PEDAGOGICAL USE OF ICT IN SCIENCE EDUCATION: THE CONSTRUCTIVIST PERSPECTIVE

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Abstract

We are in the period of new progress and thus concerned for creating innovative approaches to teaching, particularly science subjects. Modern developments of innovative technologies have provided new possibilities to teaching profession; but at the same time have placed more demands on teachers to learn how to use these new technologies in their teaching. It is not necessarily the technology that has to be innovative in instructional process, rather the approach to teaching and learning using the technologies. Constructivism is increasingly becoming a leading idea and promising approach to using technology in teaching and learning of science subjects. Its pedagogical principles reflect appropriately how learners acquire and construct knowledge and skills in the field of science education, as well as using technology in learning. Thus, to derive the best of the potentials in ICT, science teachers should be reoriented to incorporate ICT in their Professional tasks.

Introduction

Information and Communication Technology (ICT) is not a panacea for all educational problems, despite that today's technologies are essential tools for instructional process. Organization for Economic Cooperation and Development (OECD, 2001) noted that the potential for technology-supported teaching and learning has developed rapidly and dramatically with advances in ICT. ICT can increase the richness and breadth of learning. It can support the development of higher order thinking skills including analysis and synthesis. A variety of ICTs can facilitate not only the delivery of instruction, but also learning process itself.

Combining new technologies with effective pedagogy has become a daunting task for educators. Modern development of innovative technologies and the concurrent paradigm shift from traditional rationalistic paradigm to constructivist paradigm have provided new possibilities for teaching/learning. Researchers and educators are becoming progressively aware of the notion that learning is an intensely individualized skill and that a constructivist approach emphasizes the process of learning rather than the submission of a product (Osborn and Plunkett, 2003). As Lee, Teo, Chai, Choy, Tan, and Seah (2007) may put it ;the shift from teacher-centered didactic pedagogy to student-centered constructivist pedagogy has redefined the meaning of learning. This ideological paradigm shift, as Forsyth (1996) points out, has been matched by a rise in the use of computers and the internet as teaching devices and in fact, the one upholds and allows the facilitation of the other. "This shift means that the process of education which could be described as teacher-telling is changed to process of teacher facilitating access to information for learner, who is expected to take control of their learning" (Forsyth, 1996:16) Elucidating further, he opined that the image of the platonic teacher who is the sole possessor of knowledge is broken down, not only by liberal humanist theory but also by access to vast store of conflicting and in-exhaustive information that is in the internet. Many researchers have asserted that this shift should focus on knowledge construction which will enhance, not replace the traditional information transfer paradigm (Warschaver, 2003; Etheris and Tan, 2004).

Information Communication Technology (ICT)

Ali (2004:1) defined ICT as the "physical structure of network of computer – based systems for the purpose of organizing, processing, communicating, accessing, presenting, storing, retrieving and simplifying information, when needed and in the form it is needed". Onyebuchi (2005:319) explained that ICT refers to "any equipment or inter – connected system or subsystem of equipment that is used in management, movement, control, display, switching, interchanging, transmission or reception of data or information processing and electronics communications to be handle by ICT experts, who are equipped with capabilities that will maximally utilize ICT in science education. In this paper, ICT is taken to mean all contemporary digital tools as computer systems, telecommunication systems and multimedia, networked and standalone plus hardware and software, which can be used in science education, in order to facilitate the achievement of its goals.

Science Education

Science may be regarded as a vast body of knowledge concerned with understanding and appreciation of the principles of nature, the universe and all that are contained therein. It deals with humans' understanding of real world, inherent properties of space, matter, energy and all activities involving man. Otubelu (2003) defined science as trained and organized common sense, organized knowledge and knowledge arranged in an orderly manner especially knowledge obtained by observation and testing of facts. Science education equips the individuals with the capabilities to understand and interact with things around him. It raises curiosity, inquisitiveness and rational mind about the environment. Its instructional strategy emphasizes investigation and inquiry and encourages active participation of the learner.

Constructivism

Constructivism is a learning theory or educational philosophy, which started dominating the concern of many educators in the 1990s. Formalization of this theory is generally attributed to Jean Piaget, who articulated the mechanisms by which knowledge is internalized by learners. According to Piaget, through the process of what he called accommodation and assimilation, individuals construct new knowledge from their experiences. When learners encounter new ideas they have to reconcile it with their previous ideas and experiences, may be by changing their beliefs or discarding the new information as irrelevant. The common core of constructivism is that knowledge is not found but constructed (Boghossian, 2006). This implies that people learn by engaging in activities, the consequences of those activities and through reflection.

Constructivism taps and triggers the student's innate curiosity about the world and how things work. Students become engaged by applying their existing knowledge and real world experience, learning to hypothesize, testing their theories and ultimately drawing conclusion from their findings. This means there is no such thing as knowledge out there independent of the knower. Learning is not understanding the "true" nature of things, nor is it remembering dimly perceived perfect ideas, but a personal and social construction of meaning out of the bewildering array of sensations which have no order or structure besides the explanations which we fabricate for them (Hein, 1991).

Knowledge is built in a process where new observations/insights are connected into a mental framework, causing a reorganization and harmonization of different perspectives, which leads to making judgments and inferences. To facilitate these processes, there is need to put things together in a way that make sense of them via (maybe);

- ➢ prompting students to formulate their own questions (inquiry)
- ➢ allowing multiple interpretations and expressions of learning (multiple intelligence)
- ➢ Encouraging group work and the use of peer as resources (collaboration and cooperative learning)

Constructivist Principles of Learning

From the review of literature, the following principles of learning from the theories of constructivism were coin out.

1) knowledge is actively constructed by the experiential world and not by the discovery of ontological reality (McCombs, 2001; Scardamalia and Bereiter, 2006)
2) students are not blank slates upon which knowledge is etched; they possess previous knowledge which acts as raw materials for building the new meaning
3) learning results from thinking and rethinking (i.e. reflection) upon our actions (full participation)
4) each learner is unique, complex and multidimensional, determined by his/her background and culture
5) the responsibility of learning resides increasingly with the learner; they are encouraged to set their learning goals and monitor the learning progress (self monitoring) (Glasgow, 1997; Hannafin, Hill and Land, 1997).
6) sustaining motivation to learn resides on learner's confidence in his/her potential to learn which is

dependent upon previous success and experience.

7) the educator is not a teacher rather an active facilitators, moderator and a coach (Brown, 2003)

8) knowledge is built and shaped in a process of dynamic interaction among task, instructor, learners and community of learners, i.e. meaningful collaboration and cooperative learning (Lim and Chan 2007; Jonassen 1996)

9) people learn to learn as they learn; that is to say each constructed meaning provide opportunity to give meaning to other sensations which can fit a similar pattern

10) multiple forms of scaffolding is necessary to assist learners engage in learner-centered learning activities (Roehler and Cantlon, 1997)

11) engaging in authentic task – real world application and not on skills and esoteric concepts that have little practical use in everyday life (Brown 2003)

12) technology to support deep thinking (Lee et al, 2007)

Constructivism: Pedagogy for Integrating ICT into Science Education

In the case of integrating ICT in the pedagogies of science education, there is need to understand how teaching and learning change as specific technologies are used This is what Koehler and Mishra, 2008 called Technological Pedagogical Knowledge. It implies knowledge of pedagogical capabilities and limitations of the set of technological tools used for particular learning contexts of a specific discipline. One of the main goals of technological pedagogical knowledge is to develop creative flexibility based on available tools to redefine, redirect their technical purposes towards education – specific purpose.

Constructivism is increasingly becoming a leading idea and a promising approach to using technology in teaching and learning of science education in particular. Constructivism is compatible with main lines of using ICT in education. As a philosophical orientation, it transcends the limitations of Platonic view of education and provides adequate epistemological foundation for the use of technology in teaching/learning process. The constructivist perspective offers a potentially powerful way to rethink the didactics of science education. We may agree that the constructivist theory appears to reflect appropriately how learners acquire and construct knowledge and skills in the field of science education. As portrayed by Albert Einstein quoted in Drossos et al (2006), "in natural science courses, the first lesson should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds". This is a clear indication that science education demands active participation of the learner in a problem – solving enquiry-based learning activities, as well as, the use of suitable instructional materials (technologies). The didactics of science education is characterized with the principles of learning derived from constructivism. In a core science classroom, usually students are encouraged to use active techniques (experiments, real- world problem solving) to create more knowledge and then reflect on and talk about what they are doing and how their understanding is changing.

The Teacher's Role in Integrating ICT in a Constructivist Classroom

McLoughin and Oliver (1999) define pedagogical roles for teachers in a technology supported classroom as including setting joint task, rotating roles, promoting student self-management, supporting meta-cognition, fostering multiple perspective and scaffolding learning. The assumption here is ICT is changing the role of the teacher, and a compelling rationale for using ICT in schools is its potentials to act as a catalyst in transforming the teaching and learning process (HawKridge, 1990). In this sense, the shift in educational focus from a pedagogy that onuses the role of the school and teacher as shaping a future worker to one that sees it as shaping a future human mind has slowly infiltrated the mainstream public consciousness and has caused a paradigmatic shift in the way classrooms are actually organize and students taught.

From this point of view, the task of the educator is not to dispense knowledge but provide students with opportunities and incentives to build it up (VonGlaserfeld, 2005). For instance, in the study of elasticity in physics, students may be guided to perform experiment to demonstrate Hooke's law. As they perform the experiment, they collect and analyze data base on their observations, they compare their results with those of their colleagues and draw inference. The teacher makes sure she understands the students' pre – existing conceptions (say the extension of rubber or spring on application of load) and guides the activity to address them and then build on them. Constructivist teachers encourage students to constantly assess how the activity is helping them gain understanding; by questioning themselves and their strategies thereby becoming expert learners. This gives them ever broadening tools to keep learning.

Constructivism and ICT: Implications for Science Education

Science education is known for its inherent inquisitiveness and curiosity to discover the world around. It could be said that all children start out as scientists, full of curiosity and questions about the world. Consider a little kid who explores his environment, gathers all sorts of materials and constructs an object (e.g. car, houses etc), sometimes with the aid of his friends. Usually the successful construction of the first object forms a big source of motivation for subsequent progress. Thus self – discovered and self – appropriated learning significantly influence behavior. Engaging students in expensive learning allows them to take advantage of unplanned events to deepen and broaden the educational goal. In expansive learning, the broad outcome of class is generally enhanced with the unexpected. When something goes wrong, the students need to discover why and the process of learning becomes more active.

Constructivism advocates for a well-structured learning environment, whereby the constructivist educator ensures that the prior learning experiences are appropriated and related to the concept being taught. Teacher may learn to implement different constructivist instructional strategies such as cooperative learning (Jacobs, Power & Loh, 2002), problem – base inquiry learning (Savory and Duffy 1995), or knowledge building (Scardamalia and Bereiter, 2003) without understanding the theoretical considerations. The learner needs to be in thinking about learning (Not on the subject to be taught). In this case, the learner must be provided with the opportunity to interact with sensory data and to construct their own world. Again, there is no knowledge independent of the meaning attributed to experience (constructed) by the learner or community of learners.

If the facilitation of learning is focused on how, why and when the student learns and how learning seems and feels from inside, it might be on a much more profitable track. This means that platonic views need to be abandoned and all subsequent realistic views of epistemology will be adopted.

Potentials of ICT in a Constructivist Classroom

Tailoring instruction to the needs of individual students, though effective, yet remains an instructional imperative. It requires very low teacher to student ratio. Technology – based instruction can make this imperative affordable and feasible because of its intense interactivity and individualization. Practical application of constructivist pedagogical strategies demands appropriate utilization of technologies. Ruthven and Hennessy (2005:85) illustrated this when they noted that technologies serve as lever through which teachers seek to make established practice more effective, technology appears also to act as a fulcrum for degree or reorientation of practice and a measured development of teachers' pedagogical thinking".

Computer supported experiential learning means use of visual content in order to enhance the learning experience of students and supplement the method that are already in use (Schwier 2004). Conell (1998), Dreyfus and Halevi (1991) showed that the use of computer programs to produce an open learning environment allowed students to explore within a framework and given that the teacher was working as a guide even weak students were able to deal in depth with difficult topic.

Empirical evidences have shown that simulation, modeling and animation can be used to support and enhance learning in science education (Baxter and Preece,2000; Tao and Gunstone, 1999; Huppert et al, 1998; Mellar et al 1994). Most studies found that simulations, which encourage collaboration using computers fosters conceptual change. The program provides the students with many opportunities to co-construct knowledge. During this process, students complement and build on each other's ideas and incrementally reached share understanding. Another type of subject specific software used frequently are those providing animations of process that permit students to visualize and investigate phenomena that cannot easily be observed e.g. the spatial and temporal (dynamic) properties of molecules and how they fit together. ICT allows materials to be presented in multiple media for multichannel learning. Thereby changing the way knowledge is reviewed and more importantly enable us to work in different ways. It also changes these ways proactively altering the models whereby the student alters, discriminates and selects information.

Michel et al (1999) suggest that allowing students to make video clips can develop their powers of observation and open new perspectives for their understanding of scientific concepts. This is because students need to think about exactly what should be recorded in order to explain a concept. This type of enquiry-base learning involves students in deciding which problems to investigate, searching for alternative solutions collecting and tabulating data, reporting conclusions and suggesting new related problems for further investigation. The technology also gives teacher the flexibility to demonstrate scientific concepts through a method other than a live demonstration.

Further, Laurillard (1990:67) states that the freeing of students from the hierarchical system of classroom governance allows them to not only learn in a way that is commensurate with their preferred speed and style, but also allows them "control over the manipulation of the subject matter". Students are likely to be better than teachers at directing their learning. Therefore we should be harnessing the power of computer.

Conclusion

There is a growing awareness that learner are motivated when learning activities are authentic, challenging multidisciplinary and multi-sensorial. Emphasis is shifting from teacher-centered curriculum (teacher telling) to student centered curriculum (knowledge construction). Learners construct knowledge by interacting with simulations and cooperate/collaborate with other learners, exchanging opinions and facilitating collective activities. It implies dwelling in information, relating it to past experience and/or building new knowledge e.g. creating and improving ideas. Active collaboration among human peers is supported by using different kinds of collaborative technologies and especially enhanced presence. The best environment for supporting this model is a community where learners share knowledge and debate

Any successful transformation in educational practice, requires the development of positive user attitude. Filling the schools with relevant ICTs neither improve instruction nor create more effective learning environment. Getting educated solely depends on the individual teacher's role to set conditions and generate environments for learning. The benefits of ICT in science education could only be achieved when teachers that are still key to learning have developed positive attitude and competencies for instructional use of ICT.

Recommendations

1. Science teachers must receive ongoing training; technology use must be matched to curriculum's philosophy and theory of learning and adequate number/forms of ICT must be conveniently located within the classrooms.
2. The school science curriculum should be reviewed putting on the constructivist lenses to meet up with the demands and aspirations of the society. The content should be relevant to students' knowledge and experience.
3. The Federal, State, Local governments and all the stakeholders in education should complementarily fund schools in the purchase of ICT facilities.

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