Integrated Approach for Enhanced Teaching and Learning towards Richer Problem Solving Experience

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Abstract
The utilisation of a game environment for problem solving as part of the concept of three-fold, theory-simulation-experiment laboratory, enriched with advanced mobile wireless technology components for information access, is the focus of the research reported in this paper. The resource design is being motivated by the goal of incorporating both advanced gaming and communications infrastructure to realise a novel multilevel educational experience. The paper illustrates how expertise in two key technology fields – gaming and telecommunications – is combined and integrated with discipline expertise and sound pedagogy for educational content generation, and by this means, how new pathways in the natural knowledge and experience-gaining process may be created. An important principle in the research has been to exploit play and variety of contemporary ICT support for e-Learning and problem solving facilitation, including digital games, wireless mobile technology and learning management systems such as Moodle or Sakai-Sulis. A second principle is to seek an extended access to these new e-Learning paradigms beyond the physical educational campus, through their incorporation into virtual campuses.

1. Introduction
One of the goals in education in present times is to provide an easier access and flexible learning opportunities through use of technology. Technology enhanced learning opens remarkable new avenues for learning and skills development. Learning technologies can be a vital tool to enrich what Higher Education Institutions (HEIs) do best - opening the world of new ideas and helping individuals to develop their learning, critical and creative thinking skills (Anderson, 1997). Countries and HEIs willing to take advantage of these new opportunities, must be proactive in launching meaningful reforms and innovations, and embrace changes. Technology should be used to nourish, transform and enrich the strong relationship between teacher and learner and to promote more active and student-centered learning. Today, people need to be provided with knowledge to be competent, and with incentives to be motivated in acquiring this knowledge.

One reason today’s educators “are not more successful at educating children and workforce, despite no lack of effort on their part, is because they are working hard to educate a new generation in old ways”, using tools that ceased to be effective” (Prensky, 2001). Thus, the immediate task in front of today’s educators is to develop methodologies that speak the language of this highly technological generation (the Net Gen), to “stop telling”, but to invent new teaching and learning ways in order to provide
education on some of the driest and boring subject matter imaginable. The latest explorations of multimedia potential interactivity (Aldrich et al., 1998), influenced by the constructivist philosophy of learning resulted in re-discovery of play as the most fundamental concept of human instruction. Centuries ago Plato, the Greek philosopher, stated that “…children should not be kept to their study by compulsion but by play”. To this, Abraham Maslow has added that “Almost all creativity involves purposeful play”. And what better “remedy” to the problem of boredom in the classroom than the use of e-learning through multimedia game technology with its potential interactivity, vivid images, 3-dimensional graphics, and audio! Using the play as the most fundamental concept of human instruction with today’s digital game technology, there are ample opportunities to build a unique and stimulating virtual reality in order to improve learners understanding on abstract concepts that otherwise are difficult to grasp. Learners can achieve this through immersion in compelling story lines where fantasy, curiosity, challenge and control, as intrinsic motivations for learning, are met (Castellan, 1993). However, what makes good instruction is not just the medium, it is the methods that guide the way the medium is used (Clark, 1995). Thus, for games to benefit educational practice and learning they need to combine fun elements with aspects of sound pedagogy, instructional and system design that include motivational and interactive learning components (Gagne et al., 1988).

Lately, a number of Virtual Environments (VEs) has been developed for educational purposes, which are particularly useful when the learning domain is complex, abstract in nature and difficult to master, and when the virtual features of the learning environment are critical to the success of the learning process. VEs should provide a close physical resemblance to the real world, immediate feedback, and strong sense of learner’s presence. Through use of story line in a particular game concept, analogies, metaphor, simulation, and avatars, learners may play an active role in creation of their own collaborative virtual environment, that can be even more educational, entertaining and "real" than the real world.

2. Designed by Students, Aimed for Students
Motivation is the most important aspect of the learning, since learning is not just finding and memorising facts - it should be fun! And what better opportunity for this, but to utilise the creativity of post-graduate students in the development of exciting educational tools to facilitate the learning process of their fellows, namely, undergraduate students! Two such projects for system modeling have been developed at CS&IT department of Durban University of Technology, South Africa (Zheleva, 2001). The main reason for modeling is to deal with systems that are too complex to understand directly. Models reduce complexity by separating a small number of important things to deal with at a time. Since models omit non-essential details, they are easier to manipulate in comparison to the original entity. And this is possible because abstraction is a fundamental human capability that permits us to deal with complexity (Shlaer and Mellor, 1988). Both project developments were successfully integrated into the Systems Analysis and Design module and achieved a dual goal: firstly, to educate postgraduate students in the use of interactive multimedia and authoring tools for educational development, and the underlying principles of Instructional Design, to guide and enable them through an apprenticeship to develop a good quality multimedia courseware on a complex engineering content; and secondly, to implement these developments (at no developmental cost to the department) in the
undergraduate modules as part of tutorial sessions, in order to stimulate learning and foster better understanding of the content.

A digital game, as part of a PhD study, has also been designed (Zheleva et al., 2002a, Zheleva et al., 2002b). It targeted the creation of a unique virtual environment and investigated the usefulness of digital games in the process of teaching and learning on a specific engineering domain for process integration and environment protection, and the usefulness of virtual learning spaces as educationally viable tools in general. The project attempted to demonstrate that by combining digital game technologies with a sound educational pedagogy and knowledge management, it is possible to build a unique and stimulating virtual reality that may improve learners understanding on abstract and complex engineering concepts, and motivate them act intelligently in challenging situations. The project demonstrated that by instilling best practice academics can introduce engaging, experience-centred, authentic and multi-sensorial learning activities for which the new multimedia game-based technologies provide ample opportunities.

Two other projects have been developed by final year BSc: Computer Systems students at CSIS department, University of Limerick, Ireland. They aimed at harnessing the power of modern technology to create and evaluate virtual learning spaces for environment protection as an appropriate educational tool to teach on complex and abstract engineering content. Based on modern educational and design principles, the projects targeted virtual learning environments from both educational and multimedia game technology perspectives. They resulted at development of an educational product to demonstrate the ability of educators to foster critical skills in learners and learners’ abilities of becoming resourceful industrial developers and process system engineers. The projects intended to nurture expertise and gain experience in advanced software development related to game and streaming technologies, and to create an environment for training under- and postgraduate students in the development and evaluation of interactive game learning environments as well as provision of future entrepreneurial opportunities for them.

The results of the evaluation of these projects and the recent developments in technologies showed huge potential of boosting students’ learning efficiency, and called for further extension of the discussed teaching and learning concept towards development of students abilities for active problem-solving and troubleshooting.

3. The New Concept (Work in Progress)

The work presented above attempted to provide an overview on some of the modern pedagogical theories and practices. From the many cited in the literature examples, including the discussed above, it is evident that interactive multimedia and game environments can be powerful educational tools, and today’s educators should embrace the changes in technology, and provide meaningful reforms and innovations in their teaching methods. One way ahead might be the use of combined conventional methods with technology integrated teaching and learning. As Chris Dede argues, HEIs should plan for “neo-millennial” learning styles that include “fluency in multiple media and simulation-based virtual settings”, and “induce learning based on collectively seeking, sieving, and synthesizing experiences, rather than individually locating and absorbing information from a single best source” (Dede, 2005). This type of active learning, based on both real and simulated experiences, begins with direct participation and then infuses guidance and frequent opportunities for reflection. Such an approach could enhance the
efficiency of knowledge transfer towards building problem solving abilities in engineering education and enrich the engineering students’ learning experience.

The new concept is based on integrating recent technological innovations and involving different cross-disciplinary cross-institutional expert groups, with a view to deepening students' educational experiences and broadening instructors’ capacity to guide and reinforce meaningful learning towards active problem solving. Its goal is the utilisation of advanced methodologies for teaching and learning based on the original concept of a Three-Fold Laboratory (theory-simulation-experiment), enriched with virtual environments and mobile wireless technology components (mobile wireless devices (MWDs)) for media convergence and information access improvement. This approach combines two key technology fields – digital gaming and telecommunications, to generate discipline specific educational content based on the expertise of senior educators in the field. An important feature of the proposed concept is first, simulation of real problem-solving scenarios, and then building new pathways to enhance the process of experience-gaining learning. Behind this resource development is the concept of integrating alternate reality games (ARG), which incorporate digital gaming and simulations, with robust mobile communication infrastructure for a novel multilevel educational experience. Through this approach, learners can gain knowledge by participating in immersive virtual environments and simulations, where they collaboratively identify problems, form and test hypotheses, and deduce evidence-based conclusions about underlying causes. They use location-aware handheld computers with GPS technology, allowing them to physically move through a real location while collecting place-dependent simulated field data, interviewing virtual characters or real persons, and collaboratively investigating simulated scenarios. Within the realm of an alternate reality game, digital games are used to deliver understanding about particular content area, and learners are provided with opportunities for reflection on and discussions about the content in spaces that are external to the game. Simulations are regarded as dynamic systems with which learners can test theories about how systems work and are affected by manipulating certain factors, and how certain principles of dynamic systems can be observed and played out. Such systems include their own internal assessment measures that can be used to assess students understanding of both micro and macro elements. The educational games used in the larger alternate reality game may be designed to take advantage of the spare time in student’s life – the time before or after classes, going to and from classes, etc. Thus, educators do not use class time to play the games, but utilise it to discuss the data coming from the games outside the class. Using wireless PDAs to play the game and GPS services to integrate real world experiences with the virtual experiences of the game, and sending data back to a central server from where the professor may access it, this approach embed students in realistic real world scenarios for which alternate reality games are most suited.

4.1 Some Design Aspects and Components

Before the start of classes, learners sign on each semester to a website where they can post information about their interests and set up learning teams with their peers. There, they find the narrative of a scenario with clues to follow in an alternate reality game. The scenarios with clues and puzzles are designed by a supervision team of educators. These clues may be anywhere – websites, libraries and databases, on/off campus real locations or in virtual worlds, they can be printed materials or recorded telephone messages, provided by real persons, or virtual characters in a digital game. Learners may find GPS coordinates as clues that send them to a real field sites (e.g. waste-water treatment or pharmaceutical plants), where interviewing lead engineers may provide
them with significant information to solve the problem on hand. Or, the clue may point to a digital game on the website where a virtual character is holding the knowledge needed to solve a puzzle. Learners can meet and talk about their strategies, may post their findings and experiences on blogs, and have discussions in online forums.

The developing team of educators has to pre-design a clue-based algorithm for the purpose of problem-solving navigation. The general structure of each problem-solving task is planned to be within the expertise of a particular lecturer from the supervision team of educators. The problem solving process should follow the deductive “what-if” algorithm cycles thus leading to a deeper knowledge acquisition. The guided process of discovery and overcoming obstacles would utilise various possible means of information gathering in the process of achieving final solutions, based on logical deduction and induction, and variety of knowledge-gaining methods. The process will allow for accommodation of uncertainties and non-standard solutions.

The on-line multidisciplinary supervision and hints generation is another specific component of the concept. A “controlling/supervising station” will play a role of guiding navigation hub, where real world support will be provided mainly through visualisation, introduction of a set of hints, and some limiting conditions generation.

The envisaged real-time projects/workshops will facilitate students' dynamics of decision making in finding correct solutions for the problems on hand, which in essence means a time constraint for the project delivery, decision making deadlines and corresponding rate/efficiency of solutions provided in accordance to specified requirements. In practical terms such projects are more often associated with real-life troubleshooting type of problem solving. Such an educational component could be achieved through short-term supervised tasks within a short delivery spans (a day).

The last specific side of the concept is the multidimensionality of resources and methodologies to be utilised/explored, and the agility of their applications. The teaching/learning components and resources will include basic college level retrospectives (bringing old knowledge back to work), past college experience, lecture notes of current courses, library resources, games for teaching and learning, multimedia courseware and simulations, and direct communication between team members.

The composition of the problem and the process of problem-solving assistance incorporate utilisation of an InfoStation-based multi-agent system for the provision of intelligent mobile services within the University campus area. This system will pay particular attention to the interactions of the various entities in providing the e-learning services to students and educators in the ‘best possible way’ through flexible adaptation to the mix of current user preferences, mobile device capabilities, and wireless access network constraints.

The design of the learning process in such environment is to support achievement of a ‘threshold-level knowledge’ and guided transition (invisibly supervised by the lecturer in charge) to the next higher level of problem understanding and subsequent hypothesis/solution generation and testing. These levels include information gathering, followed by analysis, problems identification and formulation, and natural approaches towards problem solving. This teaching/learning experience can have both real and virtual nature as a multidimensional game environment with integrated elements of advanced mobile wireless technology and GPS services. An important principle in the concept is to maintain and exploit better the modern ICT support for e-learning (e.g. teaching and learning management systems such as Moodle or Sakai-Sulis).
4. Conclusions
Ideas on learning technologies suitable for HEI under- and postgraduate programmes covering interactive multimedia and simulations, to virtual environments and digital games, to alternate reality games have been discussed. Addressed were evidences that such systems that incorporate **play** can be effective in providing inspiration and stimulation for learning and in fostering the desire to explore advanced knowledge in specialist fields at tertiary educational level. Captured in this research is the approach of using alternate reality game incorporating digital games, simulations, the virtual laboratory concept known as ‘theory-simulation-experiment’ and the integration of advanced mobile wireless technology, as an e-Learning technological support in the educational process. The attempt to integrate recent technological innovations suggested by different cross-disciplinary cross-institutional expert groups, with a view to reinvent play in a gaming environment based on this ‘theory-simulation-experiment’ concept has realistic potential to achieve innovations in deepening the students' educational experiences and instructors' capacity to better transfer skills and knowledge to learners in solving complex educational tasks. It is speculated that while both these benefits go well beyond what has been the case heretofore, the initial investment to achieve it will be well rewarded, economically, through the economies of scale in its uptake and usage.

References