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An Investigation into the Effectiveness of Icts in the Teaching of Chemistry

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ABSTRACT: Classroom Teaching strategies in the modern world have transformed from teacher-centered to student-centered. The importance of Information Communication Technologies (ICTs) has increased manifold in teaching abstract sciences like Chemistry in this new era. Information and communication technologies offer students a visual representation of abstract concepts, which is not possible with traditional teaching methodologies. Therefore, this experimental study investigates the effectiveness of Information and Communication Technologies (ICTs) on the teaching of Chemistry in secondary schools. The current study was conducted at the Government Higher Secondary School, Charbagh, in the Swat District, Pakistan. A pretest was designed, termed the 'Chemistry Achievement Test' (CAT). The population of this study consisted of 52 students of F.Sc (pre-medical). These students were assigned to two groups (experimental and control groups), each containing 26 students, based on their pretest results. Lesson plans were developed for both control and experimental groups for the specified period. Posttests were conducted after the delivery of the instructions with traditional and ICT-integrated methodologies, and the obtained data were analyzed with Standard deviation, mean, and paired sample t-test. In terms of the academic achievements of students, the results from this study confirmed that ICT-integrated teaching is more effective than traditional methods in Chemistry at the secondary level.

KEYWORDS: Effectiveness, ICTs, Teaching, Chemistry, Secondary Level

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Introduction

Technology in the modern era has the potential to transform the education system by changing the traditional methods of teaching into more innovative and student-centered methods. It has become inevitable now to integrate it into teaching to enhance the learning process. This has created a new era of learning, distinguished by the instructional revolution (Nkomo et al., 2021). With the arrival of Information Communication Technology (ICT) tools, such as interactive applications, virtual reality, online platforms, and artificial intelligence, the ways of obtaining information, its dissemination, and integration in educational settings have completely changed (Athanasios et al., 2021). In understanding difficult subjects like Chemistry, information needs to be actively created by the learner rather than passively consumed. The abstract nature of Chemistry poses challenges for learners, and ICTs, particularly computers, can help in visualizing and understanding those concepts (Ware, 2001). Daza Pérez et al., (2009) investigated various situations in

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chemistry where digital technologies are beneficia006C for students in multiple contexts. This study confirmed that the incorporation of ICTs is important for students, as these tools help them visualize abstract concepts that are difficult to perceive with the naked eye. The students are also enabled to undertake different projects with teachers, such as creating 3D models of molecules in virtual laboratories.

For students, the integration of ICTs in teaching is beneficial as it boosts not only collaborative skills but also social and problem-solving skills. Besides this, students become more independent and responsible, and have the capacity for expression and creativity due to these tools. These elements are indispensable for a conducive teaching-learning environment (Ghavifekr et al., 2014). Difficulty in understanding physical chemistry at the senior secondary level is often associated with traditional teaching methods. Utilizing ICTs at different education levels increases learning opportunities, employs modern teaching methods, and manages the education system effectively (Bocconi, 2013). According to Krause et al., 2017, teachers' perceptions and attitudes are extremely important in the integration of ICTs in the classroom. Teachers with a positive attitude towards technology integration use ICTs more in teaching.

ICTs' incorporation in teaching is extremely useful for both students and teachers, supporting knowledge sharing and helping them stay updated with the latest educational advancements (Ferreira et al., 2014). Social media platforms like Facebook and WhatsApp offer a space for collaborative learning and sharing experiences related to course content, enhancing their significance (Rasiah, 2014; Albayrak & Yildirim, 2015). Through ICT, students can participate in interactive learning beyond the classroom, making learning active and promoting higher-order thinking (Hung & Yuen, 2010). ICT integration in teaching is still in its early phases. However, there are challenges to ICT integration, predominantly in developing countries. The biggest among these is the high cost of ICT tools to develop a technology-integrated system and then operate and maintain the system in the institute. Other challenges include operating and replacing the installed ICT system, the use of outdated and unlicensed hardware and software systems, and a lack of a proper maintenance system (Balasubramanian et al., 2009). The integration of ICTs into curricula depends on the positive attitudes of science teachers towards these technologies. Teacher education should focus on instructing relevant ICT courses to induce a favorable attitude. Time restrictions often discourage teachers from using ICTs; however, with proper training, they can integrate ICTs proficiently in a shorter time (Cuckle & Clarke, 2002). The Cognitive Theory of Multimedia Learning by Mayer and Moreno provides a theoretical framework that emphasizes the importance of presenting information in both textual and graphical formats for effective learning (Moreno & Mayer, 1999; Mayer, 2002).

Lux et al., (2017) emphasized that advanced curricula based on technology are constructed on practical reality, which provides support and tools that boost learning. This results in schools and classrooms with a better environment that is conducive to the academic process. One of the prime uses of ICT tools in education is that they provide multiple means of communication for teacher-student interactions. This enhances the teaching-learning process (Pultoo et al., 2020). According to Ramirez-Contoya et al., (2017), the key elements for integration of technology in teaching are the teachers' readiness their positive attitude, and their technical expertise to use these ICT tools in teaching. As a result, students' learning is enhanced. Moreover, the acceptance of ICTs in instruction by teachers has a very positive impact on the integration of teaching in the teaching-learning process.

Another important factor in the integration of technology in teaching is ICT self-efficacy. ICT self-efficacy refers to the ability of an individual to utilize ICTs for day-to-day uses such as searching the internet for some information, sending e-mail, or creating a presentation using a computer. (Fraillon et al., 2014). Han et al. (2017) have shown that teachers' ICT self-efficacy is increased by their pre-service training in technology integration. Based on the results of this study, it can be suggested that ICT self-efficacy should be a vital part of the teachers' educational training programs (Gudmundsdottir & Hatlevik, 2018).

ICT integration in teaching is dependent on teachers' perception of technology integration in teaching (Baş et al. 2016). Teachers who have a positive attitude toward ICTs utilize these tools more in the teaching and learning process (Sang et al., 2011). Also, the integration of technology in teaching is dependent on teachers' beliefs about the ICT tools (Prestridge 2012). Besides these factors, teachers' motivation is also a big factor in the integration of technology in educational practices. It is one of the most important issues in the integration of ICT in teaching (Uluyol & Şahin, 2016).

Methodology

This research study was conducted at the Secondary School of Charbagh in District Swat, Pakistan. A Pretest was designed, called the 'Chemistry Achievement Test' (CAT), which consisted of 40 MCQs. These MCQs consisted of three categories, namely, Knowledge, Understanding, and Application, based on Bloom's Taxonomy. Among these MCQs, 10 were based on Knowledge, 10 on Comprehension, and 20 on Application. The following tables show the number and percentages of these items.

Table 1

Test Items and their Description

Area	Knowledge	Understanding	Application	Total
Prior Knowledge	10	10	20	40

Table 2

Areas based on Bloom's Taxonomy and their proportions

S. No	Objectives	Percentage
1	Knowledge	25
2	Understanding	25
3	Application	50

The validation of CAT was done with pilot testing and expert opinion. The population of the current study comprised 52 secondary-level (F.Sc) students from the Government Higher Secondary School, Charbagh. Based on the pretest scores, 26 students each were assigned to both the control and experimental groups. Both groups were taught with different teaching methodologies, Control with traditional and Experimental with ICT-integrated methodology. Lesson plans were created for both groups. In this study, the researcher himself taught the contents to both groups using different methodologies, as he was the Chemistry Subject Specialist. Both groups received the treatment for six weeks in separate classes. Posttests were conducted for both experimental and control groups. The statistical tools, such as mean, standard deviation, and paired sample t-tests, were utilized to analyze the obtained data using SPSS software.

Results

Table 3

Control Group Pre-test and Post-test Comparison

Control Group	N	Mean	S.D	Df	T	P
Pretest Score	26	15.42	5.608	25	-1.439	.162
Posttest score	26	16.62	4.464			
(α=0.05 and N= 26)						

Table 3 compares the scores of the pretest and posttest for students in the control group. The Mean value of the pretest is 15.42, and the post-test is 16.62 for the control group. The Standard deviation value for the pretest is 5.608, and for the posttest is 4.464. Similarly, the t is -1.439. The P is 0.162, which is greater than the α value of 0.05. The value of P confirms that the posttest scores of students taught with the traditional method of teaching did not improve significantly from the pretest scores.

Table 4

Experimental Group Pre-test and Post-test Comparison

Group	N	Mean	S.D	Df	T	P
Pretest Score	26	12.73	2.961	25	-12.291	.001
Posttest score	26	27.38	5.960			
(α=0.05 and N= 26)						

Table 4 reveals the mean and standard deviation values for pretest and posttest for the experimental group. For the pretest, these values are ($\bar{x}$ = 12.73 and S.D. = 2.961). For the posttest, $\bar{x}$ = 27.38 and S.D. = 5.960. Likewise, the t-test value is -12.291. Since the P is .001, Which is lower than the α value of 0.05. This shows that the posttest scores improved significantly from the pretest scores when the ICT-integrated teaching method was used.

Table 5

Control and Experimental Groups Pretest comparison

Groups	N	Mean	S.D	Df	t-value	P-value
Control Pretest Score	26	15.23	5.708	25	-1.690	.104
Experimental Pretest score	26	13.62	3.991			
(α=0.05 and N= 26)						

Table 5 illustrates that for 26 students of the control group, the means and standard deviation values for the pretest are ($\bar{x}$ = 15.23 and S.D = 5.708). Whereas the mean and standard deviation values for the posttest of the experimental group are ($\bar{x}$ = 13.62 and S.D = 3.991). The t-test value is -1.690. The P value of .104 is larger than the α value of 0.05. This shows that there is no considerable change between the pretest scores, and both groups were equally capable before the treatment.

Table 6

Experimental and Control Groups Posttest Comparison

Groups	N	Mean	S.D	Df	T	P
Control Posttest Score	26	16.60	4.416	25	-6.733	.001
Experimental Posttest score	26	27.16	5.970			
(α=0.05 and N= 26)						

The mean and standard deviation values from Table 6 for the posttest of the control group are ($\bar{x}$ = 16.60 and S.D. = 4.416). For the experimental group, these values are ($\bar{x}$ = 27.16 and S.D. = 5.970). Also, the t is -6.733, P is 0.001, which is much smaller than the significance level α = 0.05. All of these data indicate that there is a significant increase in the posttest scores of students in the experimental group taught with ICT-integrated teaching compared to traditional methods. Therefore, it can be concluded that the ICT-integrated teaching method in Chemistry gives significantly higher scores in terms of the academic achievements of students and is hence more effective compared to traditional methods.

Results and Discussion

Due to digital advancements, teaching methods have been transformed, encouraging teachers to integrate technology into teaching for valuable outcomes. This research study aimed to compare the two teaching methodologies, ICT-integrated teaching and Traditional teaching, and to find out their effectiveness in teaching chemistry at the secondary level. The results obtained showed that the ICT-integrated teaching was more effective, compared to the Traditional method of teaching. This was confirmed by the higher posttest scores of students in the control group, taught with an ICT-integrated teaching method. The study by Avinash and Shailja (2013) identifies that ICT integration in teaching increases the academic performance of students in the subject of Chemistry. Furthermore, ICT tools improve students' visualization through pictures, videos, and diagrams, boosting their understanding of concepts and their engagement in the classroom. (Chen et al., 2020).

In the current study, the comparison of the posttest results for the ICT-integrated teaching method is significantly higher than the posttest scores obtained for the Traditional teaching method. Therefore, based on these results, it can be justified that the Integration of ICTs in the teaching of Chemistry is strongly advocated for effective teaching and better academic achievements of students in Chemistry.

Conclusions

Data analysis of the current study confirms that the incorporation of ICTs enhances students' academic achievements substantially than traditional methods. Therefore, it is strongly advisable to integrate ICT into teaching Chemistry as it contributes to improving the overall academic performance. Furthermore, the teaching-learning process in chemistry is extensively facilitated by the use of ICTs, providing students with concrete images of abstract concepts, thereby increasing their understanding significantly. Based on the results of this study, it can be concluded that ICT-integrated teaching is highly effective compared to traditional methods of teaching Chemistry.

Recommendations

The research findings establish that students' academic performance significantly improves when ICTs are used in the teaching of Chemistry. Therefore, ICT integration into science education, especially Chemistry, proves highly effective in helping students learn abstract concepts through visual aids. Consequently, the availability of ICT tools should be ensured at all levels of education.

- To ensure the effective use of ICTs in teaching, it is pertinent that teachers are given proper training. To achieve this, wide-ranging teacher training programs must be organized.
- ICT integration in education should be an essential component of a country's education policy, given that effective Science and Chemistry instruction relies on such tools.
- Governments should allocate a considerable portion of their education budgets to the acquisition and provision of ICT facilities across all educational levels.
- It is recommended that Schools should consider hiring ICT experts who can provide technical support and assistance to science teachers, mainly those teaching Chemistry.
- There is a need for more research on the integration of ICTs in education that will guide policymakers and academicians to improve the teaching and learning processes in institutions.

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