TEACHING And LEARNING Of TECHNICAL SUBJECTS In An ODL ENVIRONMENT

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Abstract:

This paper discusses the research focus of teaching and learning of science and technical courses, namely the pedagogical approach which is much centred around the constructivism theory; the mode of teaching which in recent years is centred around visualisation; and finally the role of ICT, mainly related to multimedia learning. Discussion is mainly geared towards highlighting key ideas that has been in studied throughout the years with the aim to improve the interest and performance of students in science and technical courses which seem to have declined in recent years. A list of research questions grouped under three different aspects involving students, content, and delivery of content is presented to map future research and development in science and technical education.

INTRODUCTION

Teaching and learning of science and technical subjects worldwide is facing a serious problem due to continuous decline in students' prior knowledge. A large number of students fail to demonstrate expected fundamental understanding or skills that are needed. Often their prior knowledge is flawed or refractory (Mathewson, 1999).

In a small classroom, such problems can be easily identified by a teacher. In an Open and Distance (ODL) mode (where there are very little or absolutely no contact) the situation is different. Continuous assessment is used to detect such problems at an early stage. However, it must be carefully structured to detect flawed prior knowledge else it can be effectively camouflaged through rote memory. Nevertheless, prevention is better than cure. As such efforts to resolve the problem at the root cause must be taken.

An effective solution to the aforementioned problem are teaching and learning strategies that are based on constructivism theories. These have been promoted in teaching and learning of science and technical courses especially in ODL environments. Research shows that active learning strategy incorporated in self-instruction material in almost all ODL institutions encourages learners to think and construct knowledge as they read at their own pace. This results in an effective and meaningful learning.

In addition to the pedagogical aspect, the delivery modes of content and learning strategies could also be selected based on effectiveness. This brings us to the growing realisation that visualisation is integral to teaching and learning of science as well as technical courses. The conveniences at which this mode of delivery can be realised is a result of the sudden growth of information and computer technology (ICT). This paper discusses all three aspects of teaching and learning of science and technical courses; and the mapping of future research and development strategies.

PEDAGOGICAL ASPECT

A prominent feature of the constructivism theory is a description of learning as a self-activating response to challenges, dissonance, or discrepancy rather than purely passive encoding experience (Mathewson, 1999). Constructivist theory (Bruner, 1966) is a learning approach where learners actively build new knowledge based on their current and previous experiences and knowledge. Learning takes into account experiences and contexts that motivate students' willingness to learn. According to Bruner 1996, learning should also include social and cultural aspects. Learning should engage learners in activities and realistic situations. Communication, interaction and sharing of knowledge with other learners is the expected outcome from this learning framework. This learning model emphasizes active learning compared to the traditional teacher-centred learning. Teaching methods should be used to involve learners and present challenges to learners.

A useful theory in developing teaching material using various resources is the Cognitive Flexibility Theory . It emphasizes repeated presentations of the same material in rearranged instruction sequences and from different conceptual perspectives, is most efficiently implemented in delivery systems with random access capability (Spiro and Jehng, 1990). Learning must not only be structured by a curriculum but also on the learning situations and authentic tasks. It should also involve interaction with the social environment of the learner.

The teacher should act as a facilitator, guiding, encouraging and supporting learners in their learning process. In the constructivist learning theory, the learner is guided through the process of learning to arrive at the required knowledge. Construction of new knowledge involves constant process of contextualisation and de-contextualisation of knowledge.

VISUALISATION

The role of visualisation as an effective method in teaching and learning of science and technical courses is evident through the various case studies conducted in the past (Edited by Gilbert, 2005; Khoo, 1998; Pea, 1993). Visualisation in the context of education refers to both the perception of an object or phenomena that is observed and the mental image which is the product of that perception. And perception is not independent of memory. As described by William James in 1984, "Part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes out of out mind," (as quoted by Mathewson, 1999).

Visualisation is believed to be a major strategy in all thought. The recognition of visualisation as a meta-cognitive skill is inevitable as deliberated by Gilbert. It is particularly important in science, which seeks causal explanations for phenomena in the world-as-experienced (Gilbert, 2005). In the Introduction to the Special Issue of the International Journal of Science Education (Ramadas, 2009), the seminal role of visual learning is recognised as a key which will open up new ways of looking at all aspects of science education including practical work, classroom discourse, concept understanding and assessment. This will also allow us to widen the spectrum from a predominantly verbal and textual mode to include visual and spatial mode.

The above pedagogical approach in teaching and learning of science suggest an individual to experience the various processing of arriving at a finding and construct their knowledge much like a scientist themselves. Scientists and engineers are characteristically visual-spatial thinkers and communicators (as cited by Mathewson, 1999 from Ferguson, 1977; Miller, 1987; West, 1991). As such it is equally important that students learning science become visual-spatial thinkers and communicators. This can be accomplished using teaching and learning exercises that are geared towards visualisation of entities, relationships, causes, and effects within a predetermined context of a phenomenon and onwards simplify and represent the phenomena with the aid of models (Gilbert, 2005). Creation of models in science requires creativity and imagination. The importance of imagination is also highlighted by Einstein whose famous quote is “Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand,”. Gerard Holton attributed scientific creativity to visual imagination, metaphoric imagination and thematic imagination (Mathewson, 1999).

The central question to our purpose is how visualisation-based cognitive skill can be developed effectively? Early visual-spatial learning can start with development of visual spatial self-awareness and meta-cognitive visual skills through direct experience with physiological visual processes such as focus, resolution, peripheral vision, colour and optical illusions (cited by Mathewson, 1999 from Gardner, 1982; Kelsey, 1997; Schaefer, 1995; Wandell, 1995). At tertiary education, mental models are used to capture a type of memory that instructors what students to build. However, defining the circumstances that may or may not lead to the construction of an accurate mental model is not simple especially if they are not trained from young to develop their visual-spatial skills. Yet, it is entirely reasonable to hypothesize mechanisms that may foster mental model construction (Rapp, 2005).

In using mental models in learning sciences and technical subjects, we could safely assume the presence of cognitive engagement since mental models are likely to be constructed when students are actively engaged. Engagement implies extended focus and thought on a topic. Students engaged in a task are likely more to stay involved with that task, and are more likely to learn during the task. The deeper we process information, the more likely we are to remember the information for later use. The term deeper versus shallow in this context refers to a continuum ranging from intensive processing (e.g., relating information to prior knowledge) to surface processing (Rapp, 2005). Such activity where students integrate new information with prior knowledge in memory is an example of the constructivism approach to learning. As such creating a learning environment where the use of mental models results in cognitive engagement will foster effective ways of learning science and technical subjects. Another essential learning environment which promotes the effectiveness of mental model in teaching and learning science and technical courses is the incorporation of interactivity. A lesson is interactive when students can directly impact the course of a lesson, by changing the pace or topic, or manipulating characteristics that personalize the material in meaningful ways. Such lessons tend to be dynamic. Interactive instructional technologies foster the likelihood that students will become actively involved in the given learning activity (Rapp, 2005).

The above learning environments necessary for the use of visualisation in teaching and learning of science and technical courses to be effective can be constructed with ease due to the advancement in ICT. This is elaborated in the next section.

ICT INFLUENCE

The use of computers to enhance learning began in late 60s (Atkinson, 1968; Suppes & Morningstar, 1968). The past decade, we have seen unprecedented advances in computing and communications technologies. Information and Communication Technology (ICT) enables the acquisition, recording, organization, retrieval, display, and dissemination of information in all forms (Eskicioglu A.M, & Kopec D., 2003). The digital era helps the old one-way communication technologies such as books, magazines, radio, and TV to be extended to new opportunities such as in multimedia. Multimedia is multiple forms of media that consists of text, graphics, images, animation, audio, video and interactivity. The complexity of multimedia in term of processing, storage, and transmission are increasingly used in a variety of applications ranging from entertainment to education. There are several key reports that analyse and show the contribution of ICT to education such as from National Science Foundation, President’s Committee on Advisors on Science and Technology, Project Kaleidoscope & Sigma Xi, and report by Bransford, Brown & Cocking (Eskicioglu A.M, & Kopec D., 2003). The Internet and the Web have also added a new dimension to teaching and learning. The paradigm shift from teaching to learning exploits hypermedia as an excellent way for self-paced and exploratory learning that based on the constructivist methodology than the behaviourist methodology. Personalized instruction, instant feedback, real world simulations, and most important of all, having fun while learning, is the key features of multimedia (McLean & Alem, 2009).

There are many case-studies on the use of multimedia in teaching sciences that fit-in with some of Mayer’s principles of preparing multimedia presentations. Mayer’s principles allow easy integration into the curriculum and instruction standards, saves time and allows for a more real world experience. In their empirical research, both Mayer and Sweller have used cognitive theory to study multimedia design considerations which would improve learning.

The emergence of multimedia educational technology has gotten various contradictory views and attitudes. Dastbaz & Kalafatis found that the recalling content was better with hypermedia students, while the understanding and competence level of students in the traditional lecture mode was superior to hypermedia students. Since learning involves all three – namely recall, understanding and competence – a mix of the lecture and hypermedia approaches should prove beneficial (Srinivasan & Crooks, 2005). The mix mode or blended mode of learning is one of the features implemented by open and distance learning institutions such the Open University Malaysia.

Srinivasan and Crooks (2005) quotes Wellington in mentioning certain pitfalls of using multimedia especially for a science learning environment. The first of the concerns is how realistic the simulations to be portrayed. Do they give the right impressions of science and what scientists do, or do they breed any misconceptions about scientific ideas, and about the nature of science? A number of scientific experiments can be done repeatedly without consuming a lot of cost and the problem with regular wear and tear of lab instruments. So, there is a big economic advantage for institutions. However, images have the power to mislead as well as to motivate or educate. The second concern is whether the use of multimedia in science teaching is displacing important hands-on experimentation. This is a fear expressed by many researchers including Iding et al (2002). However, there are benefits of using multimedia in science as this is a subject for which many students tend to have a phobia. With simulated experiments they will lose their fear of conducting experiments which could fail, repeat them a number of times until they feel confident, keep them more focused and most often than not are more interesting than the real experiments since they are more organized and clean (Samaras et al, 2006).

The above discussion is focused in the context teaching material for science and technical courses; and is not extensive as other important contribution of ICT to science education such as simulation and modelling. Future research should ideally lead to a comprehensive framework of principles at the micro-level of the effective multimedia learning systems. In line with these objectives current best practices followed by an outline of research and development in the area are discussed in the next sections.

BEST PRACTICES

Best practices of science teaching are often associated with student success. It is also commonly being promoted through ideology rather than findings of empirical research**.** In 2005, National Research Council has summarized four elements of the best practices in teaching and learning for science (www.phy.ilstu.edu, n.d.).

i) Engaging Resilient Preconceptions
Each student comes into the classroom with limited knowledge or idea related to their learning. It is imperative that the teacher knows student preconceptions be identified, confronted and resolved. The empirical evidence that supports their use is substantial.

ii) Organizing Knowledge around Core Concepts
Foundation of factual knowledge and conceptual understanding must be provided to the student.

iii) Supporting Meta cognition and Student Self-Regulation
In this element the teaching strategies are very important which will help students take control of their learning; and lastly

iv) Cooperative Learning
It is being suggested as the most suitable style of learning that allow students to learn together.

RESEARCH AND DEVELOPMENT

One of the three student's factor need to be considered for development is the psycho-emotion need which often require a teacher's intervention (Siti Hendon, 2007). Nevertheless, in the absence of an ideal one-to-one situation where a good teacher could teach according to the need and pace of an individual learner, an effective or a combination of effective learning material are necessary. This is especially true in an ODL institution and is evident from the focus of the educational research at these institutions.

Teaching and learning of science and technical courses have been so far focussed on various strategies revolving around constructivism, visualisation methods and ICT platform. There is a continuous need however to analyse these factors and outline the scope of research and development in this area as it is subjected to dynamic influences from various aspects from ICT advancement to globalisation. There have been impressive advances in scientific visualisation, with respect to the development of new devices, systems and software capabilities. However, this focus is problematic in that it neglects both the student and scientific content in the visualisation design (Rapp, 2005).

First aspect of research concerns the students. The identification of a student's learning style and interest in science and technical courses is important. Such information is crucial in developing essential skills that could improve student's comprehension of science and technical subjects. Another important factor that should also be studied is the extend of flawed prior knowledge.

Another aspect of research concerns cognitive goal of science education which is to ensure that students understand basic concepts and ideas found in the content of a given discipline (Siti Hendon, 2007). Should science education emulate the nature and practices of science?

The third aspect of research in science education is most critical and concerns delivery regardless of its form. The following research questions are some of the few important question that can be deliberated.

- What are the conditions for visualisation method (or for other methods) to reinforce learning?
- Should an integrated approach addressing the needs of students (visual/auditory/tactile) be considered?
- How much of the content delivered should be prescribed, learning by example and hands-on learning?
- How could assessment be designed to ensure that intensive processing has taken place rather than surface processing?

At Open University Malaysia, apart from the blended learning mode which encourages cooperative learning, active measures have been undertaken to increase the variation of delivery. The new options incorporate the use of ICT and Instructional Technology to support student's meta-cognitive skills and self-regulation. The research initiated at the Faculty of Science and Technology is in line with the university's mission to provide a conducive and engaging learning environment by leveraging on technology. This science education research is to be carried-out in three phases as described in the above section.

SUMMARY

The way forward for learning and teaching of science and technical based subjects in the 21st century and more specifically in the ODL mode is by incorporating various learning theories and strategies, also known blended-learning mode. This approach benefits largely from the use of ICT platform. Learning is a process and knowledge is developed through involvement in authentic learning settings where the technical framework is the enabler for pedagogical content knowledge to be transferred to the learner. Therefore the challenge for educators and designers is how best to explore and integrate strategies for effective learning to take place.

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