques

The research questions are developed by the researcher and comprise a questionnaire divided into sections addressing different aspects of ICT use in chemistry learning. The questionnaire includes sections focusing on the following dimensions:

1. Utilization of ICT tools in chemistry learning
2. Frequency of ICT tool usage
3. Engagement and collaboration facilitated by ICT tools
4. Effectiveness of ICT tools in aiding learning
5. Challenges encountered in using ICT tools for chemistry education

Each section contains multiple items designed to capture specific aspects of respective dimension. Likert scale items are used to measure participants' agreement or frequency of occurrence.

Procedure of Data Collection

Data will be collected through a structured questionnaire self-administered to participants in person. The data was collected from a central university located in Delhi. Before initiating the data collection procedure, the researcher took permission from the Head of Department (H.O.D.) of the respective department. After obtaining permission, the researcher approached the concerned undergraduate chemistry students and obtained their consent to respond to the questionnaire. Each participant was provided with a brief instruction and the purpose of the study was explained to them before the commencement of data collection. Finally, their completed questionnaires were collected back.

Statistical Analysis

Statistical analysis will be conducted using appropriate methods such as descriptive statistics (means, standard deviations) will be calculated for each variable. Besides this, Skewness will be calculated to assess the distribution of responses to know the significance.

ANALYSIS AND INTERPRETATION

Table 1
Use of ICT tools

Do you use ICT tools (such as computers, tablets, smartphones, etc.) to supplement your learning in chemistry?	Counts	% of Total	Cumulative %
Yes	41	82.0 %	82.0 %

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Do you use ICT tools (such as computers, tablets, smartphones, etc.) to supplement your learning in chemistry?	Counts	% of Total	Cumulative %
No	9	18.0 %	100.0 %

A survey study regarding the utilization of ICT instruments in chemistry learning. Table 1 shows that out of the respondents, 82.0% reported using ICT tools to support their learning in chemistry. Only 18.0% reported did not use any ICT tools. This indicates a relatively high percentage of respondents are using ICT devices for chemistry learning.

Table 2
Use of ICT tools in chemistry learning

			Skewness	
Items	Mean	SD	Skewness	SE
How often do you utilize ICT tools to get to a wide range of resources and information for your chemistry studies?	2.48	1.359	0.679	0.337
How frequently do you visit educational websites for supplementary materials and resources in chemistry?	2.20	0.756	0.236	0.337
How frequently do you use ICT tools for learning chemistry?	2.18	1.044	0.970	0.337

Table 2 shows the frequency at which respondents utilize ICT tools for different parts of chemistry learning. The mean score of 2.48 on the first statement indicates that respondents often utilize ICT technologies to access a wide range of materials and information for their chemistry studies. Besides this, the standard deviation of 1.359 shows that the responses exhibit less consistency with the statements. Further, positive skewness (0.679) indicates that greater percentage of respondents who report using ICT tools for accessing resources more frequently compared to those who report using them less frequently.

The mean score of 2.20 on the second statement indicates that respondents frequently consult educational websites for supplemental information in chemistry, typically several times a week. The response consistency with the proposition is indicated by the standard deviation of 0.756. Furthermore, the minor positive skewness value of 0.236 suggests a minor inclination towards more frequent visits to educational websites for supplemental information in chemistry.

The third statement mean result of 2.18 depicted that respondents utilize ICT tools multiple times a week for studying chemistry. Nevertheless, the standard deviation (1.044) shows degree of variability in the responses provided by each responder. Beside this, the skewness value 0.970 suggesting positive tendency towards a higher frequency of using ICT resources for learning chemistry. Overall, the statistics indicate that respondents typically use ICT tools to a moderate extent for several parts of chemistry learning. The presence of positive skewness suggests that there is a greater proportion of respondents who report using ICT tools more frequently.

Table 3

Engagement and Collaboration in the Use of ICT

Items	Mean	SD	Skewness	
			Skewness	**SE**
Do you find that ICT tools facilitate collaborative learning with peers in your chemistry studies?	1.96	0.968	0.926	0.337
How much do you agree that ICT tools allow for personalised learning experiences in chemistry?	3.88	1.100	-1.096	0.337
Do you feel that there is a lack of guidance on how to effectively use ICT tools for learning chemistry?	3.38	1.383	-0.342	0.337
Do you agree that ICT tools make learning more interactive and engaging in the study of chemistry?	2.28	1.246	0.956	0.337

Table 3 illustrates data on the level of engagement and collaboration in the utilization of ICT technologies in chemistry studies. The mean result of 1.96 of the first statement indicates that respondents generally agree but to some extent on the facilitation of collaborative learning with peers in their chemistry studies via ICT technologies. The SD 0.968 indicates that responses of the participants show a high degree of agreement with the statement. The positive skewness (0.926) implies that there is a greater proportion of respondents who agree significantly or to some extent compared to those who disagree.

Moreover, the mean score of 3.88 on the second statement suggests that the respondents generally agree that ICT technologies enable tailored learning experiences in the arena of chemistry. Nevertheless, the standard deviation of 1.1 indicated that the individuals' responses exhibited a significant level of variability. The presence of a negative skewness (-1.096) have a greater percentage of respondents who strongly agree compared to those who strongly disagree.

Furthermore, the mean score of 3.38 on the third statement indicates that respondents had a neutral stance on the absence of clear instructions on how to efficiently utilize ICT resources for studying chemistry. In addition, the standard deviation of 1.383 indicated that the individuals' responses were varied. However, the negative skewness (-0.342) indicates that there is a somewhat greater proportion of respondents who agree compared to those who are neutral.

Likewise, the mean score of 2.28 on the last statement indicates that the respondents generally agree that ICT tools enhance interactivity and engagement in the study of chemistry. Nevertheless, the statement's standard deviation (1.246) suggests that respondents' responses exhibit a significant level of variability, indicating a lack of consistency with the statement. Furthermore, the positive skewness (0.956) suggests that there is a greater proportion of respondents who strongly agree in comparison to those who disagree or strongly disagree.

In general, the data suggests that respondents had different opinions about how ICT technologies contribute to engagement, teamwork, and personalized learning experiences in chemistry courses. Respondents largely concur that ICT technologies enable personalized learning experiences and enhance interactivity and engagement in learning. However, there are concerns regarding the absence of clear instructions on how to use these tools effectively and differing opinions on the facilitation of collaborative learning with peers.

Table 4
Effectiveness of ICT tools

			Skewness	
Items	**Mean**	**SD**	**Skewness**	**SE**
How effective do you believe interactive apps are in aiding your learning of chemistry compared to traditional methods?	2.04	1.029	1.204	0.337
How beneficial do you find video lectures in enhancing your comprehension of chemistry concepts?	3.92	1.122	-0.740	0.337
How effective do you find virtual laboratories in helping you grasp practical aspects of chemistry?	1.94	1.168	1.082	0.337
How valuable do you consider educational websites in aiding your comprehension of chemistry topics?	3.50	1.403	-0.185	0.337
How helpful do you find online simulations in facilitating your learning of chemistry?	1.90	0.814	0.897	0.337
How effective do you find ICT tools in helping you understand complex chemistry concepts?	3.26	1.157	-0.207	0.337

Table 4 shows the efficacy of several ICT tools in facilitating the learning of chemistry. The mean score of 2.04 on the first statement indicates that respondents perceive interactive apps to be more helpful than traditional approaches in facilitating their learning of chemistry are more effective. The SD 1.029 indicates that the responses are less consistent with the statement and have a high degree of variation in their responses. Furthermore, the positive skewness value of 1.204 suggests a greater number of respondents believe that interactive apps are more effective.

Furthermore, the mean score of 3.92 on the second statement suggests that respondents perceive video lectures as very beneficial in improving their understanding of chemistry ideas. However, the standard deviation of 1.112 implies that the respondents' responses inconsistent with this assertion. The presence of negative skewness (-0.740) indicates a somewhat larger number of respondents who view video lectures as less advantageous compared to those who view them as more beneficial.

In addition, the third statement mean 1.94 signifies that respondents perceive virtual laboratories as very effective in facilitating their understanding of practical parts of chemistry. Nevertheless, the standard deviation of 1.168 indicates that respondent have variation in their responses with this assertion. The skewness value 1.082 implied positive toward virtual laboratories are more effective.

The mean score of 3.50 on the fourth statement suggests that respondents generally find educational websites very valuable for improving their understanding of chemistry topics. Nevertheless, the standard deviation of 1.403 indicates that there are discrepancies in the responses provided by the participants, which do not align closely with the statement. In contrast, the negative skewness (-0.185) indicates that there is a somewhat larger proportion of respondents who consider educational websites to be less valuable compared to those who consider them to be more valuable.

The mean score of 1.90 on the fifth statement indicates that participants perceive online simulations as somewhat beneficial in enhancing their understanding of chemistry. Nevertheless, the standard deviation (0.814) indicates the presence of individuals who consistently agree with the assertion. Nevertheless, the positive skewness (0.897) suggests a high number of respondents belief online simulations are more beneficial.

The mean result of 3.26 on the sixth statement suggests that respondents generally perceive ICT tools as moderately efficient in aiding their comprehension of complicated chemistry ideas. Nevertheless, the standard deviation of 1.157 indicates that there are discrepancies in the responses provided by the participants, which are not in line with the statement. Furthermore, the presence of a negative skewness (-0.207) indicates that there might be a somewhat larger percentage of participants perceived that ICT tools are less effective.

Overall, the data shows that people have various opinions on how successful and valuable different ICT tools are in helping with learning chemistry. While certain technologies, such as video lectures and instructional websites, are widely respected, others, including interactive apps and online simulations, are considered to be moderately useful but with greater variation in the feedback received.

Table 5
Challenges in ICT

Items	Mean	SD	Range	Skewness	
				Skewness	SE
Have you encountered technical issues such as slow internet connection or software glitches while using ICT tools for learning chemistry?	1.88	0.918	3	0.741	0.337
Have you ever experienced limited access to necessary hardware or software when attempting to use ICT tools for learning chemistry?	2.56	0.787	3	-0.599	0.337
How challenging do you find it to locate reliable and relevant online resources for your chemistry studies?	3.36	1.411	4	-0.361	0.337

Table 5 illustrates the difficulties encountered by participants when utilizing ICT resources for studying chemistry. The mean score of 1.88 indicates that respondents sometimes experience technical problems, such as slow internet connection or software errors when utilizing ICT tools for learning chemistry. The standard deviation of 0.918 suggests that respondents are exhibiting a high consistency with the assertion. Nevertheless, the value of skewness 0.741 suggesting a greater percentage of respondents who have encountered technical problems compared to those who have not.

Furthermore, the mean value of 2.56 suggests that respondents do not face any restrictions in accessing the required hardware or software while using ICT tools for studying chemistry. The standard deviation of 0.787 suggests that respondents are exhibiting a high level of consistency with the assertion. The value of the standard deviation, which is 0.918, show that the respondents are exhibiting a highly consistency with the assertion. Furthermore, the negative skewness (-0.599) shows high percentage of respondents who have not encountered limited access compared to those who have.

The average result of 3.36 implies that the respondents hold a neutral opinion regarding the accessibility of reliable and relevant internet resources for their chemistry studies. Nevertheless, the standard deviation of 1.411 suggests that respondents exhibit lower levels of consistency with the proposition. The presence of a negative skewness (-0.361) depicted a significant percentage of participants who perceive the task as less demanding incomprehension to those who perceive it as more challenging.

Overall, the data suggest that respondents encounter diverse obstacles while utilizing ICT tools for studying chemistry, such as technical glitches, restricted availability of essential hardware or software, and limitations in finding dependable and pertinent online resources. These findings emphasize the specific areas that require enhancements or interventions to increase the effectiveness and accessibility of ICT technologies in chemistry teaching.

DISCUSSION

Most students who took the survey said they used ICT tools at least once a week to do learning exercises, research chemistry topics, and obtain supplemental materials online. This suggests a notable dependence on ICT tools for many elements of chemistry learning, which corresponds with the wider pattern of the growing incorporation of technology in education.

Perceptions of efficacy differed among several categories of ICT technologies. Video lectures and educational websites were widely seen as highly advantageous and worthwhile. However, interactive apps and online simulations were seen as useful, with a wider range of opinions. This implies that certain ICT tools may be more efficient than others in aiding chemistry learning. Therefore, educators should consider the distinct requirements and preferences of students when choosing and incorporating these tools into the curriculum.

Although respondents generally concurred that ICT tools facilitate customized learning experiences and improve interactivity and engagement in chemistry studies, there were concerns regarding the absence of explicit instructions on how to utilize these tools effectively and divergent viewpoints on the facilitation of collaborative learning with peers. This emphasizes the significance of offering sufficient assistance and resources to enable students to fully utilize the advantages of ICT technologies for collaborative learning and individualized study.

The survey has revealed various obstacles encountered by respondents while utilizing ICT tools for studying chemistry. These barriers encompass technological glitches, restricted availability of essential hardware or software, and struggles in finding dependable and appropriate online resources. It is essential to tackle these difficulties to guarantee fair and equal access to ICT tools and to fully exploit their capacity to improve chemistry learning results.

CONCLUSION

Eventually, the survey results highlight the important function of ICT tools in enhancing chemistry education. Most participants reported regular utilization of these technologies to access resources, participate in learning activities, and collaborate with fellow students. While some ICT resources, including video lectures and educational websites, were seen as very successful and valuable, others were seen more modestly with a wider range of answers.

Although ICT aids in chemistry learning are generally viewed positively, some areas can be improved. These include offering clearer instructions on how to use them effectively, resolving technical problems and access limits, and increasing the availability of trustworthy online resources. To overcome these obstacles and utilize the advantages of ICT technologies, educators can enhance their assistance to students in their chemistry studies and encourage more captivating and individualized learning encounters.

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