Mixed and Added Realities: Development and Use of Web-Based Learning Module for Technology and Natural Science Educators

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Teachers and lecturers continue to grapple with the best ways to teach and learn Science and Technology using current information and communication technologies (ICT). This paper presents an introductory process of developing web-based module for technology teacher education students using Web-CT and animation tools for the effective teaching of electro-chemistry that has remained a problem to Natural Science educators in South Africa. Two research questions: how can a web-based learning module be developed to enhance technology education? And what necessary steps can be practically taken in the use of animation to enhance the work of Natural Science educators? were addressed. One main hypothesis: `the use of mixed and added realities involving the development of Web-based learning module and animation enhances the performance of technology and Natural Science educators` was tested. The design was a quasi experimental type of non-equivalent pre- and post-tests control groups and the mixed method with material development and teaching 58 learners. The main result showed that the approach of this study actually enhanced the performance of the educators and the learners in the experimental group. The study recommends the adoption of the results and increased number of subjects for possible replication elsewhere.

Introduction

Recent technological developments in information and communication technology are adding new dimensions to the strategies and instructional tools available for teaching learning. Computer technologies provide a rich learning environment that exposes the learner to a variety of representations and configurations, such as realistic models, graphics and simulations (Doppelt, 2005). The capability of computers has enabled the teaching of hands-on technology and science laboratory courses which should normally use tools, equipment and machines to be easier by computer-based virtual demonstrations. Such opportunities have reduced a range of problems for students in the areas of inadequate number of apparatus, equipment and tools, safety issues, inability to use some of the tools and equipment, and time constraints in completing hands-on projects (Borchert, 1999; Agyei-Mensah and Ndahi, 2006).

It is noteworthy to observe and agree with Owston (1997) that nothing ever captured the imagination and interest of educators simultaneously around the globe more than the World Wide Web (www). The web has become a special tool that causes teachers at all levels to re-think of the very nature of teaching, learning and schooling. Web is fast making waves in making learning more accessible through graphical screen layout, interactive multimedia learning materials, simplified access to and searching of databases, exponential growth of new resources around the world, and open technical standards that allow any modern computer to access the web (Owston, 1997).

To respond to the increased demands for technological literacy (Pearson and Young, 2002), by the use of ICT in teaching and learning has become imperative. Hence, schools and universities are gradually employing ICT in teaching, learning and assessment to cope with large classes and lack of laboratory resources. Students of the new generation are expected to display some valuable skills as critical thinking, problem-solving, written communication, and the ability to work collaboratively. This is to be able to face the challenges posed by the new global economy, where the knowledge and skills of a nation`s workers are the key to its competiveness among others, rather than factors such as natural resources and geographical location that reigned supreme in the past. Changing clientele, increased student numbers, and decreased staffing are situational barriers to quality teaching and learning.

The introduction of ICT is therefore seen as one way to overcome the barriers observed and to provide cost-effective facilitation of transformative learning where students can manage their learning in a flexible and individualized way. Indeed, the Web provides flexible learning. As a show of possibility, the Oregon State

University successfully offers Philosophy 201 entirely by on-line, using the Web and electronic mail (http://www.cs.orst.edu/department/instruction/phil201.S95/). This effort goes a long way to enhance student autonomy and intellectual community and to create a self-paced, expert-directed, time/place independent environment for learning (Owston, 1997). All readings required of the students are made available on the Web including debate issues raised during the course in electronic virtual conversations. The teacher and students interact via emails and broadcasts for necessary feedbacks. The level of success registered by Oregon State University is implied in their ability to use a mixed method approach not to remove themselves from the educational process. Their role became more of creating learning experiences for the students than just delivering of instructions to academic guides. Bates (2001) identifies the following advantages of using the Web in learning:

- its ability to combine text, and graphics;
- the Web enables free and global access to a very wide range of high quality (as well as low quality) learning resources located on the Web sites;
- the Web offers opportunities for international, cross-cultural and collaborative learning;
- the Web enables students to study at any time and, increasingly, from any place; and
- the Web allows asynchronous (time-delayed) interpersonal communication, not just between lecturer and student, but more importantly, between students and other students, through e-mail, bulletin boards and online discussion forums (Bates, 2001).

The nature of teaching changes with social-historical conditions, with information technology an emerging feature of teaching (Clift, Mullen, Levin, & Larson, 2001). Natural science teachers including Chemistry and Technology) must make much effort to create an ideal environment for teaching and learning. Including technological tools in the classroom will require teachers to employ different teaching techniques. In the recent times, studies on the effects of technological tools on learning and teaching have begun to make use of Dual coding theory and cognitive load theory (Pekdağ, 2010) and are both good pointers to need for the use of variety of teaching techniques with appropriate augmentations.

It is well known, even according outcomes based approaches that students should be engaged in active (Lunenberg and Volman, 1999), self-directed (Tillema, 2000), and self-regulated (Kremer-Hayon and Tillema, 1999) learning. In teacher education programmes, constructivist pedagogies promote the creation of knowledge (Gibbons et al., 1994; Holt-Reynolds, 2000). Reasoned dialogue rather than instructional dialogue mediates knowledge. The student-teachers need to transform knowledge rather than reproduce what the teacher says. There is minimal understanding, of what and how teachers integrate knowledge into frameworks that guide their practice (Schoenfeld, 1999). According to Beijaard et al (2000), teachers derive their competence from how they see themselves as experts in subject matter, pedagogy (how teachers engage with students), and didactics (how teachers plan, present, and assess lessons). Active and independent learning is being promoted within each of these factors identified as contributors to teacher education: subject matter that is transformed into teachable knowledge, pedagogy that aims to enhance students learning outcomes, and didactics that facilitate students' knowledge construction and use. Many countries have developed and implemented technology education, for example, in 1992 Botswana developed a national curriculum policy in which Design and Technology (Technology) became one of the eight core subjects (Molwane, 2002). In 1990, England introduced Design and Technology into schools (McCormick, 2002). The quality of technology education programmes is greatly determined by the successful students having acquired the skills, knowledge and values needed by society, more specifically the workforce (Frantz et al, 1996). Curriculum reform in technology education seeks to modify the traditional laboratory and workshop-based science and technical courses from the usual focus on industrial hand and machine skills to a more emphasis in critical and creative higher order thinking skills (Walmsley, 2003).

This definition, in common with international statements, stresses the importance of providing students with opportunities for participation in meaningful learning experiences in which they could draw upon their existing knowledge of materials, tools, machines, and systems, as well as gather and use information from a variety of sources. The meaningful learning experiences should facilitate the engagement of students in problem solving to produce an end process, product, or artifact, thus enabling their construction of new and deeper understandings of technology concepts and processes (Davis et al, 2002). The technology education learning outcomes and assessment standards reflect the attainment by students of range of problem solving skills, manipulative skills, and in particular, understanding technology concept knowledge (Department of Education, 2002). The following skills are essential to advance technological literacy now and in the future:

- Skills of analyzing and problem solving
- Skills of information-processing and computing

- An understanding of the role science and technology in society, together with development of scientific and technological skills
- An understanding of and concern for a balanced development of the global environment
- Communication and entrepreneurial skills
- A capacity to exercise judgment in matters of morality, ethics, and social justice (Martin, Dakers, Duvernet, Kipperman, Kumar, Siu, Thorsteinsson, & Welch, 2003)
- Designing and making skills (Pimley, 2004)

In the final analysis, the critical outcomes of natural science and technology aim at enabling the learners to:

- communicate effectively using visual, mathematical and language skills;
- identify and solve problems by using creative and critical thinking;
- organise and manage activities responsibly and effectively;
- work effectively with others in a team, group, organisation and community;
- collect, analyse, organise and critically evaluate information;
- use science as technology effectively and critically, showing responsibility towards the environment and the health of others; and
- understand that the world is a set of related systems.

The main focus or problem of this paper is to demonstrate the introductory process of developing web-based module for technology teacher education students using Web-CT and animation tools for the effective teaching of electro-chemistry that has remained a problem to Natural Science educators in South Africa. Two research questions were thus raised for the study as (1) how can a web-based learning module be developed to enhance technology education? (2) What necessary steps can be practically taken in the use of animation to enhance the work of Natural Science educators? The hypothesis stated was that `the use of mixed and added realities involving the development of Web-based learning module and animation enhances the performance of technology and Natural Science educators`. Animation is the rapid display of a sequence of images of 2-D or 3-D artwork or model positions in order to create an illusion of movement (http://en.wikipedia.org/wiki/Animation, 2011).

Methodology and Design

We made use of a quasi experimental non-equivalent post-test control groups design on two groups of pre-service natural science and technology students from two Universities in Pretoria, South Africa. This research design was chosen because it provides a platform to determine differential effects of phenomenal changes in any cause-effect study. A non-randomized sample of 58 made up of 31 (18 and 13) students in the experimental groups and 27 (17 and 10) students in the control groups was used. The student-participants, though most of whom were adults, volunteered to take part and none of them was constricted to be part of the study in view of ethical requirements. The method involved the demonstration of the process of developing a web-based module for technology education and animation tools. The researchers then applied these tools in teaching selected aspects of electro-chemistry to the sample students in the experimental groups while students in the control groups were taught without such mixed and added realities for six weeks. Data were collected with the use of well-structured questionnaire to be able to answer the research questions and post test scores of the students on electrochemistry (from AIEEE Chemistry Redox Reactions and Electrochemistry online Test 2011 at *http://www.wiziq.com/tests/chemistry-electrochemistry* and selected questions from different years at *http://apchemistrynmsi.wikispaces.com/.../Electrochemistry+FR+worksheet...*-) were analyzed to test the stated hypothesis.

Module Content and Context

The technology teacher education programme is a full contact qualification; however, the web-based learning is developed to offer the recipients an alternative and added innovative way of le,arning. The module content is presented on the Web, providing information on its Website. Students tackle learning activities at their own time and environment (library). The lecturer is fully aware that students have a limited access to computers, both at home and at the institution. The environment uses a problem-based approach to teach theoretical and practical task for using the Web to present, manage and facilitate resource-based learning (Cronje′, 2001).

Design of the Context

The design is based on a constructivist theory embedded in the learning activities. It is popularly known that learning is an active process of knowledge construction on the part of students. This has led to the popularity of constructivism as an instructional approach to learning (Reddy, Ankiewicz and de Swardt, 2005). In Web-based learning environments, learning occurs through navigating the learning content on the web. Lee and Baylor (2006) noted that students experience disorientation with these non-linear contexts. This type of orientation is often observed in learning, and can notably limit instructional effects (Collis, 1991). It is believed that metacognitive map can support students' orientation within the learning content (Lee and Baylor, 2006).

Web classroom

The Web-based classroom design should provide a more attractive and interactive environment for students to learn. Although the virtual environments cannot replicate contact-teaching, the designer should portray the objects and events of a typical classroom. The learning content and the learning activity should be reviewed every year to be up to date with latest developments in the field of study. Figure 1 shows the home page of a Web classroom with the following parts:

1. Buttons, which link to learning outcomes, learning activities, assessment criteria, presentations, internet, formative assessment, summary, assessment criteria. Clicking on them provide information similar to lists on notice boards or printed material.
2. Resources centre provides a place for downloading conventional lecture notes or viewing short video clips for better understanding of each topic. The section attracts attention, generates interest to learn, and facilitates students' understanding.

Students will be able to apply the theory learned to finish the assignments and tasks. To assess what students have learned from the content, there are automatically marked short quizzes. Students must answer correctly to certain high percentage before moving to the next unit.

Analysis, Findings and Discussions

To answer the first research question that says how can a web-based learning module be developed to enhance technology education? 49 (84.5 percent) of the 58 subjects affirmed that a proper way of developing any web-based learning module must be in categorized steps. According their responses, the steps are as follows:

- Determining appropriate topic taking into consideration the three key learning outcomes areas as *technological processes and skills; Technological Knowledge and Understanding; and Technology, Society and the Environment* in agreement with the South African policy (Department of Education, 2006).
- Determine Assessment standards, designs and plan for the topic.
- Generate and communicate at least 2 innovative design solute-ions that solve the problem, using appropriate communication techniques and make a choice of one of these through valid argument. Develop a list of materials, tools, equipment and sequence of manufacture they might use in making their product using simple presentation techniques.

The second research question: What necessary steps can be practically taken in the use of animation to enhance the work of Natural Science educators? was answered by 53 (91.4 percent) of the participants in the almost in the same manner.

- It was clear to them that a major step is being computer literate by both teachers and students. The teacher is expected to declare the objectives of any topic to be animated in such a manner that text and object animations are a compelling way to positively punctuate his/her message.
- The teacher is further expected to be able to fine-tune his/her animations by setting the duration, choosing which element is affected first, and defining the animation path along a straight line or a curve.
- Both teacher and students should be able to achieve some impressive animations with basic programs; an animation database is a database which stores fragments of animations which can be accessed, analyzed and queried to develop and assemble new animations thereby further creating knowledge.

The stated hypothesis was tested using mean score (x) and standard deviation values to determine differential effect in performance between the students taught with mixed and added realities in the experimental group and those taught the same topics in the control group in the conventional way.

Group	Number (N)	Mean Score (x)	Standard Deviation (SD)
Control	27	52.44	7.32
Experimental (Web-Based)	31	83.68	6.47
Sum (N)	58		

Table 1. Mean Scores (x) and Standard Deviations (SD) of Pre-Service Technology and Natural Science Educators` Performance Test (PSTNSEPT)

Table 1 above shows a total of 27 Pre-service Technology and Natural Science educators that were taught electrochemistry lessons not based on the use of Web-teaching and learning in the control group. Their mean score is 52.44 in the post performance test compared to the 31 educators in the experimental group with a mean score of 83.68 in the post test after being taught the same topics using the mixed and added realities (Web-based learning materials and animations). A considerable lower standard deviation of 6.47 for the experimental group compared to 7.32 of the control group proves that there is a great advantage in the use of carefully developed Web-based learning materials including animations to enhance the performance of the educators and learners in the experimental group.

Conclusion

This study aimed at the use of mixed and added realities through the development of learning modules and Web-based materials to enhance the tasks of technology and Natural Science educators especially in the teaching of electrochemistry. We believe from this study that no one method of instruction is the best, but that there are methods and strategies to be employed in the design of Web-based learning environments that help to bridge learners and reduce feelings of alienation (Dickey, 2004). In agreement with Dori, Barak and Adir (2003), we discovered that students strongly favoured the use of web-based activities in the study of technology and chemistry in general. According to the students, they gained wider experiences with higher knowledge retention as they kept on working as individuals and sometimes in groups at their own pace and time as they could repeat such activities as often they would want. This study found out increased interest in the students about the study of electrochemistry as they virtualised the activities of ions and molecules with slightest efforts. This proves why the experimental group performed significantly better than the control group in the post test and hence, Information Technology (IT) significantly enhanced the performance of the educators. We therefore recommend that the use of mixed and added realities in the form of animations, simulations, web-based learning modules should be given the right place in the teaching and learning process particularly for science and technology courses to help reduce the usual abstractness associated with such courses.

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