ADAPTIVE E-LEARNING: HARNESSING MOBILE E-LEARNING TO ENHANCE THE THIRD LEVEL ACADEMIC EXPERIENCE

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Abstract

With the advent of wireless networking at University College Dublin, education through blended learning has been embraced by staff and students alike. Due to the transient nature of students, mobile technologies and wireless local area networks have been employed to facilitate ubiquitous access to resources. This paper assesses the e-learning tools currently available at the university and subsequently evaluates their suitability through qualitative analysis. The results obtained emphasized those issues raised by current undergraduates and solutions were drawn. An intelligent framework of adaptive e-learning facilities is presented that enables students to avail of ubiquitous learning.

Introduction

"The underpinning philosophy behind the development of e-learning is that it should be considered a normal activity. It should be undertaken by professionals in the modern teaching world and should not to be the preserve of the fearless or privileged few" (Gauder et al., 2004). University College Dublin (UCD) has, in recent years, transitioned from its once traditional educational metaphor to a modularised educational framework. The vast scale of the undergraduate community requires that ubiquitous access to all resources be made available. This has been achieved through the establishment of a fast and efficient WAN. The MLE'S currently offered act as both a resource and administrative repository. The alternatives discussed draw upon intelligent learning strategies to ensure that students are continuously assisted.

Managed learning environments (MLEs) have been designed to assist academic institutions in the management of student records. UCD Horizons is the realization of modularisation at the University College Dublin. Its modularised and credit-based learning strategies have enabled students to combine core and preference subjects in order to achieve a flexible degree programme. This paper considers the tools that have facilitate and enhance the learning experience of undergraduate students.

Each student should be facilitated according to his or her individual academic goals and requirements. In UCD, this task is performed through a knowledge

structure that is aware of the student's current abilities. It is the purpose of this paper to analyse the MLE's currently available at UCD from the perspective of the undergraduate student. The remainder of this paper is structured as follows: section two highlights similar research, section three introduces an evaluation of the MLE's used, sections four and five consider two alternate mechanisms for assisted learning at UCD, and section six draws conclusions and introduces some future areas of research.

Summary of Related Work

The vast array of e-learning tools currently available in second and third level education has furthered academic achievement in Ireland (Williams et al., 2002). One of the primary objectives in the deployment of e-Learning tools at University College Dublin (UCD) was to ensure a high level of standardisation across the entire university. There are, however, costs associated with maintaining multiple e-Learning platform campus wide: registration costs, same modules on multiple platforms, time costs, redundancy of knowledge. There was recognition within the university that a single supported online platform was the most suitable means of improving the diversity and flexibility of courses delivered at ACU (Gauder, 1990). This was analogous to the conclusions drawn through our research at UCD.

Kulik (1994) discovered that student's who receive computer-based instruction, learn faster and are increasingly motivated in class. Human-computer-interaction (HCI) research has enabled the development of adaptive e-learning environments (Dillon, 2004). Schacter (1999) concluded that facilitating students with computer-assisted instruction could enhance academic achievements.

With new technologies come challenges, hence collaborative tools such as computer mediated cooperative work benefit students with common goals and interest (Duval et al., 2005). "Argue Graph" tracks the influence of collaboration in learning (Jermann et al., 1999). After the emergence of portable computer and WANs in the early 1990s, researchers focused on distributed systems with mobile clients which the mobile computing domain is derived from (Satyanarayanan, 2002).

Mobile devices make use of agent-oriented intelligent interface that are proactive and autonomic (Alcaniz et al., 2005). M-learning enables people to have access to distant education. Mobile phones are ideal for this task. Issack et al. (2006) developed a prototype application which combines mobile and e-learning into a single computer-based infrastructure.

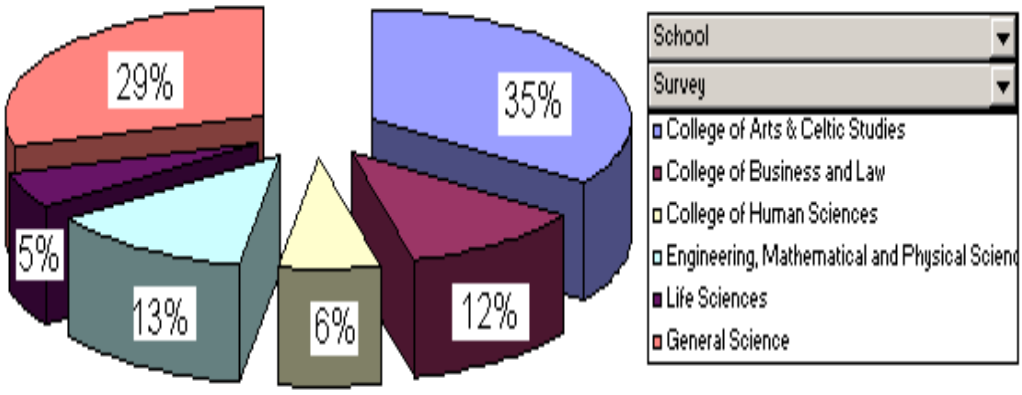
E-Learning Software Evaluation

It was our intention to undertake a survey of the e-Learning tools available at University College Dublin in an attempt to determine if they benefit students. UCD has facilitated "Anytime/Anywhere Access" through the focused implementation of services such as off campus access with UCD Connect, e-learning, and mobility with wireless hotspots. The inclusion of a wireless local area network (LAN) at UCD has enabled the adoption of widespread laptop facilities. Over 40 hotspots have now been installed. UCD offers an online map where website visitors can locate the Wireless Hotspot and computer laboratory open access locations. This wireless network has also had a positive impact on the number of laptop users at UCD. Previously, a new laptop centre had been created where students could connect their devices to the university's network both wirelessly and through wired access.

For some students, especially business students, it is obligatory to own a laptop. For others it is optional. Under the University's Laptop Programme, UCD in conjunction with Dell has enabled students and staff the opportunity to purchase laptops at affordable prices. When buying the laptop, up to date anti-virus software and security updates are included as standard.

A survey was undertaken to ascertain satisfaction levels with the e-learning facilities available at UCD. This information procurement would ensure future development of superior tools and resources. The survey was administered to 100 students. Of the completed surveys, 79 were suitable for breakdown and analysis. The gender breakdown of respondents was 43% female and 57% male. Due consideration was given to the acquisition of an even distribution of respondents across the various schools in UCD (Figure 1).

Figure 1: Distribution of respondents



UCD is currently experiencing 110% mobile phone penetration. The overall trend towards mobile phone ownership continues to rise in Ireland, with levels of 114% in the second quarter of 2007 (Watts, 2006). 78% of students own a laptop computer. In a previous study 80% ownership was alluded to (Annon, 2007). Ownership levels of PDA's are substantially lower (3%).

When asked to indicate the brand, make and model of those mobile phones owned, it appeared that many of these devices had 2.5G capabilities and had more in common with PDAs than their generic mobile phone counterparts. Lamentably, this alludes to the fact that these devices are being used as mere telephones and students are not fully embracing their intrinsic capabilities. This must be overcome if our goal of ubiquitous e-learning at UCD is to be realized. Undergraduate students have embraced mobile technologies; using their mobile phones hourly and their laptop computers daily (70%). This frequency of use breeds familiarity and acceptance of our developed software.

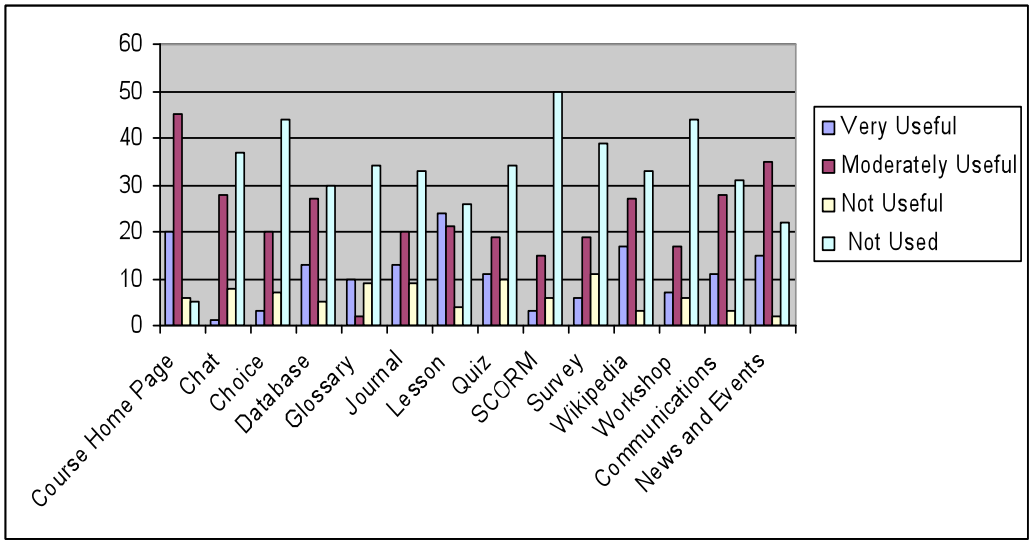
UCD Connect is a shared portal for staff and students that provides access to a vast array of services and information. It offers e-mail, access to the files on students' accounts, online classes, a calendar service and group tools for discussions. Two managed learning environments are also used at UCD, Blackboard and Moodle. "Around 16,000 students and 800 courses are available on Blackboard." Before its transition, UCD had its own e-learning system called TopClass from WBT (Lennox, 2004). The main difference between these MLE Shaw mentions is that Blackboard offers fuller integration options.

The Blackboard managed learning environment is a Web-based server software platform. It provides an array of tools and features that include an open architecture that facilitates course management, and a scalable design that allows for integration with student information systems and authentication protocols. Its primary purposes are to add online elements to courses traditionally delivered face-to-face and to develop completely online courses with few or no face-to-face meetings. Moodle is a free software e-learning platform used at several of the schools at UCD (McGovern, 2005). Moodle is designed to assist lectures in the creation of online courses that enable and varied online interactions. Its open source license and modular design means that people can develop additional functionality in order to best suit their individual needs.

Most of the students only use Blackboard, and the majority of those students undertaking modules in the College of Engineering, Mathematical and Physical Sciences have used Moodle. Ubiquitous computing enables computing resources to be widespread and intuitive (Weiser, 1994). According to the results obtained, this ease of use is lacking and the skills learned are not transferable.

The facilities made available are often redundant (Figure 2). Many of the facilities made available through UCD Connect were unused. It appears that lecturers neither understand nor make full use of these facilities and one must question if they are a necessity. When these facilities have been used, students have indicated that they are not conducive to learning. The ones that are used and found to be useful are; Course Home Page, Communications, Lessons and News and Events.

Figure 2: Respondents satisfaction levels of MLEs used



Some of the comments raised include:

- Blackboard is not robust or efficient
- Blackboard is not as efficient as Moodle
- Not all lecturers makes use of both MLE
- The MLE should provide better information

The Student Information System facilitates remote management and ubiquitous access of undergraduate student records. The application enables students to register and pay fees online, peruse through and enrol in core and elective modules, remotely manage academic timetables and access examination information on demand. It is capable of handling inquiries from prospective students. It was designed to enable online registration and enrolment. It facilitates the selection of module combinations and laboratory times. It is also responsible for the handling of examinations, assessments, marks and grades and academic progression. The integral nature of this facility has ensured that a detailed analysis be undertaken (McGovern, 2005).

The results obtained indicated that students often have difficulty locating the application on the UCD website and, of those that did, 82% highlighted that navigation through and around its facilities was cumbersome: “Its disorganised, the menu system is all over the place.” Student’s inability (71%) to effortlessly access personal records and academic resources signified that it was not wholly intuitive and the help files were decidedly inadequate (91%).

Furthermore, on completion of elective modules selected via SIS many displayed dissatisfaction in their choices and felt that a more complete module synopsis would have prevented poor module selection: “Finding elective [modules throughout] the college is difficult as is locating specific information i.e. exam timetables.” Students also felt that the lottery system employed in the allocation of elective modules hampered academic progression: “In relation to electives, I think for example more business elective places should be provided and kept by just for business students and the rest open to all faculties.” These, and further results obtained indicated that the Student Information System urgently required attention and improvement. IUMELA was developed in response to many of those issues raised.

Intelligent Tutoring System for Java

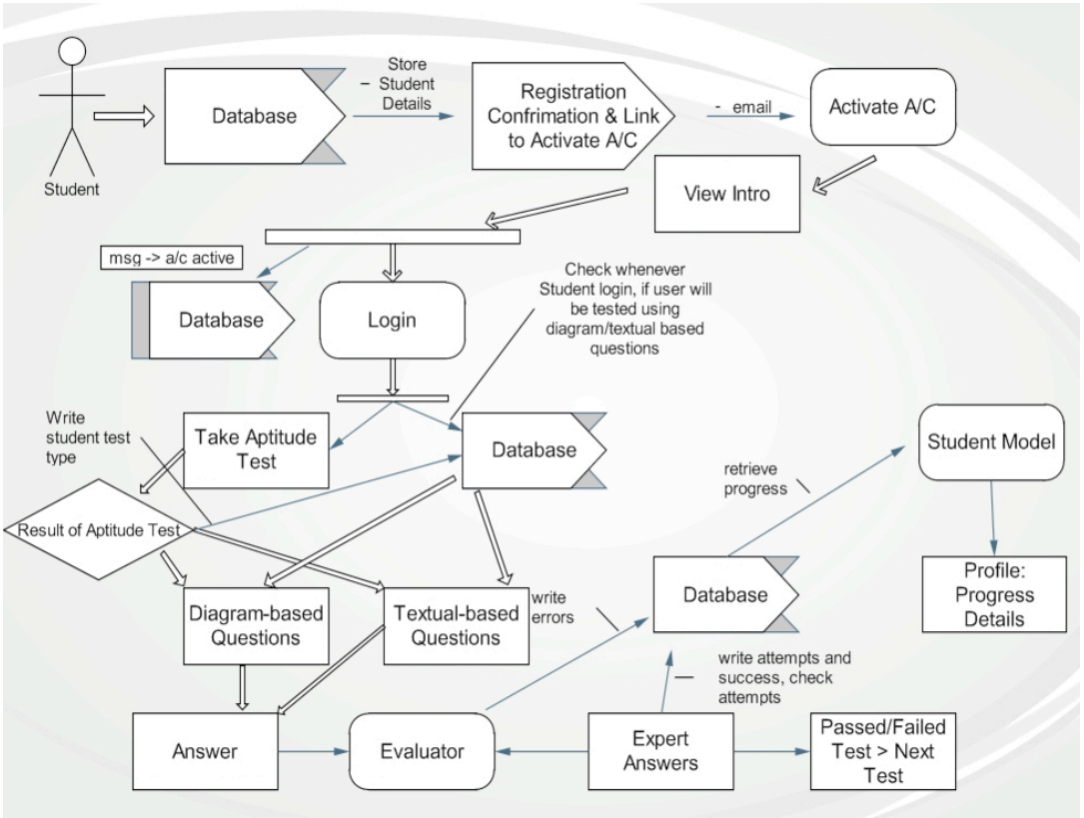
Intelligent tutoring system (ITS) has been applied to enhanced e-learning in domains such as Mathematics and Computer Science and it has proven worthy in these domains (Gascuena et al., 2005; Woolf et al., 2001). ITS comprises of qualities that enhances individualized tutoring by emulating behaviour of human tutor, helping to develop students ability by saving time the learner uses to acquire skills and knowledge. These qualities made ITS more popular and gain more acceptance (Koedinger, 2003). ITS empowers students to use their skills in an interactive learning environment, students taught by ITS learned faster and showed further improvements compared to classroom trained participants (Ong et al., 2003).

Intelligent tutoring system for Java (ITSJ) (Ayoola, 2007) is an automated system that provides one-on-one tutoring and instructions for Java programming language. The architecture of the ITSJ comprises of three main components - the Student Model, the Instructor Model, and the Expert Model. An Evaluator is included to make comparisons between student and expert models. The ITSJ is designed to emulate a human tutor that is guiding a student through learning process of Java programming language. The Student Model captures the student understanding of a subject matter and uses this knowledge to adapt instructions to the student’s particular needs.

The Expert Model is the Java expertise that provides the ITSJ with a syllabus and possible solutions to exercises. The Instructor Model facilitate ITSJ teaching technique which is an embedded algorithm that studies the structure of a student's mind, and simulates the instructional strategies through ITSJ web-based interface. A student learns from ITSJ by submitting solutions for exercises. The system selects an exercise, compares the solution of the student with the expert's solution and diagnoses the difference between solutions. The system then gives the student progress feedback for the student's solution. The student can attempt the test three times with the aid of examples, hints, etc. The system reassesses attempts and updates student skills, and the cycle continues.

The Java programming language is an ill-defined domain that can have many possible solutions for an exercise. ITSJ was evaluated by students for its efficiency, reliability and correctness. ITSJ is designed to increase learners' motivation, empower them to use initiative and gives guidance on how to use resources available in the learning process: 50% considered ITSJ to be very efficient, 37% confirmed that ITSJ is robust and efficient.

Figure 3: ITS UML diagram



IUMELA

The IUMELA application was designed in an attempt to resolve the issues raised as a result of the conducted e-learning applications survey. The multi-agent system (MAS) conforms to FIPA specifications (FIPA, 1997) and was developed using Agent Factory (Collier, 1995) toolkit with Java as the programming language. In order to ensure ubiquitous access to the tools available, the Assistant Agent manages the user interface accessible via a desktop computer or mobile device, in this instance the XDA Mini S. The high-level communication protocols have been implemented using ACL messages, whose content refers to the IUMELA ontology. IUMELA uses a FIPA compliant MAS architecture to fulfil the task of an intelligent application capable of autonomous human computer interaction for communication, event monitoring and the performance of higher order cognitive tasks. The IUMELA multi-agent system consists of a community of five agent types: assistant, moderator, learning agent, expert agent and analysis agent. They co-operate in order to analyse the students' learning patterns and make an accurate module recommendation in an on demand manner, at a time and location appropriate to the students' needs.

The user interface was designed and made accessible via a mobile or desktop device. This would provide enhanced ease of access and would ensure that once proficient in accessing IUMELA via either variant, the student would be capable of transferring to its counterpart seamlessly.

IUMELA has an initial login screen that provides access to a registration screen. The initial login screen is minimal and uncomplicated in its design. It employs tabular navigation for ease of use. The registration process was designed so that third level students would be capable of registering online without encountering any hard copy procedures. It makes use of the Felder and Solomon Index of Learning Styles (McGovern, 2007) to provide an initial profile. The results obtained are then used by the IUMELA MAS to assist in the recommendation of modules. Screen real estate usage has remained minimal to ensure enhanced usability on the smaller, more mobile device.

Upon successfully logging in, the student enters the personalised welcome screen (Figure 4). Studies have shown that a personalised application is conducive to learning and can enhance information retention. It encourages students to frequently interact with the application and results have shown that students remain on these pages for longer than their generic counterparts. This has the effect of enhancing knowledge absorption.

Figure 4: Personalised welcome screen

The navigation controls enable students to navigate through the IUMELA screens in order to retrieve the required information. Some of the tasks that a student might wish to complete in order to achieve their academic goals include: to obtain information on all modules available at the university, determining student compatibility with the module of interest, comparison of current student compatibility with other current students compatibility, comparison of current student compatibility with similar past students achievements in the particular module of interest, recommendation of suitable modules for consideration, message interaction with other students, tutors and lecturers on the course. The assistant in the IUMELA application helps students successfully complete their current module selection. It is also capable of assisting the student in exam preparation and future module selection.

The learning journal facility has been created as a dedicated academic journal for each student. It is a private space that enables each student to gather their thoughts. It is a space that enables them to assemble a personal record of their module experiences from lecture to lecture. It is an outlet for a student to voice their feelings about projects, assignments and tests undertaken during the course of the module. It enables the student to gain a preliminary understanding of their overall academic journey prior to their end of term examinations. When revising, it enables the student to analyse their achievements for each completed lecture. Did they think they gained an understanding of the topic or will more study of the topic be required? Did they find it difficult? Do they think they will struggle when revising? The MAS uses the learning journal facility to formulate an association with the language in their learning journal and the students personal lecture rating. A lecture star rating of five is a positive grade. So, adjectives and phrases that frequently appear in the learning journal on that day can be considered positive

also. This further enables the assistant agent to gain an understanding of the student's strengths and weaknesses.

Continuous communication and student integration appear to be central themes for ensuring improved student participation throughout the academic year. Many EU governance decisions have highlighted the importance of reducing student drop out rates at universities and colleges. The University of Ulster in Northern Ireland has had great success in the use of SMS messaging for the reduction of student drop-out. It found that sending SMS messages to students who have been identified as being at risk has been a very successful approach for keeping students in the system and for maintaining the government per capita grant. The University of Ulster sent out messages to students of the type 'Sorry, we missed you today'. The university initially feared that this might be intrusive. On the contrary, the students did not find it intrusive at all. The students appreciated it and wanted the university to expand the service to other areas — like assignment deadlines. The IUMELA messaging screen contains a representation of both students communicating. A further instant messaging facility enables students to undertake a real time chat, either through video messaging or if they cannot contact the receiver the student can leave a message in the message drop box for later perusal. Any task alluded to in a message can be immediately stored in the IUMELA task list facility. This facility has yet to be completed but initial results appear promising.

The most innovative part of the IUMELA application is that of the module and assistant facilities. They are also the facilities that make most use of the MAS intelligence. It has multiple views; all designed with the intention of assisting a student determine the most suitable module combination for their needs. Multiple views were provided to ensure that a student can browse or search for modules in a manner that suits their current situation. For example, if a student is aware of the school and faculty in which they wish to attend but are unsure of the available electives they can navigate to that school and browse through the available modules under title, lecture, complexity level or key word.

The assistant has access to all past academic records of all modules previously taken by the student. Furthermore, it maintains a directory of all HCI interactions that took place with the student via IUMELA. These interactions include the initial survey taken during the completion of the initial registration process, the students learning journal entries, and also message interactions between the student and their fellow classmates, tutors and lecturers. The results from these interactions are aligned with specific academic preferences. These include what learning tasks best suit the current student, what style of lecturing best suit the students learning preference, where do their strengths lie, do they work well in group tasks or are better suited to working alone, do they prefer continuous assessment or one single

examination at the end of the module, what modules are their friends attending, what type of modules have they successfully completed in the past and so on. Upon correlating these details, the results are ranked according to suitability. They are then meaningfully displayed.

Initially, all the modules that lie within the suitability threshold range will be displayed to the student. He or she is then given some options that enable the quantity of suitable modules to be reduced. These options include sorting by faculty, school, lecturer, semester, time and core components. When only those modules that are of interest remain, the student can select a module for consideration. They are then redirected to a module details screen, in which they can obtain a greater understanding of the module under consideration, view a sample lecture, peruse sample presentation slides, read recommended material, see some sample examination questions, communicate directly with the teaching assistants or lecturers and read feedback given by past pupils. This provides a level of interactivity that was previously only alluded to.

Figure 5: Module details screen

Summary and Future Work

E-Learning tools currently available at the university have been evaluated, assessed and conclusions have been drawn. Our consideration of past research into the areas of e-learning evaluation and mobile technologies has enabled us to comprehensively assess those used. Evidence presented, as a result of the survey, indicates that many of the e-learning facilities currently available are lacking in cohesion and functionality. In sections four and five, two alternative intelligent e-learning tools that have gained acceptance and offer assistance in a meaningful manner were presented.

Future work will involve the implementation and development of a distributed system that can supplement existing MLEs through the provision of a mobile managed e-learning platform that enables students to access their academic resources via hand-held device in a ubiquitous manner. Ontology for successful association between on-line lectures and lecture notes will be created for the purpose of implementation and evaluation. Tools, including multimedia tools, will be developed. This facility will enable users to connect to the multi-layered architecture of the system for relevant lecture download and also acts as a Graphical User Interface. A knowledge-base that will encapsulate user's profile, including students' interaction with mobile platform for system retrieval and evaluation of its employment, will be constructed.

References

Alcaniz, M., Rey, B., Riva, G., & Davide, F. (2005). *New technologies for ambient intelligence.* IOS Press, http://www.ambientintelligence.org.

Annon, A. (2007). Retrieved from http://www.business2000.ie/cases/cases_9th/case1.htm

Ayoola, O. (2007). *Intelligent Tutoring System for Java (ITSJ).* University College Dublin, School of Computer Science and Informatics, Dublin, Ireland.

Collier, R. (1995). *The realisation of Agent Factory: An environment for the rapid prototyping of intelligent agents.* (MPhil. Thesis, UMIST, Manchester, UK.)

Curson, N. (2004). *Learning technology group recommendation on learning system platform for managed learning environment.* University College Dublin, Ireland.

Dillion, A. (2004). Designing a better learning environment with the Web: Problems and prospects. *CyberPsychology and Behavior, 3*(1), 97–102.

Duval, P., Merceron, A., & Scholl, M. (2005). *Reactive learning objects for distributed e-learning environments.* Computer Science Department, Engineering School Leonard de Vinci, F-92916 Paris La Defense – Cedex (France). 1st International Kaleidoscope Learning GRID on Distributed e-Learning EnvironmentsWorkshop.

Fernández-Caballero, A. (2005). Motion direction detection from segmentation by liac, and tracking by centroid trajectory calculation. *PRIS 2005*, 213–218.

FIPA. (1997). *FIPA 97 Specification*. Retrieved from http://www.fipa.org

Gauder, J., Christie, A., & Strong, J. (2004). Management of e-learning within a university setting through partnership with industry. *NetSpot Pty.*

Issack, S. (2006). A M-E (Mobile-learning) adaptive architecture to support flexible learning. *Malaysian Online Journal of InstructionalTechnology (MOJIT).*

Jermann, P., & Dillenbourg, P. (1999). *An analysis of learner arguments in a collective learning environment.* TECFA, University of Geneva, Switzerland.

Kulik, J. (1994). Meta-analytic studies of findings on computer-based instruction. In E. L. Baker, & H. F. O'Neil, Jr. (Eds.), *Technology assessment in education and training.* Hillsdale, NJ: Lawrence Erlbaum.

Lennox, D. (2004). *The role of a learning content management system in speeding time to performance.* A WBT Systems White Paper. WBT Systems.

McGovern, E. (2005). *A comparative study of multi-agent and object oriented methodologies for mobile managed learning environments.* (MSc Thesis, Department of Computer Science, University College Dublin.)

McGovern, E., Mangina-Phelan, E., & Collier, R. (2007). IUMELA: The inception of an intelligent modular education learning assistant. In *Proc. of 3rd International Conference on Web Information Systems and Technologies (WEBIST 2007).*

Satyanarayanan, M. (2002). Pervasive computing: Vision and challenges. *IEEE Personal Communications.*

Schacter, J. (1999). The impact of education technology on student achievement, what the most current research has to say. *Milken Exchange on Education Technology.*

Weiser, M. (1991). The computer for the 21st Century. *Scientific American.*

Watts, N. (2006). *Rapid development of media-rich, interactive elearning.* Audio Visual Centre, Library Building, University College Dublin, Ireland.

Williams, F., P., & Conlan, O. (2007). Visualizing narrative structures and learning style information in personalized e-learning systems. In J. M. Spector, D. G. Sampson, T. Okamoto, Kinshuk, S. A. Cerri, M. Ueno, & A. Kashihara (Eds.), *IEEE Computer Society, 2007,* pp. 872–876.

Woolf, B. P., Beck, J., Elliot, C., & Stem, M. (2001). *Growth and maturity of intelligent tutoring systems: A status report.* Cambridge, MA: MIT Press.