Challenges and Implications in Teaching-Learning with ICT Tools with Special Reference to Chemistry Education

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Abstract

Today's world is globalized and the world has shrunk on account of massive strides in the development of science and technology. Technology embodies a specific way of revealing the world in which humans try and power over reality. We Indians don't lag behind in incorporating the innovative methods of technology in every field. Information and Communications Technology (ICT) at present pervades all parts of life, allowing people to network, communicate and promote their businesses via different sites, seek help at the time of need, be it war or any natural calamity, accessing bank accounts, travel booking and even booking for any event, getting reviews of the products and services of many brands etc. If we talk about our education system, ICT has provided with learners education that is high in both quality and equity. The changing digitalized knowledge inspires creativity, critical thinking, communication and collaboration among learners. Thus and so forth, ICT proves to be an effective tool for making a new world of education in which learners are well acquainted with the new 21st century skills and attitude.

Key Words: ICT, Technology integration in education, Innovative methods, Teaching-learning, Chemistry, 21st century skills

Introduction

Education system is the major contributor in building any nation's economy. It is a powerful tool in the hands of mankind to bring a revolutionary and positive change and make this world a better place to live in. In the past few decades, the concept of education has tremendously changed because of advanced technology and globalization. The Internal Commission on the development of Education in its report "Learning to be" (UNESCO, 1972, p. 143) emphasizes:

Education from now on can no longer be defined in relation to a fixed content which has to be assimilated, but must be conceived of as a process in the human being, who thereby learns to express himself, to communicate and to question the world, through his various experiences, and increasingly-all the time-to fulfill himself. It has strong roots, not only in economics and sociology, but also in finding from psychological research which indicate that man is an unfinished being and can only fulfill himself through constant learning. If this is so, then education takes place at all ages of life, in all situations and circumstances of existence. It returns to its true nature, which is to be total and life long, and transcends the limits of institutions, programs and methods imposed on it down the centuries.

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In the context of the above nature of education, the limits of educational research and teaching –learning practices have to be extended from the formal and conventional modes of education to the non-formal, open and innovative systems. Information and Communications Technology (ICT) can make this happen. Research has shown that appropriate use of ICTs catalyze a paradigm shift in both content and pedagogy. Now the whole approach of imparting knowledge has become learner-centered as opposed to former traditional teaching. With the advent of technology, the conventional boundaries of education has been transformed and expanded. Innovative deployments of ICT solutions have been instrumental in transcending multiple barriers in providing access to education in the country. With increasing digital literacy in the country, ICT solutions have gained momentum in driving quality education.

Operational Definition of Term ICT and ICT Tools:

Information and Communication Technology (ICT) is an extensional form for information technology (IT) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals) and computers, as well as necessary enterprise software, middleware, storage and audiovisual, that enable users to access, store, transmit, understand and manipulate information.

ICT in Education is the mode of education that uses information and communications technology to support, enhance, and optimize the delivery of information.

ICT tools for teaching and learning means to digital infrastructures such as printers, computers, laptops, tablets, software programs, data projectors, and interactive teaching box. These can be used to find, explore, analyze, exchange and present information responsibly and without discrimination. ICT can be employed to give users quick access to ideas and experiences from a wide range of people, communities and cultures.

Categorically, Luo and Lei (2012) suggested that there are four different common types of ICT in educational purposes, those are, (1) educational networking: online learning platforms that connect learners using social networking technologies (Classroom2), (2) web-based learning: an internet –based instructional delivery tool or online application or services allowing those who access the platform to have interactively collaboration in searching, accepting, organizing, and delivering educational content(Wikipedia, blog, podcast), (3) mobile learning: means of technologies conducted by portable devices aiding in educational activities(smartphones and laptops), (4) classroom equipment: any facilitation in the form of devices to support the interaction between the teachers and the students in classroom(projectors, interactive white boards).

Importance of Integration of ICT in Education

ICT has encompassed the total teaching-learning process involving the elements like specification of goals and behavioral objectives, analysis of the characteristics and needs of the learner, selection and organization of the content to be taught, methods and strategies of the delivery of the content, use of aid-material, software and hardware, mass media and communication techniques, effective classroom management, continuous feed-back and evaluation of the results along with the organizational and administrative activities.

Through ICTs, effective networking and collaboration, easy sharing of resources and effective accessibility to resources is also possible. Thus ICT contributes in the dissemination of knowledge and information to a larger community.

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The inception of ICTs supports inclusion. With the help of ICTs the challenge in terms of special provisions and specific education can be met. Other than this, with the advent of ICT tools, non-formal education for out of school learners and adults in remote areas or regions of conflicts are also possible.

ICT provides assessment and evaluation tools to check and measure students 'progress in any exam. Teachers can use various tools in classroom such as Socrative for quizzes and questions with real time grading, Google forms for multiple-choice questions and short answer questions, Mentimeter to poll students, or ask to vote and Hotpotatoes6 for interactive multiple-choice, short-answer, jumbled-sentence, matching/ordering and gap-fill exercises and Kahoot- a game based assessment tool. These tools reflect on how well students learned and where they are struggled.

Applications of ICT Tools in Chemistry Education

The subject chemistry is the study of matter and the changes it undergoes and it considers both macroscopic and microscopic information. Chemistry is significant in our civilization because it affects our basic needs for food, clothing, shelter, energy, clean air, water, and soil, among other things.

It plays an important and useful role towards the development and growth of number of industries. This includes industries like glass, cement, paper, textile, leather, dye, paints and pigments, petrochemicals, sugar, plastics and Pharmaceuticals. In short, chemistry is the bedrock for national technological and economic development. And so, there is a great demand of chemistry professionals in the Indian as well as global market. For this reason, the teaching of chemistry at secondary school level and at higher level must be taken serious. In chemistry education, ICT can provide solutions to many of the problems afflicting chemistry and thus assist in improving students' skills and attitude towards effective performances in chemistry.

In this paper an ICT based system is proposed for enhancing teaching and learning of some integrated concepts and aspects of chemistry.

- Using ICTs Integrating ICT in chemistry class assist students in accessing digital information efficiently and effectively. They can get every type of guidance and answers of their questions Their curiosity can be easily satisfied and they can get valuable information regarding the subject and activities related to it or can take career guidance on different branches of chemistry and their future scope.
- Based on a constructive learning approach that assumes learning as a process individuals construct new knowledge based on their prior knowledge and experience (Johassen, 1991). Thus ICT help students to focus on high order thinking skills and develop problem solving ability. This emerging pedagogy makes students more productive and creative in terms of various educational outputs.
- Computer aided instructions supports student-centered and self-paced learning- Computers have the ability and capacity to provide individually tailored learning to a limitless number of learners at a time. Teaching machines present systematically programmed sequences of instructions to students and provide sufficient drill and practice by instantly display the proper feed-back and further drill work. Thus they may open a wide variety of opportunities for the improved self-learning to all types of learners. This self-learning is further facilitated by the advanced services of the computers like online dictionaries, digital encyclopedias, electronic books and journals etc.

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ü ICT provides valuable teaching aids for instruction. Students may get graphics along with texts and also hear the explanation for further understanding with the use of Presentations, Flash Movie, Interactive Multimedia (interactivity can be added using animations), Online Demonstrations/ Virtual Lab e.g. Chemlab (for any experiment that may be too difficult, expensive or dangerous to perform in class room situations), Some Fun Activities/Games e.g. Periodic table game and Mind Maps (that provide subject concisely, making even the most complex topic easy to understand and interesting) can also be used to engage students instantly.

Some e.g. of the above tools are given below:

For Presentations,
http://www.curriki.org/
http://www.chalkbored.com/lessons/chemistry-11.htm
http://www.teacherplanet.com/resource/chemistry.php
http://www.worldofteaching.com/chemistrypowerpoints.html

For Interactive Multimedia, http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/hybrv18.swf
http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/molvie1.swf

For Online Demonstrations and Virtual Labs, http://www.wiredchemist.com/chemistry/instructional/anim_dichloroethene_symmetry.html
http://demonstrations.wolfram.com/education.html?edutag=High+School+Chemistry&limit=20

For Games
http://funbasedlearning.com/chemistry/chemBalancer/default.htm

And Mind Maps,
http://www.inspiration.com/
www.Webspiration.com

- Application soft wares like MS Word, MS Excel, Originpro, Keleidagraph are powerful tools to write and record any document and to draw graphs, to do calculations, to show the relationship between various quantities (graphically) respectively. The latter two are widely used by research scholars also for publication of their work.
- Learning chemistry sometimes requires students to relate chemical equations and symbolic notation to real data. There are various CD-ROMs available with different strategies and focus for teaching chemistry with large databases of visual information. For e.g. 'chemistry set' http://195.200.1.5/newmedia/products2kasp. Amongst other things the CD-ROMs contains a picture of the periodic table in which the color of the box for each element depends on whether it is a solid, liquid, or gas. The system lets the user set a temperature. As this varied the color of the box for each element changes as its state does. This allows the periodic variation in boiling and melting point to be seen in a way that neither book nor paper based activities would allow.
- Course content/resources can easily be shared via Teacher Tube and School Tube. Collaborative learning tools like Google docs and Google sheets allow students and teachers to resource organization in addition

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to streamline homework assignments and class projects. Thus using ICT enables users to communicate, share, and work collaboratively anywhere, anytime.

- ICT can arrange for Simulation, a technique that can be effectively used for training the students in an effective way through the provision of some artificial situations, and mock-ups. Or in other words, imitation of a situation or process which needs visualization. For e.g.- chemical equilibrium http://www.chm.davidson.edu/vce/index.html
- Simulations soft wares (in the form of flipped classrooms) are also there. We can share the links to students and then can ask students to prepare any topic (mainly sort of open education resources). One other way is we can simply play on the spot or we can also download them. For e.g. www.chemtube3d.com/lithiumionbattery.
- Modeling uses computers to generate images of atoms, molecules and atomic orbital of any organic matter through internet based project. According to Branvold (2007) computers have made two new methods of studying molecules, molecular modeling and combinatorial chemistry possible.

  In molecular modeling, chemist use computers to stimulate the structure and motion of macromolecules. In combinatorial chemistry, a chemist can use robotic tools to make huge number of slightly different molecules. This set of molecules help the chemist search for useful molecules. Both of these tools are particularly useful to pharmaceutical and biological chemist.

- Scientifically proven visual techniques like Doodle Notes can be used for making chemistry learning interesting for students. Doodle Notes have brain-based learning techniques to help students with recall. They can be used to illustrate concepts, to break down steps, to examine cycles. We can use them to illustrate solubility rules, to show the steps to calculate molar mass (Source: https://www.doodlenotes.org/in-the-classroom.html)
- Using Offline soft wares such as Chemsketch, Argus Lab, Chemdraw (also includes Periodic table) and Marvin sketch or Online websites for e.g. https://chemdrawdirectperkinelmer.cloud/is/sample/index.html www.chemspider.com/structuresearch structures/reactions can be drawn/ written.
- Using http://academia.org and http://researchguide.org students and teachers may converse with top notch working scientists about scientific topics or latest researches/discoveries in the field of their interest. For e.g. The UNICEF voices of youth website https://www.unicef.org/voy offers them opportunities to participate in discussions on current global issues such as global warming. Thus ICT has made possible a unique collaboration and cooperation among the subject experts, teachers and students of diversified capabilities and interests for enriching their thirst of knowledge and sharing their contribution in the field of education in a distance mode environment.

Although this paper focus mainly on the contribution of ICT in chemistry education yet its role in other science subjects and areas like language learning, numeracy etc. cannot be neglected. The use of ICTs has made the subject more concrete rather than abstract for learners.

In this regard, Silvin-Kachala (1998) pointed out that, students in technology rich environment experienced positive effects on achievement in all major subject areas. Furthermore, their attitude toward learning and their own self-concept improved consistently when computers were used for instruction.

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Along these lines, considering all the applications and advantages of ICTs, we can say that ICT has found its niche in education Also, when it comes to the time s of COVID-19 Pandemic, its role in the field of education was recurring and unavoidable. During that time, we had seen and experienced a huge shift from offline to online mode of education to ensure continuous delivery of content to learners through various apps like Zoom, MS office, Google meet etc. Although, our country was not well prepared for this 'Digitalization' of education, concerted steps were being taken by government to make the teaching-learning process easier for both students and teachers. And as Charles Darwin in his famous 'The *Theory of Natural Selection' quoted, "It is not the strongest of the species nor the most intelligent that survives adversity. It is the one that is most adaptable to change that survives."* So we, as the stakeholders of education sector also have to be adaptable to 'Digital revolution' in order to survive.

Barriers and Solutions

Although the advantages of using ICT in the classroom have been demonstrated in previous section, yet barriers or challenges associated with its use still exist. To effectively harness the power of technological innovations to improve learning experiences, the following three essential conditions must be met:

- To begin with, the potential of these technologies must be exploited in order to broaden the reach of basic education, particularly in the direction of the excluded and underprivileged groups; and to enhance and improve class room teaching. For this, students and teachers whether at primary level or at university level should be provided with equal, easy and affordable access to ICT tools and resources.
- High quality, meaningful and culturally responsive digital content in all languages must be developed and available for teachers and students. Moreover, the availability of such e-content should not only be confined to disciplines of science and technology only but for other disciplines like humanities and commerce as well.
- Teachers can act as catalysts for the integration of technology through ICT. But professional development and readiness of the teacher to accept the change to promote critical thinking skills and collaborative learning practice in the learners is the key factor to the successful implementation of technology based teaching-learning.

The processes of ICT are based on computer knowledge and not all teachers are computer literate. Fundamentally, when there are new tools and approaches to teaching, teacher training is essential (Osborne & Hennessy, 2003) if they are to integrate these into their teaching Therefore, there is a need for pre-service and in-service training for teachers, so as to upgrade their knowledge and skills in using ICTs in class room environment. In this regard, Newhouse (2002) stated "teachers need to not only be computer literate but they also need to develop skills in integrating computer use into their teaching/learning programs" (p. 45). According to Becta (2004), providing pedagogical training for teachers, rather than simply training them to use ICT tools, is an important issue. Almekhlafi and Almeqdadi (2010) stated, provide workshops that allow teachers to reflect upon effective strategies for technology integration into instruction and unveil issues that are central to understanding the process of technology integration into instruction.

Thus, if the encouragement, equipment, and necessary technological support are available from institutes for the teachers, developing an ICT class will be easier for them.

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Conclusion

The author wholeheartedly agrees that technological advancements deserve the highest accolades and reflect on our scientific capabilities. This is because technological innovations have ensured maximum user/ customer satisfaction in a demanding market environment. But as always, every coin has two sides, and the same is applicable here. Technology and its progress remain inevitable and critical. Simultaneously, it also leads to physical, emotional, mental and social issues. Too much reliance on technologies has minimized the human power of creative thinking. People no longer bother to read, write, or calculate without computers. ICT brought-up-generations do not have better skills of self-expression through writing. It has brought about rampant ways of copying other people's work, so to inculcate critical and analytical thinking skills in learners is a matter to think about.

Furthermore, according to Dorup (2004), the use of ICTs cannot replace the traditional teaching activities but it can be easily used as a supplement. To complement this, Ahmed and Abdulaziz (2004) summarized that "the different learning environments did not produce significant difference in students' attitudes toward technology. Students' positive attitudes toward information reveal that IT plays a role in students' learning, albeit a secondary role. Although students recognized the potential and significant role of information in teaching and learning, the recognition is limited to the use of information technology as an instructional media, and not a key determinant of learning."

In a country like India, where there is a sheer paucity of teachers, funds and resources, a proper action plan is required if we wish to implement technology based education in class rooms. First and most important, we should encourage positive attitudes among all the stake holders of the education sector about the significance of integrating ICT into instruction. With this, capacity building, curriculum development, infrastructure, and state and central government support is required to achieve successful integration of technology in education.

In the times of the COVID pandemic, technology has already started ruling over the planet. So the need of the hour is judicious use of technology with necessary checks and balances to confront and overcome any future challenges.

In future studies more focus should be given on management strategies and policies to address the key issues and challenges in the process of teaching and learning with ICT tools. If the barriers can be overcome, it is a step forward to provide education that is innovative, goal oriented and universally affordable to all without any discrimination.

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