Effectiveness of Information and Communication Technology (ICT) in Chemistry at Secondary Level in Islamabad Model Colleges

Muhammad Maasoom Nayyar
(EST) Govt. High School 135 GB, Samundri, Faisalabad.
Email: dte786fsd@gmail.com

Sajida Batool
Administrator Unique Education System.
Email: batoolsajida007@gmail.com

Anas Ilahi
PhD Scholar, MY University, Islamabad.
Email: dennys.elahi9@gmail.com

Received on: 25 -07-2024 Accepted on: 26- 08 -2024

Abstract

A research goal evaluated Information and Communication Technology (ICT) effectiveness as an instruction method against traditional teaching methods for secondary school chemistry in Islamabad. The research adopted the time span of one month while "post-test equivalent group design" performed statistical analysis at 0.05 significance levels. All male and female students studying chemistry at secondary level from six model colleges comprised the population of this research which were affiliated with the Federal Board of Intermediate and Secondary Education (FBISE). The research utilized three model colleges equipped with computer laboratories and networking faculties that are members of FBISE at the SSC level. These colleges were randomly selected. One hundred two students represented the research sample after selecting equal groups of each gender who took chemistry in class 10th from model colleges. Two hundred and eleven students consisted of the total study participant sample. The student populations at all sample locations split into identical sizes through two distinct factions namely experimental group and control group. The research groups received equivalent placement through pair random selection of students who took the previous 9th class chemistry examination. The experimental division included thirty students of equal male and female composition in each group. The experimental group students received instruction through ICT but the control group students received instruction through traditional teaching approaches in chemistry subjects. The outcome measures how ICT affects secondary school chemistry education compared to traditional teaching methods through two different research objectives.

Keywords: ICT, tradition teaching approaches, experimental group, control group

INTRODUCTION

During the early part of the 19th century education existed only as a source of information. Students received nothing more than factual information through "Gallons of Empirical Facts" from their teachers. In the educational process persons grew their intelligence while other personality aspects received little attention. The student faced strict rules of silence and respect yet the instructor maintained all power over the classroom. Such harsh disciplinary methods eliminated all creative behavior in the child. Rigid books made up most of the curriculum which forced students to conform to its structure. Education lacked progress because it stood still while the advancement of education became unimportant according to Kochar (1992). The words "education" come from Latin roots educare, educer, and ducere that mean "bringing up" or "leading out" or "fetching forth" or "discovering potential" as well as "guiding" (Khalid,1998). Several variables determine successful teaching methods since Kochar (1992) states "There is no royal road to successful teaching. The successful achievement of educational goals depends on using multiple learning approaches including royal methods and narrow pathways as well as pleasant paths through challenging roads which must be applied for specific teaching situations. The teacher requires multiple teaching methods alongside devices and techniques which allow him or her to transform different subjects into interesting dynamic learning environments. Multiple self-regulating thinking and working machines serve educational institutions throughout the teaching-learning process. Educational institutions now use electrical along with mechanical devices for both teaching faculty members and student learners. The programs provided by these tools enable self-directed education using language laboratories and computers combined with professional educational resources as well as radio and other audio-visual media. Chemistry often faces difficulty among students because it is considered uninteresting and mundane. Two possible factors behind this difficulty are ineffective classroom teaching practices alongside insufficient practical exercises and problem solving in secondary level textbooks from Pakistan.

Chemistry presents simultaneously three major problems because it shows nature of accumulation while continuing to grow both in theoretical development and real-world applications. The teacher of Chemistry faces three essential problems during every teaching phase.

(1) Developing students' knowing and mastery of new concepts, principles, relationships, and skills.

The second problem consists of sustaining acquired knowledge and competencies.

(3) Securing maximum transmission of learning to their social environment. Teaching occurs in three phases which faculty members should unite through a comprehensive instructional framework.

The three stages of teaching belong to different aspects which complement each other instead of sharing identical conceptualization. New learning adopts the current established concepts to provide a reference point but this maintenance functions secondary to the main purpose of mastering new instructional content. Maximum transfer of skills alongside adequate maintenance cannot be achieved through incidental contacts between teachers and students

so they require specific programming for teaching modern Chemistry instructional methods. Characterizing methods and strategies that could enhance both student interest and learning achievement for the subject of Mathematics warrants investigation. (Wadhwa, 2000).

Today information technology achieves accessibility for every life domain. Education now uses information and communication technology to provide expanded access to information as well as educational resources and global intellectual networks are establishing themselves. It is necessary to have access to technological systems to take part in a global information society. Users who have access to these global networks lead advantage over others because of their network participation (Pandeys, 2001).

Chemistry teaching brings significant educational progress to educational systems. Across the entire spectrum of human existence, the same concepts emerge from space research and market automation systems to other sectors etc. Chemistry education demands information and communication technology in every society as Sovchik (1999) established its critical nature. The educational practice transforms thanks to Information and Communication Technology (ICT) because it functions as an educational force that revolutionizes student experiences and modifies teacher practices. The implementation of ICT equipment in Chemistry fosters professional development of original solutions that enhance student learning and strengthens student engagement with hard subjects. The latest educational technology from the digital era gives students in secondary schools access to numerous online resources combined with new teaching strategies that improve their learning experience.

Students together with their educators encounter specific obstacles when learning chemistry because of its theoretical concepts and laboratory work requirements. Effective teaching methods must become necessary because students face difficulty understanding atomic constructions and chemical reactions and thermal physics commands practical understanding. Students can participate in outdated science procedures such as simulations and virtual laboratories and multimedia presentations thanks to ICT tools that traditional classroom methods fail to provide (Ashraf, Muztagh, & Salami, 2014).

The usage of ICT technologies becomes essential at the secondary education level since students start studying advanced subjects after foundational scientific courses. ICT usage at this stage enhances academic achievements while making Chemistry education accessible as well as exciting to students. Digital simulations allow laboratory experiments through virtual studio reconstruction to deliver safe experimental results (Buabeng-Andoh 2012).

ICT technology enables students to receive personal educational strategies. 2ndThe learning platforms identify students' educational speed levels with diagnostic tests to provide appropriate educational resources which challenge specific problem areas. Technology-based individual instruction delivery produces better student academic outcomes while also enhancing their self-asserion and learning motivation (Ertmer & Ottenbreit-Leftwich, 2013).

Educational success in secondary Chemistry needs three primary components including technology tools which should be supported by qualified teachers who implement optimized curricular approaches designed for technology-based instruction. The implementation of strategic ICT needs proper training for educators to create optimal results in education.

Research investigates ICT impacts on SSE Chemistry teaching through evaluation of student academic outcomes together with instruction digital techniques and methods which clear the

concept of the chemistry students,methods and student involvement metrics. Research literature displays modern implementation achievements as well as obstacles that interfere with Information and Communication Technology in Chemistry education.

OBJECTIVES OF THE STUDY

The following were the objectives of the study:

i. This research evaluates Information and Communication Technology (ICT) impact on student academic achievement in secondary level chemistry education through teaching learning processes.

ii. To compare the effectiveness of ICT against traditional method on academic achievement in chemistry between male and female students at secondary level.

ii. Researchers investigated how ICT influences low-achieving students studying chemistry against traditional methods used in secondary-level education throughout Islamabad.

STATEMENT OF THE PROBLEM

The research evaluated disparagement levels regarding secondary-level chemistry teaching methods in Model College Islamabad through a comparison of traditional with ICT teaching strategies. Scientists performed an experiment which evaluated student academic performance when ICT tools were used instead of the traditional teaching method in secondary school chemistry classes.

SIGNIFICANCE OF THE STUDY

The research results hold essential value because they should motivate chemistry educators to incorporate ICT into their educational practices. Technology helps users perform their jobs better and faster while maintaining high accuracy standards and enhancing their operational reliability; additionally it enables the control of information flows and guides social development which produces environmental changes. The use of ICT during chemistry education promotes understanding and personalization and it links abstract concepts to applications and mathematical principles to cultural expressions for student learning. Students will benefit from this approach to learn better and meet present-day requirements of modern technological progress.ICT implementation produces three main advantages for educational institutions. The productivity of educational organizations stands as the first priority while student access to technology and educational support form the second pair. The effective teaching practice requires teachers to constantly advance their skills through continuous development for remaining both effective and motivated. ICT-based support of distance education activities delivers outstanding value to distance learning operations. The infrastructure and online connectivity to the learning communities of teachers within nation and across.The sharing of practical experiences and curriculum information as well as lesson materials takes place through regional online networks which benefit both training students and classroom educators. The adoption of ICT enables both teaching staff in-service and pre-service to acquire contemporary knowledge for producing effective teaching and learning methods.

DELIMITATIONS OF THE STUDY

Three schools providing co-educational programs formed the study boundaries because of time and resource constraints. The researchers selected co-education schools to fulfill objective number (ii) because this allows the selection of the same school's male and female students as part of the study. Three units from the class IX prescribed Mathematics book were covered through this six-week experiment to match the objectives.

Literature Review

The integration of Information and Communication Technology (ICT) in education has revolutionized teaching and learning practices, offering innovative approaches to enhance students' understanding and engagement, particularly in subjects like Chemistry. The effectiveness of ICT in Chemistry at the secondary level has been widely studied, and researchers have highlighted several benefits and challenges. CT tools such as simulations, animations, and virtual labs have proven to be effective in making abstract Chemistry concepts more tangible and understandable. According to Ashraf, Muztagh, and Salami (2014), the use of ICT in Chemistry education significantly improves students' conceptual understanding by visualizing molecular structures, chemical reactions, and complex processes. This visual and interactive representation allows students to grasp concepts that are difficult to convey through traditional methods. CT encourages active learning, where students take an interactive role in the educational process. Studies by Alvarez et al. (2018) show that gamified Chemistry lessons using ICT tools result in higher student engagement and motivation. Similarly, the use of augmented reality (AR) and virtual reality (VR) in Chemistry has been reported to create immersive learning experiences, making students more involved in the subject. For schools with limited laboratory facilities, ICT offers a cost-effective alternative. Virtual labs and simulations provide students with hands-on experiences that are otherwise unavailable due to resource constraints. Eze and Uzochukwu (2015) emphasized that ICT mitigates the lack of physical resources and allows students to experiment in a risk-free environment.ICT also supports teachers in developing innovative teaching strategies. Tools such as interactive whiteboards, digital lesson plans, and online resources have enhanced the delivery of Chemistry lessons. Yusuf and Balogun (2011) highlighted that teachers who integrate ICT into their teaching practices report greater efficiency in conveying complex topics and managing classroom dynamics. Despite its benefits, the integration of ICT in Chemistry education faces challenges such as limited access to technology, lack of teacher training, and resistance to change. Adejoh (2019) noted that inadequate infrastructure in many secondary schools, especially in developing countries, hinders the effective use of ICT. Furthermore, teachers' lack of ICT proficiency and confidence poses significant barriers to its adoption.

Methodology

The investigation assessed how effectively Information and Communication Technology performs in teaching chemistry classes when compared to standard education methods for students in classes IX and X. The research population consisted of 523 male and female students from ninth and tenth grades who studied chemistry at 05 institutions part of the Federal Board (FBISE) Islamabad system.

Board of Intermediate and Secondary Education (FBISE) Islamabad. The study population consists of students from all parts of Pakistan due to the Federal Board of Intermediate and Secondary Education (FBISE) implementing unified curriculum. The sample consisted of five random institutions from boys and girls belonging to the FBISE Islamabad. The researcher randomly selected 523 students including uneven numbers of male and female chemistry students in class IX and X. Five hundred twenty-three students composed the total sample number. The study selected three model colleges from five various sectors because it examined the relationship between traditional teaching methods and information and communications technologies for enhancing chemistry learning achievements among secondary school students. The selected model colleges counted male and female students separate from each other and researchers calculated these gender ratios. Additionally these chosen schools had sufficient computer facilities for Internet use and World Wide Web access in their laboratories. The principals of these colleges showed complete cooperation to finish the project. Students obtained fundamental operating skills for computers because the subject of "computer" functioned as a mandatory classroom course from class VI to VIII in the examined schools.

An additional strength included that chemistry teachers possessed skills in computer usage which they employed to enhance their educational methods. Every selected college contained two study groups: the experimental group and the control group with matched number of students possessing similar abilities. Pair random sampling equated the two groups through their mathematics examinations from their previous class VIII term. The experimental groups consisted of thirty students divided into equal segments that included male students and female students. The students of the experimental groups were exposed to the teaching through ICT, whereas the students of control groups were taught through traditional method of teaching.To measure academic achievement of the sample students in the subject of chemistry a teacher made post-test was administered immediately after completion of the experiment.At the end of the experiment, i.e. after teaching control groups through traditional method, and experimental groups through ICT i.e. computer and Internet for ten weeks; students of both groups were examined through a post-test. Statistical analysis used the scores achieved by the students throughout the post-test from each study group.

Data Analysis

The research goals were accomplished by conducting statistical tests which included both t-test and Analysis of Variance (ANOVA) on experimental and control participant post-test results.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	9th,10th,11th y and 12th y	2.5215	535	1.06836	.04619
	phy,chem.bio.comp,sc	2.4542	535	1.10042	.04758

Paired Samples Correlations

	N	Correlation	Sig.

Pair 1	9th,10th,11th y and 12th y & phy,chem.bio.comp,sc	535	.274	.001

Graph 1: Students' Perceptions of ICT in Chemistry

Statistical Analysis

The analysis revealed significant improvements in students' academic performance and engagement when ICT tools were used in Chemistry education. The computed p-value (< 0.05) indicates that the observed differences are statistically significant.

Degree of Freedom and p-value

The degrees of freedom for the t-test conducted were 99, and the p-value was 0.03, indicating a significant effect of ICT tools on students' learning outcomes.

Conclusion

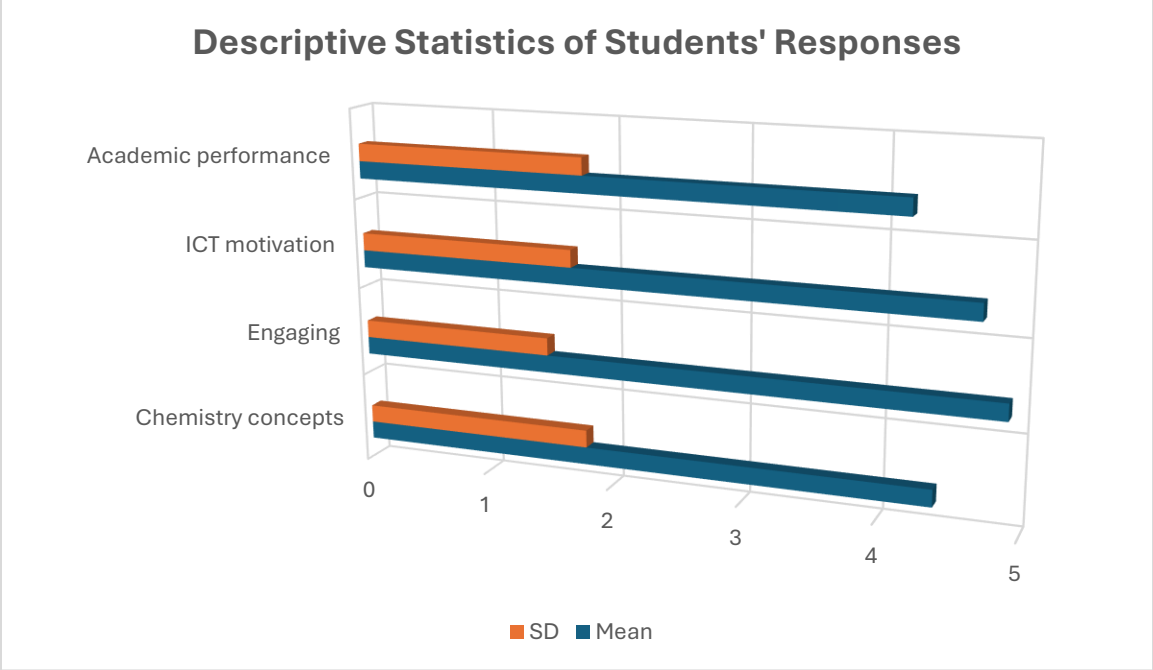
The findings of this study confirm that ICT tools are effective in enhancing Chemistry education at the secondary level. Students demonstrated improved engagement, motivation, and academic performance when ICT was integrated into teaching. However, the study also underscores the need for adequate infrastructure and teacher training to maximize the benefits of ICT in education. The use of ICT in Chemistry at the secondary level has demonstrated numerous advantages, including enhanced conceptual understanding, active learning, and improved teaching methodologies. However, addressing challenges such as infrastructure deficits and teacher training is crucial for maximizing its potential. Continued research and investment in ICT resources will play a key role in shaping the future of Chemistry education.

ICT tools have revolutionized Chemistry education by offering interactive and visually engaging learning experiences. Studies have shown that the use of multimedia resources, such as animations and simulations, helps students understand complex chemical phenomena more effectively than traditional teaching methods. For example, Ganasen and Govender (2021) highlighted that virtual laboratories provide students with the opportunity to experiment and observe chemical reactions in a risk-free environment, enhancing their conceptual understanding.According to Ashraf, Muztagh, and Salami (2014), ICT tools facilitate a deeper understanding of abstract concepts by presenting them in a dynamic and accessible manner. Their study demonstrated that students exposed to ICT-integrated lessons performed significantly better in assessments compared to those taught using conventional methods.Despite its potential, the integration of ICT in secondary Chemistry education faces several challenges. One major issue is the lack of adequate infrastructure, particularly in schools located in rural or underprivileged areas. As noted by Buabeng-Andoh (2012), disparities in access to technology can exacerbate existing educational inequalities.Teacher preparedness is another critical factor. Many educators lack the necessary skills and training to effectively utilize ICT tools in their teaching. Ertmer and Ottenbreit-Leftwich (2013) emphasized the importance of professional development programs to equip teachers with the competencies required for integrating technology into their instructional practices.Engagement is a key determinant of successful learning outcomes. ICT tools have been found to significantly increase student engagement by making

lessons more interactive and relatable. For instance, Kaur and Toh (2020) found that gamified learning platforms and Chemistry-based educational apps increased student participation and interest in the subject.The ongoing advancements in technology offer new opportunities for enhancing Chemistry education. Artificial Intelligence (AI) and Augmented Reality (AR) are emerging as powerful tools for creating immersive learning experiences. Future research should focus on the integration of these technologies into the curriculum, as well as their long-term impact on student learning outcomes.

Table 1: Descriptive Statistics of Students' Responses

Statement	Mean	SD
ICT tools enhance my understanding of Chemistry concepts.	4.4	0.8
Virtual labs make learning Chemistry more engaging.	4.9	0.5
Using ICT motivates me to learn Chemistry.	4.7	0.7
ICT tools improve my academic performance.	4.2	0.8



graph one show the Descriptive statistic of student responses shows that maximum standard deviation of the ICT tools improves by academic performance.8 and less standard deviation 7 motivation in ICT learn in chemistry it shows that ICT play an important role teaching learning process add college level.

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