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Special Issue

Engineering Behind Technology-Based Educational Innovations

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**Francisco José García-Peñalvo and
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**Jorge Joo Nagata, José García-Bermejo
Giner and Fernando Martínez Abad** 768–780 Augmented Reality in Pedestrian Navigation Applied in a Context of Mobile Learning: Resources for Enhanced Comprehension of Science, Technology, Engineering and Mathematics

This paper describes the creation and educational effectiveness of a digitally-enabled learning module. The module is linked to the implementation of several Mobile Pedestrian Navigation and Augmented Reality features (MPN-AR), which are used to carry out training processes. In particular, the information imparted is related to territorial information on several relevant disciplines like Science, Technology, Engineering and Mathematics (STEM). This is done in a context of digital information about the environment of Santiago de Chile. The research focuses on two main areas, of which the first is the territorial delimitation, in the thematic context of the study area, in order to carry out the design of an MPN-AR application. This includes defining the architecture, functionality, user interface and implementation of the application. A second step deals with the empirical verification of the results produce by the various modes of operation of the application, as well as the comprehensibility and effectiveness of the model. This is done by means of an MPN-AR application, which has been created in the context of mobile learning and ubiquitous learning as applied to territorial or environments systems. The precise context will be students in a formal educational context. Finally, the implication of these results is discussed, determining their effectiveness within the context of m-learning and u-learning scenarios in comparison with traditional teaching

Keywords: computer uses in education; computer-managed instruction (CMI); computer-assisted instruction (CAI)—mobile learning; ubiquitous learning; STEM; qugmented reality

**G. Hendeby, F. Gustafsson, N. Wahlström
and S. Gunnarsson** 781–789 Platform for Teaching Sensor Fusion Using a Smartphone

A platform for sensor fusion consisting of a standard smartphone equipped with the specially developed Sensor Fusion app is presented. The platform enables real-time streaming of data over WiFi to a computer where signal processing algorithms, e.g., the Kalman filter, can be developed and executed in a Matlab framework. The platform is an excellent tool for educational purposes and enables learning activities where methods based on advanced theory can be implemented and evaluated at low cost. The article describes the app and a laboratory exercise developed around these new technological possibilities. The laboratory session is part of a course in sensor fusion, a signal processing continuation course focused on multiple sensor signal applications, where the goal is to give the students hands on experience of the subject. This is done by estimating the orientation of the smartphone, which can be easily visualized and also compared to the built-in filters in the smartphone. The filter can accept any combination of sensor data from accelerometers, gyroscopes, and magnetometers to exemplify their importance. This way different tunings and tricks of important methods are easily demonstrated and evaluated on-line. The presented framework facilitates this in a way previously impossible.

Keywords: electrical engineering education; student experiments; sensor fusion; inertial sensors; Kalman filter

**Patricio R. Humanante-Ramos,
Francisco J. García-Peñalvo and Miguel
Á. Conde-González** 790–796 Electronic Devices and Web 2.0 Tools: Usage Trends in Engineering Students

Personal Learning Environments or PLE are student centred spaces, which take into account their needs, learning styles and preferences. These spaces appear as important alternatives to overcome the shortcomings encountered with the use of institutional platforms. On the other hand, there is widespread use of mobile electronic devices and Web 2.0 tools among university students, mainly for communication and leisure activities, but that could be used for educational purposes. This research aims to make a diagnosis on access to and use of electronic devices and the web tools by students of the degree of Systems Engineering and Computer Science at Faculty of Engineering at the National University of Chimborazo in Ecuador, from the viewpoint of PLE. A methodological level corresponds to a quantitative and non-experimental research, ex-post-facto. The results show certain trends in the types of devices and their frequency of use, as well as their preferences for the tools to obtain and to find information, not only to create but to edit content and communicate with others, where they prioritize the use of certain social networks and some tools of synchronous and asynchronous communication. One of the main conclusions of this study mentions the huge potential currently offered by Web 2.0 tools to structure the PLE of college students, as well as the great potential for integration with mobile device.

Keywords: Personal Learning Environments (PLE); mobile learning; Web 2.0; ICT; higher education

**Francisco Jurado and Renato
Echeverría Meza** 797–806 An Exploratory Study in the Use of Gamer Profiles and Learning Styles to Build Educational Videogames

When designing and developing Educational Games, the educative and ludic values they provide should be balanced. Teachers have the knowledge on designing the best learning/teaching strategies, but they are not videogame designers who know the best mechanics to engage people. Under this perspective, this paper details a proposal to develop Adaptive Educational Games that uses adaptation rules that take into account Gamer Profiles to engage students in the use of the educational tool and Learning Styles to help the system to determine the teaching/learning methods, learning-objects and learning-services that best suit each particular student. In addition, we show the exploratory case study that we developed on an Adaptive Educational Virtual World and we

analyse the obtained initial results. These results show that, although most of users affirm that the provided adaption rules were right, some preferences on their Learning Styles changed due to the Virtual World features.

Keywords: educational virtual worlds; adaptive systems; gamer profile; learning style

Francisco J. Gallego-Durán, Carlos Villagrà-Arnedo, Faraón Llorens-Largo and Rafael Molina-Carmona 807–815 PLMan: A Game-Based Learning Activity for Teaching Logic Thinking and Programming

This paper presents PLMan, a game-based learning activity designed to face problems observed in practical lessons about Computational Logics. The main of these problems was unmotivated students, who were showing lack of interest in learning activities. Other problems were a high percentage of students abandoning or committing plagiarism, and teachers' overload, that was leaving no time for re-designing lessons, activities and workflow. This paper describes the analysis and design steps undertaken from the problematic situation to the implementation of PLMan. Experimental data confirms that this intervention reverted the problematic situation, improved learning results, raised student motivation and involvement, and left time for teachers to maintain and improve the system. Results clearly show that students have moved from literally hating activities to enjoying them and being enthusiast on participating beyond lessons.

Keywords: serious games; student motivation; game-based learning; education software

José A. Ruipérez-Valiente, Pedro J. Muñoz-Merino and Carlos Delgado Kloos 816–830 Detecting and Clustering Students by their Gamification Behavior with Badges: A Case Study in Engineering Education

Engineering degrees are often regarded as complex and one usual issue is that students struggle and feel discouraged during the learning process. Gamification is starting to play an important role in education with the objective of providing engagement and improving the motivation of students. One specific example is the use of badges. The analysis of users' interactions and behaviors with the badge system can be used to improve the learning process, e.g., by adapting the learning materials and giving game-based activities to students depending on their interest toward badges. In this work, we propose some metrics that provide information regarding the behavior of students with badges, including if they are intentionally earning them, the concentration for achieving them and their time efficiency. We validate these metrics by providing an extensive analysis of 291 different students interacting with a local instance of Khan Academy within our courses for freshmen at Universidad Carlos III de Madrid. This analysis includes relationship mining between badge indicators and others related to the learning process, the analysis of specific archetypal profiles of students that represent a broader population and also by clustering students by their badge indicators with the objective of customizing learning experiences. We finalize by discussing the implications of the results for engineering education, providing guidelines into how instructors can take advantage of the findings of the research and how researchers can replicate experiments similar to this one in other general contexts.

Keywords: badges; gamification; engineering education; distance learning; learning analytics; khan academy; educational data mining; modelling behavior

Fadi Castronovo, Peggy N. Van Meter, Sarah E. Zappe, Robert M. Leicht and John I. Messner 831–846 Developing Problem-Solving Skills in Construction Education with the Virtual Construction Simulator

The ability to solve complex problems is an essential skill that a construction project manager must possess when entering the architecture, engineering, and construction industry. Such ability requires a mixture of problem-solving skills, composed of lower and higher-order thinking skills, which include the ability to develop and evaluate construction plans and manage the execution of such plans. However, introducing students to such complex problems can be a challenge in a typical construction educational program. To support this challenge, the traditional methodology of delivering design, engineering, and construction instruction has been going through a technological revolution, due to the rise of computer-based technology. For example, in engineering classrooms, and other disciplines, educational simulation games are used to support the development of problem-solving skills. This paper presents evidence to support the contention that educational simulation games can help the learning and retention of transferable problem-solving skills, which are crucial to solve complex construction problems. A sample group of 34 architectural engineering students, from a 4th year construction class, participated in a quasi-experiment where they had to play the three modules of the Virtual Construction Simulator 4 (VCS4). A crossover repeated measures quasi-experimental design assessed the gains in problem solving skills that construction students gained from playing the VCS4. The participants completed all three learning modules of the VCS4, and they were assessed before and after each treatment. Based on a series of analyses of the results, the researchers were able to conclude that the students gained and transferred problem-solving skills from playing all of the VCS4 modules. This study provides evidence that the implementation of educational simulation games can support the gain of problem-solving skills necessary to solve complex construction problems.

Keywords: construction education; engineering education; simulation games; serious games; problem-solving

Darinka Ramírez-Hernández and Alejandro Montesinos-Castellanos 847–854 Improving Understanding and Motivation in Learning Transient State by Using a Remote Lab

The purpose of this study is to show how a remote lab (RL) is used to supplement theoretical courses for first- and second-year engineering students. This is an exploratory study. The study centers on their learning and motivation in using an RL to learn about the transient state. The main concern of the study is that students at this stage are not yet familiar with the equipment. The specific objectives of this study are as follows: (1) to demonstrate that using a remote lab as an aid in class during lectures about the transient state improves students' understanding and application of the concept; (2) to establish that it also motivates students while they learn. This study uses a mixed-methods approach. The quantitative part of the study employed statistical analysis (ANOVA) using a pre-test and a post-test to evaluate the learning of the following three groups: (1) with a traditional method (control group); (2) with a remote lab; (3) with a group using only a traditional lab. In the qualitative part of the study, data were collected to determine the students' motivations. The instruments used included a survey, observation (photographs), and classroom note-taking and recording. With this information, an analysis of categories was conducted to gather and triangulate the data. The results showed that the students were more motivated to learn and performed better when they used the RL. Supplemented by RL experiments during class time and as homework, effectively designed activities could improve the understanding and application of some engineering concepts.

Keywords: improvement in the understanding of concepts; motivation; transient state; remote lab

Ángeles M^a Moreno Montero and David Retortillo Manzano 855–864 Design and Deployment of Hands-on Network Lab Experiments for Computer Science Engineers

Computer networks is an essential area in the training of computer science engineers. Delivery of networking laboratory experiments with specialized equipment is a challenge for computer networks teachers. The high cost of networking equipment makes it necessary to use simulation software to overcome the challenges of a large groups of students and working with complex topologies. This paper presents the first version of practical teaching materials to be used in networking courses for the Computer Science Engineering degree at the University of Salamanca (Computer Networks I and II). This material will allow students to work with real equipment in some cases and with simulation environments in others, maximizing the benefits of both.

Keywords: computer networks; networking laboratories; network simulation; network emulation; hands-on experiments; virtualization; cisco equipment; Packet Tracer (PT); GNS3; Cisco IOS

Octavian M. Machidon, Alina L. Machidon, 865–876 Leveraging Web Services and FPGA Dynamic Partial Reconfiguration in a Virtual Hardware Design Lab
Petru A. Coffas and Daniel T. Coffas

The recent rise and development of a variety of virtual and distance learning platforms in the field of engineering has brought on common downsides for most of these solutions. Among them, the difficulty in offering access to physical equipment in fields where a practical, hands-on approach is mandatory and also a low effectiveness in resource sharing, due to the fact that traditionally, one hardware equipment can be used by only one student at a given moment. This paper describes the design and implementation of a digital hardware design remote virtual laboratory that provides solutions to these issues. Reconfigurable hardware development platforms are made available online using Web services, thus providing easy access for student practice by the means of an intuitive Web interface that offers the user the possibility to remotely configure and communicate with its designated hardware resource. Another particular feature of this implementation is that the same development board can be shared simultaneously by several users by using dynamic partial reconfiguration, thus achieving an improved resource sharing effectiveness. The developed laboratory works are oriented on digital hardware design but also on using the digital hardware for running the mathematical models of renewable energy sources. In order to evaluate the system, an analysis is being presented showing the technical and learning benefits brought by using this virtual platform.

Keywords: remote lab; distance learning; hardware design; System-on-Chip

Vladimir Djurica and Miroslav Minović 877–886 Linux Based Virtual Networking Laboratories for Software Defined Networking

With the fully mature and a vast number of available virtualization solutions, there is an uptake in creating the opportunity for remote and/or virtual laboratories to either supplement or fully replace physical networking laboratories. Our approach focuses on nodes, rather than environments hosting the nodes. The paper addresses setting up virtual laboratories made of widely available, general purpose, operating systems based on Linux that act as a network operating system. We discuss several Software Defined Networking solutions, and lay out the configuration setup for virtual laboratories. We evaluate them by the opportunity they provide in the context of learning and a potential experience. We conclude with an observation that with an increasing number of Linux based network operating systems, management of network forwarding devices becomes management of servers, which leads to the unification of the cloud fabric.

Keywords: remote laboratory; virtual classroom; education in computer networking; Linux-based network operating systems

Nikolas Galanis, Enric Mayol, Maria José Casañ and Marc Aliet 887–897 Towards the Organization of a Portfolio to Support Informal Learning

The accelerating change that the society is experiencing worldwide is exposing the weaknesses in the education system we have inherited from previous generations. Every year lots of kinds of jobs disappear and new job descriptions are being created as well. Lifelong learning is no longer a theoretical concept, but a very real need for most people. Not all learning comes from formal education processes. Students and professionals are getting actionable knowledge from all kinds of sources and activities.

Thus, informal learning, alongside competence-based learning and learning outcomes is getting a lot of attention lately from human resources departments, academics and policy makers. A number of countries and organizations are busy defining guidelines for validating and evaluating informal learning experiences and formalizing its outcomes. In a globalized society where technology has brought together different cultures and educational systems, managing to keep track of a learner's competences is a daunting task, and especially when trying to take into account the competences acquired through informal means.

In this paper, we propose a framework to gather, enhance, organize, evaluate and showcase a user's informal learning using a social approach to engage the learners to use the system by providing valuable recommendations, contacts and feedback.

Keywords: informal learning; non-formal learning; e-learning; eLearning; lifelong learning; social learning; validation; evaluation

Martín Llamas Nistal, Fernando A. Mikic 898–907 BeA Add-ons to Support On-line Assessment and to Improve Review Communications
Fonte, Manuel Caeiro Rodríguez, Adrián Queipo Pardo and Martín Liz Domínguez

During the last years, ICTs (Information and Communication Technologies) have been used extensively for supporting teaching and learning processes for both distance and in-person scenarios. In case of in-person scenarios, a key part of these processes involves the assessment of the students using written exams. BeA (Blended e-Assessment) has been developed for addressing this kind of assessments with ICTs. This platform supports the streamlining of the whole cycle required for assessing traditional written exams from preparation to print in paper, to grade and review on-line. This paper introduces new developments in BeA to support also on-line assessment and automatic grading of written multiple-choice tests, and communication facilities to allow student-professor communication during the reviewing stage. Using these facilities professors have more options to prepare exams and tests, and different assessment processes, including self-assessment, are facilitated in a more comprehensive way.

Keywords: e-assessment; e-marking; on-line grading

J. Ángel Velázquez-Iturbide and Antonio Pérez-Carrasco 908–917 Using the SRec Visualization System to Construct Dynamic Programming Algorithms

Dynamic programming is a demanding algorithm design technique. In this article, we introduce an extension of the recursion visualization system SRec, intended to support dynamic programming. The contributions of the chapter are threefold. Firstly, we present SRec support to several phases of the systematic development of dynamic programming algorithms: generation of recursion trees, checking recursion redundancy in a recursion tree, generation of the dependency graph associated to a recursion tree, and matching the graph to a table. These facilities require high degree of interactivity to be effective. The article illustrates these facilities with the construction of a dynamic programming algorithm for the 0/1 knapsack problem. Secondly, we address several pragmatic issues: usage in educational scenarios, our experience with dynamic programming algorithms, and limitations. Thirdly, the article reports on the results of an evaluation of the system usability. The results were very positive, providing evidence on the adequateness of extensions. Furthermore, they allowed identifying minor opportunities for improvements.

Keywords: algorithms; multiple recursion; dynamic programming; program visualization; human-computer interaction; SRec

Miguel Á. Conde, Lidia Sánchez-González, 918–926 Application of Peer Review Techniques in Engineering Education
Vicente Matellán-Oliviera and Francisco J. Rodríguez-Lera

Improving students' involvement in universities classes is a challenging problem. This problem is particularly relevant in technical studies, even worst in computer related subjects where students tend to be very independent. In this paper, we propose the use of peer review as a methodology that can help students to get more involved and to develop specific abilities has critical thinking. We have successfully used this approach in three different courses in different years (freshman and sophomore) and different studies. Quantitative and qualitative data was collected during these experiences to evaluate students' opinion and performance. This information is analysed and discussed in the paper and our conclusions are also highlighted as well as some ideas for future improvement.

Keywords: peer review; technical studies; evaluation; workshop

In any organization, the individual is considered an issuer of knowledge who can improve corporate knowledge, and learning is considered to be a key factor in promoting the creation of knowledge. As the knowledge of the individual increases, the organization's knowledge also increases. The same happens in educational institutions, but there is a tendency in most educational methodologies to consider the student as a mere recipient of knowledge. This paper presents a model where the student is shown as a knowledge issuer both for their own benefit and for their peers. The key idea is the transfer of knowledge produced by students to organizational knowledge through the knowledge management system the Collaborative Academic Resources Finder (BRACO, for its acronym in Spanish). At the same time, certain quantitative measurement instruments provide insight into student perception of the use of this knowledge in a particular subject in their engineering degree studies as well as the measure of BRACO impact on their learning outcomes. The results of this work show that an experimental group obtained higher scores in tests than a control group. Results also show that BRACO had a significant impact on learning, and students promoted, organized and used the resources generated by fellow students.

Keywords: knowledge spirals; knowledge sharing; cooperative learning; learning content management system; repository; teamwork competence; higher education