IMMERSIVE ICT TOOLS FOR TEACHING AND LEARNING SCIENCE

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The importance of hands-on experimentation in understanding concepts of science is well established. However, due to various constraints, every student does not get enough hands-on opportunity, and this limits their creativity and cognitive development. The Information and Communication Technology (ICT) offers various tools helpful to visualise and explain science in an effective manner. This article lists some of the available avenues for such interactive learning. It further discusses some of the possible ways of adopting emerging technologies for the purpose of science education, particularly in the context of school education.

Key words: *Science education, ICT, Augmented Reality (AR), Virtual Reality (VR), Simulation, Hands-on activity.*

Introduction

The emergence of Massive Open Online Courses (MOOCs) as well as availability of high quality educational text, video and other e-contents are in a way furthering the globalisation of education. This trend is helping address the challenge of access in education. Education is becoming available to every individual learner, regardless of the place, time and pace at which one is accessing or the culture, background and other socio-economic status one belongs to. Many world class institutions are offering credit based courses in fully online mode which are being recognised by other institutions. For example, the University Grant Commission (UGC) of India has come out with the regulation "Credit Framework for Online Learning Courses through SWAYAM" for learners who complete online courses through the SWAYAM MOOC portal.

Online course contents are constrained by the fact that concepts of science inevitably require laboratory activities as part of the skill acquisition process. The ideal solution may be having remote access to physical laboratories. But, a remote-access physical laboratory is complex to build and operate, especially with regard to the communication and sensory-control hardware and software required, and the equipment and their maintenance expenses. A fully software-based virtual laboratory and simulated experiments therefore appear to be good alternatives. Therefore, virtual laboratories should be a necessary component of science teaching-learning in online or virtual modes. Such virtual facilities although cannot replace the hands-on experience with real equipment or apparatus in a physical science laboratory. However, with the advancement in computer graphics and computing powers, and the emergence of technologies like Augmented Reality (AR) and Virtual Reality (VR), the boundary between the real and virtual world are reducing [1].

This article is an introductory overview of some of the ICT based tools that help in creating interactive environments required

for understanding concepts of science. The next section discusses the need of ICT tools in teaching and learning of Science, followed by the listing of some of the emerging ICT tools and their use cases. This is followed by the section on integration of ICT in science teaching.

Need of ICT Tools in Teaching and Learning of Science

Science teaching must happen in the laboratory, for experimentation is the most effective tool [2, 3]. This holds true for explaining scientific concepts to school children as well. That is why science at the higher secondary classes of the 10+2 school system has a mandatory component of laboratory work [4]. In the laboratory, students get the opportunity for cooperative learning using a limited number of experimental kits, and this improves their overall quality and efficiency as well [5].

But there are many concepts of science which appear to be abstract for learners due to the absence of direct or hands on experiences. As an example, behaviour of atoms and molecules in a chemical reaction, dynamic equilibrium, the mechanism of evolution, study of nuclear fusion and fission, behaviour of alternating current in a circuit, etc. This limitation of experiencing the phenomena directly is a constraint in comprehending and understanding of the abstract concepts. This can be overcome to a certain extent with the help of ICT tools. It has been observed that systematically designed multimedia material correctly depicting a scientific phenomenon has a greater potential than a printed textbook especially in learning abstract concepts in science [6].

Science students sometimes encounter phenomen which appear to be static when viewed macroscopically whereas it is dynamic in nature when studied microscopically, such as, dynamic equilibrium in reversible reactions. It has been found that using animations to show the dynamics involved at microscopic level simplifies the complicated static illustrations used to represent the dynamics in the books [7].

ICT tools also help students in visualising objects that are either very difficult or almost impossible to be seen even with the finest equipment, such as interaction between molecules, internal structure of atoms, molecules, cells, bacterias and viruses.

In some parts of the world killing animals for experimental purposes has been banned which became a constraint in the learning of life science related things. In vivo experiments can be replaced by in silico experiments performed on computers via computer generated simulations. Virtual Reality (VR), Augmented Reality (AR), simulation, or simply an animation sometimes has the capacity to remove this barrier to a great extent.

According to the *National Curriculum Framework* (NCF) 2005 of India, one of the important aims of science education is to nurture the natural curiosity of children [8]. While it is suggested that children should become independent learners, in actual laboratory practices they are given very little space to do the things independently. They are given prescription for each and every step and are not allowed to deviate from the predefined path. This kills the innate curiosity of the child, instead of nurturing it. The associated risks of accidents due to chemical explosion or mishandling of equipment are there when

children are allowed to try out things on their own. This may cause irreparable damage to the instruments as well. But use of ICT tools, such as, virtual laboratories may give children the required space to explore more and understand about the chemical reactions or instruments without any fear of damage either to the apparatus or to themselves. In this way, ICT can provide more scope to children to work independently and quench their thirst of enquiry. It encourages and engages students in the process of learning science and making their experiences in science a fun [9].

Immersive Technologies

Information and Communication Technology (ICT) includes both hardware and software that can be used for teaching-learning purposes, including science education [10]. It allows us to create and share a variety of e-contents such as text, image, audio, video, animation, etc. These contents were usually used to be delivered through offline modes like Radio, Television, CD/DVD, Pen Drive, Portable Hard Disc Drive, etc. But, the evolution of faster and affordable Internet facilities (3G, 4G and upcoming 5G) has made it easy to create, share and access a rich variety of e-contents available across the globe.

The continuous improvement in hardware and software technologies are resulting in emergence of experiences, such as, Simulation, Augmented Reality (AR), three Dimensional (3D) Virtual Reality (VR) and various other interactive e-contents.

The Augmented Reality (AR) basically enhances the objects in the real physical world by integrating digital content, such as, visuals, sound, or other sensory stimuli created using technology. AR basically superimposes the computer generated contents onto a user's view of the real world, thereby creating a seamless experience for the user. Popular examples of application of AR are devices like Microsoft's HoloLens, Magic Leap, and Pokémon Go game. Some of the educational use of AR can be educational tours of museums, historical places, etc. For example, during a physical visit to a museum, the visitor can turn on a mobile camera and point to an object. The AR App can help by providing additional useful historical facts and information about the object. AR applications are considered to support preschool children's cognitive development as well.

Virtual Reality (VR) is a computer generated virtual environment, mimicking the real world. Unlike AR, VR creates a fully virtual environment by simulating the real world. VR technology is being applied in the area of 3D cinema, video games, entertainment, and education, particularly in military and medical training. It too generates an immersive feeling by placing the user inside an experience. VR uses head-mounted display equipment with a small screen in front of the eyes, hand-controllers, and various sensors. Popular among them are Oculus Rift and HTC Vive. Using such equipment, a user is able to look around the artificial world, move around in it, and interact with virtual features or objects.

Integration of ICT in Science Education

The AR and VR are two promising areas that have the potential to disrupt the pedagogies of science teaching. Studies have shown that AR technology can enhance the development of students' laboratory skills, and generate interest and curiosity to carry out actual hands-on activities in a physical setting [11]. AR has been used in chemistry teaching,

particularly to explain non-perceptible notions such as atoms, molecules, chemical bonds, etc. It helps students develop spatial thinking, ability to visualise and interpret three-dimensional structures of molecules and crystals, and understand the bonds between the structures of molecules [12].

VR technologies are immensely useful in medical education, particularly surgery. The three-dimensional (3D) virtual reality (VR) based technologies create peripheral view of objects such that students get a feeling of virtually touching, interacting and examining objects. Students can practice surgeries on virtual patients, before performing surgeries on real patients.

Virtual reality allows teachers to teach science in a lot more effective and interesting manner. In order to provide remote-access to labs in various disciplines of science and engineering, the Ministry of Education, GoI, under the initiative National Mission on Education through ICT has come up with the Virtual Labs (https://www.vlab.co.in/). Interactive simulations help in attainment of student's scientific literacy, which is an indicator of inquiry behaviour.

All these interactive technologies allow us to create an immersive experience for users to better understand and visualise certain concepts which are otherwise difficult to visualise or experience.

Conclusion

Although it has been established by several studies that nothing can actually replace the real hands-on experiences in learning of science but it is also true that in depth understanding of many of the scientific concepts is not possible without the intervention of ICT tools, such as, the interaction at microscopic levels, or abstract concepts like intermolecular bonds, atomic structures, etc. Due to the recent advancement in the field of hardware and software technologies it has become possible to integrate different ICT tools in teaching and learning of Science for making the concepts of science more understandable, more easy and more enjoyable.

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