The Role of ICT in Science Education

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Abstract

ICT is helping to bring in a change in the way schools teach and assess students. The use of ICT is especially making inroads in the possibilities of how science is taught; going from rote-learning to developing higher order thinking skills like building scientific temper and critical thinking. To enable this journey, ICT makes available two types of interventions; content-based applications with rich multi media effects that explain concepts and software applications which help in data collection, documenting – thus helping children build knowledge actively rather than watch a readymade multimedia passively. Experts of education prefer the latter because in these applications lie the potential to reshape pedagogy, not just support it. The use of ICT in science education by itself cannot bring about change unless, we as educators consciously plan on how and where to use it within the teaching - learning processes in the classroom. The use of ICT in science can also holds the promise to bring in more constructivist learning experiences.

Key Words: ICT in Science, constructivism, science pedagogy, ICT pedagogy, re-shaping pedagogy, changing schools.

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There is a popular story that educators narrate to express the state of education. It goes like this. Those of us born in the 60s, have witnessed a great deal of development around us. We are surrounded by change. There are more cars on the street, homes have modern amenities like water heaters, mixer-blenders and perhaps even microwave ovens. Banks have ATM machines, hospitals have X-Ray machines & body scanners. Our modes of communication have changed dramatically. And the list goes on. But, what about schools? They still look the same as they did in the 60s. A class full of children, a teacher using mainly lecture-based methods and the good old chalk and duster. It is as though change has not touched schools all this time.

Fortunately, this story of an unchanging school is fast becoming untrue. And we have Information and Communication Technologies (ICT) to thank for that. The last decade has witnessed a host of Government-led and private initiatives which strive to bring ICT to schools. And while there is a long road ahead to be covered in terms of ensuring a complete bridging of the digital divide, it is safe to say that we are already witnessing a change in the way schools look and function.

This article introduces and describes

two ideas. First, it describes the various ICT-led interventions and their use specifically for Science education. Next, it suggests how these interventions may be integrated into a science classroom as is recommended in the NCF 2005 document.

Learning science is about developing a scientific temper. Learning science is about being curious, being a keen observer of patterns and being the owner of a mind-set asking questions relentlessly. It is the ability to move from casual observations to the next level of systematic enquiry which involves the recording of observations, hypothesizing, constructing experiments and proposing theories or models that support the hypothesis. The aim of science education is thus to inculcate a spirit of enquiry. This approach to science education is also reflected in the NCF 2005 Position Paper on Teaching on Science. The paper states that science education should nurture children's natural curiosity and creativity & aid cognitive development. The paper goes on to add that science education must lead to the cultivation of objectivity, critical thinking and freedom from fear and prejudice. And hence a good pedagogy must essentially be a judicious mix of approaches, with the inquiry approach being one of them (NCERT, 2005).

ICT is a collective term that refers to a wide range of tools that includes hardware, software and Internet based applications. The way it can be used in education is limited only by our imagination. Technological advances ranging from stand-alone desktop applications to Internet enabled mobile technology has given us many different types of interventions that can be used creatively to support educational practices. Given below is a description of some the popular ICT interventions, classified on the basis of their function and how they help while learning.

As such it is beyond the scope of this paper to list all the possible applications of ICT in science education. Hence this paper emphasizes two broad categories of ICT that can be used in science education; Type A–ICT based multimedia learning content that serves as a vehicle for the development of scientific reasoning and Type B – Software applications that support practical work as a vehicle for scientific investigations (McFarlane & Sakellariou, 2010).

a) ICT-based multimedia learning content: This type of ICT intervention is where students interact with content specially created for learning. ICT based learning content is a direct form of ICT in education.

This type of ICT intervention is where learning content, designed by experts, is presented in various forms as described below:

- Text with graphics -Text with graphics followed by interaction in the form of quizzes.
- Animation - Animation is where a complex process like cell division or respiration can be shown in detail, at a pace that the student prefers. The animation is usually accompanied by a voice over that also explains each aspect of cell division in detail. Students may be asked to answer a few questions

about cell division after the animation, to check their knowledge.

- Simulations - In simulations, students can manipulate certain variables and observe the results. For example, students can increase or decrease the 'wetness' of a road and see the resulting change in speed of a car that travels on it to study the concept of friction.
- Games - Games are a type of simulation, where students can learn specific skills. For example a computer-based card game that makes it fun to learn about the valence of various elements while trying to form molecules and compounds.
- Computer-based laboratories

Virtual labs try to give students a virtual laboratory set up experience. These labs are similar to simulations, except that are often visually rich and try to give a feel of a real lab. For example, students may 'pick up' different types of lenses from a 'box' to study the refraction of light. Another example could be where they could 'select' different compounds from a 'shelf' full of compounds and apply different variables of heat and pressure to see how the compounds are affected.

Science education content offered in these formats is not just educative, it can also be engaging. The flip side however is that while this type of content brings alive scientific concepts, it is simply a visually rich & interactive form of existing knowledge. While there is no denying of their role in helping students understand scientific concepts, the role of ICT must be expanded to not just visualization of scientific concepts but also to foster higher order thinking skills. In his paper, 'The role of ICT in teaching science education in schools' Hannatu Abdullahi states the use of ICT is largely done to support, enhance and complement existing classroom practice rather than re-shaping subject contents, goals and pedagogy. (Abdullahi, 2014).

b) Software applications: This is a more indirect form of learning through the use of different software applications (that may be used for other work as well).

Practically most software applications, desktop or mobile-based, which enable us to accomplish our tasks in an efficient manner can be also be used effectively in our educational tasks. ICT applications that may be used for education are listed here.

- Spreadsheets - Spreadsheets allow us to organize data (usually numbers or text) in rows & columns. Once this data is stored in a spreadsheet, mathematical operations can be performed on it using different formulae available in the spreadsheet. This data can also be represented graphically. For example, you may use the spreadsheet to record subject wise scores of your students of each academic year and compare their progress over the years in a graphic form. Microsoft Excel is an example of a spreadsheet. Let's say your students are working on a project related to climate change where they are collecting data about maximum and minimum temperatures in their district over the last 10 years. A

spreadsheet can help them record this data systematically and represent it graphically.

- Search engines and browsers - Search engines provide a space for us to enter a 'search string' - like 'examples of ICT tools' whereas a browser is a software which allows us to see what is inside those pages. Students can search for information on various topics using software applications like Google and Firefox which are both search engines. An application like Duck Duck Go is only a search engine. For the climate change science project example given above, students are likely to find past information about temperature for their district. They can even find data about neighbouring districts for a comparison.
- Presentation software - This software allows us to display text and graphic information on slides. Students and teachers may use this software to share information in a systematic way, or to prepare a poster or a small book.
- Mind mapping software - Mindmaps are a powerful tool for education which students can use to meaningfully organize the concepts they have learned. Mind mapping software can be used by both teachers and students. Teachers can use mind maps to show how different scientific concepts are linked to one another. For example, a teacher may create a mind map to show how various concepts distributed across the Physics syllabus converge into core concepts of Physics. Not just this, when students make mind maps on their own, the retention and comprehension of these concepts is far greater.
- Modeling software - Modeling software allows us to create virtual 2D or 3D models of physical objects as well as of concepts. A classic example would be to be able to create and manipulate a model of the atom. For example, ISIS-Draw is a software that allows students to create molecular structures. Drawing these structures can help students in understanding aspects of molecular structure that is not otherwise possible to appreciate in regular learning.

There are other software applications equally important and useful; such as Email, Blogging, Wikis, Video sharing platforms; each of these can take up a specific role in learning - either by way of gaining new knowledge, viewing it in different forms or by sharing it.

Recent advances in technology have brought advanced forms of knowledge sharing and representation to our fingertips for example, Augmented and Virtual Reality. Augmented Reality or AR enhances reality by taking you closer to it. For example, there are specifically designed AR apps on a mobile phone, which when you point at a plant, you can see a simulated (artificial, not the actual) process of photosynthesis taking place. Virtual Reality or VR on the other hand takes you away from reality. For example you may able to witness a chemical reaction at the level of orbitals where particles of an atom get exchanged during the formation of

an electrovalent bond.

The ICT interventions discussed above hold the potential to bring new life to science education. If we want to use ICT for the development of the desired science educational outcomes, we need to find ways to place the ICT interventions listed above into a classroom.

ICT by itself cannot bring about change unless, we as educators, consciously plan on how and where to use it within the school's learning environment and the teaching - learning process in the classroom. This calls for a seamless integration of ICT in within the existing learning environment.

One of the ways to consider ICT in classrooms is by aligning it with the teaching-learning process. While teaching science, or any other subject, a teacher might be doing any one of the following; introducing a topic, providing deeper explanation of that topic and assessing students' knowledge in the form of a quiz or a test. She may carry out additional activities, like projects, to reinforce what they already know, or to enable them to learn advanced concepts. Other such activities in the classroom may include refreshing a prior lesson, providing new information and so on.

The tools and applications described above may be used creatively in conjunction with the process of teaching described above. For example, a video or an animation may be an appropriate tool to introduce a new topic or to refresh an earlier topic. A spreadsheet may serve as a simulation to show how mass is directly proportional to potential energy. Similarly, a presentation software can be used to share information having text and graphics in a step-by-step manner. Effectively, each tool can be leveraged to bring out its inherent strength and limitation. The idea is to use each tool judiciously; in a way that it is effective and simple, both for the teacher and the students.

Imagine a classroom where high school students are learning about sound waves. The classroom has a large number of students, a teacher, the usual chalkboard or whiteboard, textbooks, notebooks, pencils and wall charts. The class may even have an access to a well-stocked library. The teacher is explaining waves, & eliciting different examples from students and provides some of her own. She may also occasionally use a few selected diagrams from a reference book or display charts. Students may also access a laboratory and use tuning forks to perform experiments in science.

In which parts of a learning environment and the teaching - learning process above should ICT interventions be placed in?

While it is relatively easy to imagine how ICT-based multimedia content (Type A) can fit into a classroom, in some cases it may be difficult, as well as expensive to acquire. Fortunately though, the last few years have seen a surge in the availability of OER or Open Educational Resources which are based on the science curriculum here in India. The OER initiative for schools developed with the collaboration of Homi Bhabha Centre for Science Education (HBCSE), Tata Institute of Fundamental Research

(TIFR) and Maharashtra Knowledge Corporation (MKCL) is a case in point (MHRD, 2013). Software applications (Type B) on the other hand, can be relatively easier to obtain and use. Most of the type B software applications can be acquired easily as they are available free of cost for educational purposes and also offer freedom from privacy concerns. The word Free here refers to not just free of cost, but software where your data and personal details also remain secure. To learn more about 'free' software, read about the FOSS movement.

Here is an example of how some of the type B applications may be used in a science classroom.

Imagine the physics classroom described above, except that this one is ICT enabled, mainly using type b software applications. This classroom has the potential to look and function in a very different way.

The teacher may now conduct her classroom as a flipped classroom where instead of teaching a chapter from the textbook, she might have students pre-read definitions and explanations of sound waves from the Web using a browser. She may begin the class with a question based on what students have read. She may then proceed to show them a simulation of a sound wave where she might ask students to observe the behaviour of waves in a different medium. Using the simulation as a base she can trigger discussions about where they may have observed sound behave differently in real life applications. She can search for and show simulations of how sound waves are involved in the functioning of a stethoscope or a mic. She may direct their attention to questions about waves, providing guidance & feedback to their responses. She may also have students record their voices or clapping sounds and observe the waveform of each through an audio recording software like, Audacity. Students may manipulate the wave to create modifications of their own voices.

The activities above are likely to generate a different level of engagement and learning about sound waves compared to the classroom described earlier. So much of this transformation in a classroom is possible due to the ICT tools that are now easily available to teachers. Incorporating ICT in the classroom also has the potential to lay the foundation of a learning environment that is far more constructivist than one without.

In the example of the ICT enabled classroom above, it can be seen that students are not just receiving and storing information. They develop deep understanding of sound as a wave, experience it, think about it and visualize it (using a software like, Audacity). Above all students are likely to feel highly engaged and excited with the knowledge the concept learned in the classroom is not tied to the textbook - that it is in fact all around them. They are more likely to experiment about it in their own way and discover a few more principles related to Sound on their own. This is the way in which ICT tools, when used and placed meaningfully in a classroom, can change the learning characteristics of the classroom. As an additional example, let's say

students may be asked to work on a project where they can collect different types of flowering and non-flowering plants from their surroundings and create a Wiki page for the same. Similarly, they may also catalogue the different types of illnesses children in primary section of their school and co-relate illnesses these with concepts in biology. They may use spreadsheets like Google spreadsheet or MS-Excel to record their data and presentation software like, LibreOffice presentation or MS-PowerPoint to share their findings.

This article begins with a story of a 'school, unchanged and untouched' by time and technological advances. ICT in education has brought in the potential to change the way schools look and function. There is a need to utilize this potential fully. On our part, we as educators need to shift our ideas about pedagogy rooted in many years of conditioning. We need to move toward learning by doing, creating and thinking rather than by just listening. And ICT in education makes that shift possible.

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