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Special Issue

Part I
Mobile Technologies in Engineering Education (I)

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E-learning has enabled a variety of ways for teachers to give instruction and students to learn that were not possible in a traditional education environment. This paper describes the Cyber Schooling framework that enhances the familiar traditional school paradigm by identifying different modes in which technology is able to serve the learning process. The Cyber Schooling framework includes four elements: Cyber School, Cyber Classroom, Cyber Teacher Desk (teacher's WiFi laptop) and Cyber Student Desk (student's WiFi laptop). The paper describes the principle of the Cyber Schooling framework and provides case studies for various possible modes.
Keywords: international education; cyber schooling; mobile learning; educational administration; distance education; e-learning

This study describes the application and effects of technological support for collaboration in a computer science course for engineering students. The technology in question is based on a wireless network of PDAs that implements a classroom dynamic to stimulate communication, discussion while arriving at agreement on questions put to students. The results obtained permit us to conclude that permanent use of Mobile Computer Supported Collaborative Learning (MCSCL) sessions improves the performance of students and their interest in the course. Furthermore, they demonstrated a greater ability to communicate both with their fellows and the professor, thus bettering their course results.
Keywords: face-to-face collaborative learning; assessment; computer science teaching

The potential of new developments in mobile technology, with capabilities for anytime, anywhere wireless access, to affect pre-engineering education and technical literacy at the K-12 level remains poorly understood. Mobile access to digital libraries provides unique opportunities for leveraging valuable experiences outside of the classroom. This paper presents a user needs analysis of teachers, students and parents with regard to understanding the potential of such mobile digital library services to enhance science and technology learning in informal environments for students in U.S. grades 4–5 and middle school. To study this area we discuss a methodology at the intersection of design and research that borrows from qualitative research methods and traditional user-centered design, together with frameworks for translating qualitative data into concrete user needs. We present a summary of twelve need "themes" that emerged from the analysis together with recommendations for how these themes inform the development of a mobile digital library infrastructure and its digital learning resources. The recommendations are illustrated on an informal learning scenario intended for a pre-engineering exercise using resources from the NEEDS engineering education digital library at www.needs.org.
Keywords: mobile learning; engineering education; mobile devices; digital library; mobile library; K-12; informal learning; science education

The present paper introduces two computer science projects related to experiences in the use of mobile technologies in higher education and training, particularly in e-learning systems. The first project, called 'Learning Messages Notification System', is a new communication tool that can be added to any learning management system. With this tool the students will receive educational messages in their mobile devices: phone or PDA. The second project is the 'Mobile Assessment System', which can help us in the assessment process of the knowledge acquired by the student in a virtual environment.
Keywords: mobile technologies; PDA; learning management system; mobile assessment

This paper presents a prototype system that combines novel kinds of hardware devices, such as wireless multimedia players and wireless projectors, with an intelligent sketch-based drawing application running on wireless Tablet-PCs. It provides a mobile assistant that can be used by a teacher to communicate graphic information to students in a very intuitive and friendly way, allowing the creation of exact geometric constructions using freehand drawings. Hardware requirements to support this application are described and a pilot experience where the prototype system was used is presented.
Keywords: freehand sketching; sketching recognition; wireless projection

In recent years the fast growth of mobile technologies has opened up new opportunities in CAL (Computer Aided Learning)—mobile learning and mLearning. Although still in its infancy, mLearning is taking off very fast as it gives both teachers and learners the 'true' freedom of space and time. It also provides a new way of interaction for teaching and learning. This paper reviews the state-of-the-art of mLearning technology, underlines the potential of mLearning, and discusses the appropriate use of mLearning. Finally, it introduces a Mobile Intelligent Learning Environment or MILE, a conceptual framework for an authentic mLearning situation, explains its system architecture and describes the various pedagogical features implemented in this framework.

Keywords: mobile learning; CAL; e-Learning; learning paradigms

Professionals who work in conceptual design spaces have very different communication needs than those who work in design spaces for detail design. In the conceptual design stage, people, ideas and technologies are typically mobile, fluid and distributed—even when relatively co-located. While our approach is exploratory, we hope that this endeavour can help organize a new family of techniques and ideas in the engineering design community. Some key concepts that we deploy are conceptual design, informal graphics, rapid graphical communication and optimal ignorance in the graphical communication process. We will illustrate what we mean by describing a few new methods such as feature-based sketching and edited/annotated photos. We will also discuss preliminary trials using new mobile technologies, such as digital ink pens since 2004, and our research plans for student design teams using Tablet PCs.

Keywords: conceptual design; informal graphics; rapid graphical communication; optimal ignorance; feature-based representations; digital link

This paper presents a critical overview of our experiences in using mobile computing for supporting both faculty and students in integrated lecture–lab classroom environments. Three case studies describe how handhelds, laptop carts, tablet PCs, and student-owned laptops/tablets can enable adaptive, active, applied learning. We identify the remaining challenges to be overcome before the potential of mobile computing can be fully realized. Some of those challenges are specific to mobile computing; however, many others are broader problems in engineering education, such as the need for involvement beyond the primary instructors (e.g., technical staff) and modern classroom facilities.

Keywords: mobile computing; integrated classroom; technology literacy

Nowadays, many educational and research objectives can be achieved through the use of configurable, small, low-cost mobile robot kits. Using these systems, students must learn to work in teams and deal with topics such as real-world issues, integrated systems building and multidisciplinary information. This paper deals with mobile robot control. It presents a low cost laboratory experiment based on LEGO Mindstorms. In order to avoid the limitations of the original communication system, a new one is proposed. This system is based on Bluetooth and establishes communication between a host computer and/or mobile robots. With this environment a wide variety of robot activities can be developed due to its flexibility, power, and simplicity of use. The paper also presents examples of these activities related with robot control design, artificial vision, trajectories planning, etc.

Keywords: mobile robots; Bluetooth; LEGO

In this study, a mobile application called MOGRAPH, which has been developed for the teaching graphs, is presented. By using MOGRAPH, students can draw and edit previously formed graphs, apply Depth First Search (DFS), Breadth First Search (BFS), Dijkstra's Shortest Path, Euler Path/Circuit, Hamilton Path/Circuit and Graph Coloring algorithms on the undirected (weighted or unweighted) graphs created by them and take a quiz to test their knowledge. Results show that at least 79% of the students have liked the educational features of the MOGRAPH package and have thought it would be beneficial for future use.

Keywords: mobile learning; graph algorithms; PDA

The effectiveness of four instructional delivery modalities, (i) traditional lecture, (ii) Web-enhanced lecture, (iii) Web-based self-study and (iv) Web-based self-study and classroom discussion, was investigated for a single instructional unit (Non-linear Equations) over separate administrations of an undergraduate engineering course in Numerical Methods. Two assessment instruments—student performance on a multiple-choice examination and a student satisfaction survey—were used to gather relevant data to compare the delivery modalities. Statistical analysis of the assessment data indicates that the second modality, in which Web-based modules for instruction were used during face-to-face lecture delivery mode, resulted in higher levels of student performance and satisfaction.

Keywords: assessment; distance learning; instructional modes; numerical methods; web-based resources

Over the 7 years in which Carnegie Mellon University's multi-disciplinary Engineering Design Projects course has been offered, the processes for forming the student teams and then associating the teams with client-sponsored projects have matured into what we believe are a pair of best practices. This paper describes our suggested best practices for team formation and associating teams with projects. Further sections describe the path we followed developing these processes and compare our processes with some benchmarks.

Keywords: Design Projects; Multi-discipline Teams; Student Teams.

Part II

Contributions in: Engineering Education Policy and Research, Engineering Design, Engineering Mechanics, Chemical Engineering, Construction Engineering, Hydraulic Engineering and Mechanical Engineering

Universities have three missions: education, research and public service. The Idea to Product® program supports the service and research missions of a university. Faculty at UT Austin developed I2P® as an educational program; previous publications have stressed the pedagogical approach and educational value of the program. This paper examines how the program, which includes both courses and competitions, fosters technology commercialization, thereby supporting the research and service missions of a university. By examining student projects, the I2P® program's support of university missions and technology commercialization can be illustrated. Ultimately, the I2P® Program helps to foster an entrepreneurial culture within a university.

Keywords: Idea To Product; i2; international; entrepreneurship; technology commercialization; innovation

This paper reports a collaborative courseware development project in Geotechnical Engineering between the University of Melbourne and Monash University in Australia. The project produced two learning modules. This paper describes the development and implementation of one of the two modules—the Deep Excavation module. The module provides students with a visual experience and interpretation of a range of key design and construction-related elements. It comprises a self-learning programme and a 25-minute video component in DVD format, which was filmed over a 12-month period recording the entire construction sequence of a deep basement excavation. The evaluation of the impacts on the students' understanding of relevant concepts based on a survey is reported. Results from the survey and students' marks show that their understanding of design and construction-related content had improved substantially in comparison with their understanding of other concepts that were not covered by the multimedia module.

Keywords: evaluation, excavation, geotechnical, multimedia, university partnerships

While the education in agricultural engineering has been evolving worldwide to include more biological emphasis, there are still problems for this part of the profession to be identified and recognized correctly by the general public in Turkey. Agricultural engineering education and profession in Turkey has long been controversial since it has been confused with agricultural science education. We present the current interpretation of 'agricultural engineering' in Turkey and highlight how engineering education has been mixed up with science education in agriculture. We take a historical approach and propose possible remedies within the world's general engineering education trends.

Keywords: agricultural engineering; biosystems engineering; curriculum history

Project work is increasingly used to help engineering students integrate, apply and expand on knowledge gained from theoretical classes in their curriculum and expose students to 'real world' tasks [1]. To help facilitate this process, the department of Design, Manufacture and Engineering Management at the University of Strathclyde has developed a web–based groupware product called LauLima to help students store, share, structure and apply information when they are working in design teams. This paper describes a distributed design project class in which LauLima has been deployed in accordance with a Design Knowledge Framework that describes how design knowledge is generated and acquired in industry, suggesting modes of design teaching and learning. Alterations to the presentation, delivery and format of the class are discussed, and primarily relate to embedding a more rigorous form of project-based learning. The key educational changes introduced to the project were: the linking of information concepts to support the design process; a multi-disciplinary team approach to coaching; and a distinction between formal and informal resource collections. The result was a marked improvement in student learning and ideation.

Keywords: Design education; digital repository; Design Knowledge Framework

Multidisciplinary research projects in biomedical engineering (BME) may require undergraduate students to perform in areas where they have limited exposure or on tasks that challenge their emergent engineering skills. However, an undergraduate's inexperience can be offset and the likelihood of project success can be improved with careful selection of faculty and graduate student preceptors. Unfortunately, overtaxed faculty mentors, especially in today's competitive medical and academic centres, often are inaccessible or reluctant to mentor if time commitments and outcomes are uncertain. Thus, we proactively restructured the typical mentoring hierarchy in a top-down manner by pooling two bioengineering faculty, a clinician scientist and a senior graduate student to mentor one undergraduate. Our approach generated a project that fulfilled educational and research objectives. Participants reported satisfaction with project outcomes, their role in the process and the mentoring paradigm employed. We believe that alternative mentoring models for multidisciplinary BME research projects should be employed when establishing senior design experiences and that superior results are achieved when equal weights of effort are expended in defining the composition of the mentoring team as well as in defining the project itself.

Keywords: Capstone; mentor(ing); multidisciplinary; biomedical engineering

The rapid growth in nanoscience and technology and its implementation in modern 'flat world' industry and engineering are calling for a new curriculum for engineering education. The change in curriculum involves the introduction of new concepts and examples at scales that are new territories for engineers. These territories were previously acknowledged as the exclusive knowledge-based playground of scientists, in which their explorations broaden the horizon of basic understanding. Engineering mechanics concepts are taught to most engineering disciplines as essentials to basic and practical engineering understanding. At the introductory level engineering mechanics is taught in the courses of statics, dynamics and strength of materials. This paper addresses the need and importance of reforms and revisions of engineering mechanics courses to include experiences in these new territories so that the engineering mechanics education expand beyond continuum and macro-based level to include all the scales. This revision can be done by introducing the concepts of multiscale engineering and development of new lesson modules perhaps including example problems in micro- and nanoscales. Relying upon the framework of existing courses and using the existing physical and intellectual resources, an array of educational activities will be suggested to provide such an opportunity for undergraduate engineering students. The efforts will be facilitated through the visualization capabilities of computer-aided engineering and drawing (CADD) techniques as well as the analysis capabilities of finite element model (FEM) and molecular dynamics (MD) procedures.

Keywords: continuum mechanics; dynamics; engineering mechanics; multiscale mechanics; nanomechanics

Civil engineering graduates report that exposure to actual construction sites during their undergraduate training may be beneficial to their career development. This research describes the incorporation of a field journal assignment at construction sites into a land development engineering course. The authors sought to determine if student observation of active construction would result in self-reported increased proficiency in two areas: field journal skills and construction engineering skills. Results suggest that this assignment does facilitate students' proficiency in these two skills sets and can increase students' understanding of the complexity involved in active construction sites.

Keywords: on-site learning; field journals; construction engineering; civil engineering

The learning-oriented approach, with its emphasis on student engagement, has been implemented in a course that utilizes a slug flow simulator (SFS), in the context of research assignments that complement traditional engineering lectures. The course is a Master's degree in Theoretical and Applied Fluid Mechanics, at the Engineering Faculty of Porto University (Portugal). The goal is to engage students proactively in the learning process, so as to enrich their learning experience and foster knowledge retention. The main features of the simulator are presented (main windows, input parameters and monitored variables) and the potential benefits of its use are discussed. A series of tasks of increasing complexity are proposed, covering both undergraduate and graduate levels.

Keywords: student engagement; visualization tool; slug flow simulator

Students in a water resources engineering course consider the infiltration of water into soils, a topic through which instructors can reinforce many fundamental engineering principles. In this paper, undergraduates used two 80 minute classes to explore Green-Ampt infiltration through integration, differentiation, Newton-Raphson numerical methods and Visual Basic programming. Students used calculus software to check solved problems, programming software to modify and execute model code, and spreadsheet software to examine model outputs. Outputs included tables and graphs showing infiltration for a single precipitation event. Student assessment of the lesson is used to complement measurement of curricula outcomes and satisfy the US Accreditation Board of Engineering Technology criteria.

Keywords: MathCAD; Excel; Visual Basic for Applications; Student Assessment of Learning Gains

A team of undergraduate mechanical engineering technology students designed and built a heat exchanger learning module. Hot and cold fluid delivery systems provide fluids to a heat exchanger that is used to teach fundamental concepts of heat transfer in a thermal science laboratory. Design provisions enable analysis of heat exchangers in either parallel or counter flow configurations. The module uses a data acquisition system to record temperatures along the heat exchanger loops. The effect of flow configuration and mass flow rate on heat transfer characteristics of the heat exchangers is evaluated. Overall heat transfer coefficient (U) of 500 (W/m^2 C) for a heat exchanger with parallel flow configuration was determined. Assessment results for this module obtained through a survey by students who used it in their thermal science laboratory course during the Spring 2005 semester is presented, and indicates that this home-made instrument is user friendly pedagogically sound and safe to operate.

Keywords: heat exchanger; ASHRAE; thermal science laboratory