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Special Issue

Innovative Methods of Teaching Engineering

Guest Editor

Francisco José García-Peñalvo, University of Salamanca, Spain

Ricardo Colomo-Palacios, University Carlos III of Madrid, Spain

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This article presents a proposal for applying mobile technology in teaching laboratory and the threefold purpose of creating a safer environment for students, enhancing their culture of safety, and training engineers sensitized to safety, which eventually will allow them to make responsible decisions in their professional practice.

Keywords: mobile technology; augmented reality; safety in educational lab; engineering education

Noemí Merayo, Guillermo de las Herad, Juan C. Aguado, Ramón J. Durán Ignacio de Miguel, Patricia Fernández, Rubén M. Lorenzo and Evaristo J. Abril	702–712	The Software Application AIM-Mobile Learning Platform to Distribute Educational Packets to Smartphones
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In this article, we propose the design and implementation of m-learning strategies to enhance the quality of the teaching-learning process in engineering degrees. In the new Higher Education framework students become the main characters, as well as their learning capacity and their autonomy to acquire the required skills. The integration of technology by means m-learning strategies allows the adaptation to the new university scenario, especially in engineering degrees due to their high complexity. Therefore, we propose to design a multiplatform software application, called AIM-Mobile Learning platform, focused on designing and delivering interactive learning packets to smartphones and tablets. In particular, the software platform permits teachers to easily develop educational material accessible by students from anywhere and anytime. This functionality is very attractive, because when technology is introduced in the educational framework it should be taking into account that existing contents have been designed over time using other techniques, and teachers cannot waste a lot of time to continuously adapt these contents to new technologies. Even more, another advantageous functionality of the software platform is that teachers can integrate different educational resources into the same packet, such as text, images or video-tutorials. Then, students can easily download these didactic resources in their smartphones or tablets, making the teaching process more dynamic and attractive than traditional methodologies. Apart from safeguarding previous developed contents our proposal aims to increase the motivation and the autonomous learning process of students. This mobile learning strategy promotes the individuation chance of the students' learning process, since they can use and adapt these interactive learning packets according to their abilities, objectives and skills. On the other hand, a quite interesting strength of the tool is that, although it was initially designed for High Education Engineering degrees, its implementation in other disciplines and educational levels is direct and simple. Indeed, the software tool has been designed so that teachers do not require a deep knowledge of informatics. Consequently, the designed platform could be used in multidisciplinary scenarios and different educational contexts.

Keywords: educative software; multidisciplinary engineering application; mobile-learning; Android; iOS; engineering degrees; optical communication laboratories

Quang Tuan Le, Akeem Pedro, Chung Rok Lim, Hee Taek Park, Chan Sik Park and Hong Ki Kim	713–725	A Framework for Using Mobile Based Virtual Reality and Augmented Reality for Experiential Construction Safety Education
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Due to the complex working environment, construction site still presents high accident rate, causing serious project delays and cost overruns. Safety education is important in promoting a safe and healthy working environment in construction; however current pedagogical methods and tools at the tertiary level are unable to provide students with realistic and practical safety experiences. This study proposes a framework for using mobile based Virtual Reality (VR) and Augmented Reality (AR) for experiential construction safety education. The framework consists of the following three modules: Safety Knowledge Dissemination (SKD), Safety Knowledge Reflection (SKR), and Safety Knowledge Assessment (SKA). The system prototype was developed and evaluated with case studies to identify the system's benefits and limitations. The results concluded that using mobile based VR+AR would improve construction safety & health effectively.

Keywords: mobile computing; construction safety; virtual reality; augmented reality; experiential learning; safety education

Gonzalo Esteban, Camino Fernández, Miguel A. Conde and Vicente Matellán	726–735	Learning Systems through Haptic Simulators—A Domain Expertise Approach
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Teaching and learning does not only imply transferring knowledge, but also experience. And there is a special kind of experience that involves the use of hand skills and both visual-spatial and bodily-kinesthetic intelligence. One possible solution involves the use of knowledge-based systems to transmit expertise through virtual reality simulators. These simulators have to include the sense of touch, so haptic devices are needed. They have also to act as teaching/learning tools whose goal is to improve students' performance, so individual assessment is a vital characteristic. In order to fulfil these requirements, a framework and the associated methodology for building haptic simulators as learning objects is proposed. The use of this framework reduces the time to develop haptic simulators by using software engineering and including expert knowledge as the core of the system. There are two main

actors, besides the user, involved in the development of every new simulator: the expert and the engineer. The expert brings the knowledge to be included in the simulator. The engineer is in charge of building the system using the framework as foundation. The main fields where haptics are being used are engineering and surgery. A proof of concept on surgery is included bringing together engineering and surgery.

Keywords: software engineering; e-learning system; design patterns; haptics; expert knowledge

**David Fonseca, Ernest Redondo,
Sergi Villagrasa and Xavier Canaleta** 736–750 Assessment of Augmented Visualization Methods in Multimedia Engineering Education

This paper presents a mixed-method study that combines quantitative and qualitative techniques to evaluate the technological profile and the motivation and satisfaction of Multimedia Engineering degree students using augmented visualization methods. New uses of technology in the education framework have been extended to all levels and sectors, but these innovations require approval, validation and evaluation by the final users (i.e., the students) to ensure that they are suitable. In this paper, we will discuss the advantages and disadvantages of applying mixed evaluation technology in a case study of the use of interactive and collaborative tools for the visualization of 3D virtual models in a subject related to a Multimedia Engineering degree. The main objective is to evaluate whether our students are prepared to use the systems proposed, and to determine if the designed experiment generates an increase in the motivation and satisfaction using new devices and systems to visualize complex models. Results showed that the combination of mixed-methods allowed us to obtain adequate feedback to improve future iterations of this type experiment.

Keywords: user experience; mixed method research; multimedia engineering innovation; augmented reality, motivation and student satisfaction

**Daniel Rodríguez-Cerezo, Antonio
Sarasa-Cabezuelo, Mercedes Gómez-
Albarrán and José-Luis Sierra** 751–763 User-Centered Development of Generative Educational Systems for Computer Engineering: The *Evaluators* Case Study

This paper describes the development of *Evaluators*, an educational system oriented to the generation of different kinds of interactive simulations for introductory Compiler Construction courses in Computer Science and Computer Engineering degrees. *Evaluators* consists of three main instructor-oriented components: (i) an authoring tool that instructors use to author collections of exercises concerning attribute grammars, which are a basic formalism for describing language processing tasks, (ii) a generator, which is able to automatically generate different kinds of interactive simulations from these batteries of exercises, and (iii) an analytic tool used to assess student performance by analyzing the logs recorded while students use the simulations. The underlying development principles behind *Evaluators* promote: (i) a generative approach to the production of interactive simulations from high-level descriptions of exercises, and (ii) a user-centered approach, according to which the system was iteratively enhanced according to the continuous assessment of the successive versions of the system with instructors and students. In this way, these principles illustrate a development approach centered on the construction of generative educational software (instead of on the construction of individual applications) and guided by a continuous assessment of this software with end users (not only students, but also instructors), which can be meaningfully extrapolated to other fields of Engineering Education.

Keywords: development process model; application generators; computer science and computer engineering education; attribute grammars; compiler construction courses

**P. Molins-Ruano, C. González-Scaristán,
F. Díez, P. Rodríguez and G. M. Sacha** 764–770 An Adaptive Model for Computer-Assisted Assessment in Programming Skills

In this work, we show a methodology aimed to improve the quality of the assessment process for subjects related to basic programming. The method takes into account the relevance of the items and the students' answers to follow different paths to improve the accuracy of the assessment process. We have developed numerical simulations and experiments with real students that demonstrate the advantages of this model when compared with traditional evaluation tools. This method improves the objectiveness and takes into account the relevance of the subject contents. We also demonstrate that the architecture of the algorithm is fully compatible with traditional multiple choice test formalisms. Our results can be directly used in computer-assisted tests for different subjects and disciplines, as well as used by the students as a self-evaluation tool with the objective of correcting their deficiencies in the learning process.

Keywords: completion tests; computerized adaptive tests; programming skill evaluation; student modeling

Lasse Hakulinen 771–785 Using Alternate Reality Games to Teach Computer Science Concepts—Case: Stop Toilworn Diamond

Alternate reality games (ARG) are games that deliver an interactive narrative to the players using different types of media. ARGs often blur the boundaries of reality and fiction and entice players to collaborative puzzle solving in order to solve a mystery or quest included in the game. In this paper, we describe an alternate reality game that was organized to study the potential of using ARGs in education and especially in computer science education. The game was evaluated in terms of how authenticity, intrinsic motivation, and replayability were taken into account in the game design. Furthermore, the learning effects of the game were evaluated by analyzing the feedback collected after the game as well as the spontaneous player discussions during the game. The results show that the players were able to learn various computer science concepts because of the game. Furthermore, the discussions during the game showed how the players were solving the puzzles collaboratively. Main themes that emerged from the feedback about positive aspects of using ARGs in educational settings as well as possible issues are also discussed in the paper. The educational potential of alternate reality games is not limited to a certain discipline and the results reported in this paper can also be applied to topics other than computer science.

Keywords: alternate reality game; serious game; game-based learning; collaborative learning; informal learning; computer science education

**Michel Galaup, Frederic Segonds,
Catherine Lelardeux and
Pierre Lagarrigue** 786–797 Mecagenius[®]: An Innovative Learning Game for Mechanical Engineering

The present paper provides a description of Mecagenius[®], a learning game to teach mechanical engineering at an engineering faculty. Firstly, the Mecagenius[®] game and learning content are introduced before practical ways of integrating this application in educational activities are explored in relation to the skills the teacher seeks to transmit knowledge. This is followed by a review of the literature on the educational effectiveness of serious games. Secondly, the learning game experience of Mecagenius[®] on a course is reported, providing evaluations from both students and teachers. Interviews with teacher and students together with the collected computer records allow for an assessment of the advantages and drawbacks of teaching and learning with this kind of tool. Through a qualitative analysis of students' game reports, the different strategies used in this educational environment are assessed.

Keywords: Serious game; learning game; learning; mechanical engineering; higher education; Mecagenius[®]

This article describes the experience of using Action-Research as the method to study the educational reality of robotics teaching in the Computer Engineering Degree, to improve its comprehension and to achieve its transformation in line with the European Higher Education Area (EHEA). The systematic process of the educational practice modification is detailed: problem detection, plan formulation to solve it, implementation in the classroom and evaluation of the obtained results based on the evidence collection and analysis. These evidences are taken from questionnaires, students performance and teacher reflection during different academic years, applying Action-Research in the classroom.

Keywords: action-research; engineering education; robotics, computer science engineering, European Higher Education Area (EHEA).

Jorge de la Torre Cantero, 805–813 STELLA 3D: Introducing Art and Creativity in Engineering Graphics
José Luis Saorín, Dámari Melian and Celine Meier Education

The current higher education curriculum is designed based on the acquisition of skills. In engineering degrees at Spanish Universities, the improvement of spatial skill is a basic competence to develop together with other general ones such as the ability to make a decision, teamwork, creativity and so on. There is much research work related to the improvement of spatial skills in engineering but the same does not happen with the incorporation of artistic and creative aspects, for instance teaching methodology. In La Laguna University, all along the 2013/2014 academic year in the subject First Year Engineering Graphics Studies, a workshop on creative tridimensional modelling (Stella 3D) has been carried out. Its objective is to improve the spatial skill competence which uses traditional concepts of normalised views. The above-mentioned workshop starts from a pictorial work of art by Frank Stella that will be used as a normalised view from which we will be able to generate different tridimensional solutions. Before and after carrying out the experience, aspects such as spatial skill, knowledge about normalised views and students' opinion about creativity in engineering are measured. The obtained results show us that Stella 3D workshop may be a creative tool which does not only help to improve knowledge but also develops competences such as spatial skill and creativity.

Keywords: creativity; spatial ability; 3D modeling; STEM education

Jorge Martín-Gutiérrez, 814–828 Improving the Teaching-Learning Process of Graphic Engineering Students
Melchor García-Domínguez, Alejandra Through Strengthening of their Spatial Skills
Sanjuán-Hernández, Cristina Roca-González and Jesús Romero-Mayoral

The engineering profession, in its various branches, is developed around the design, planning, construction, maintenance, etc. of products, equipment and services that are characterized by three-dimensional realities. Consequently, one of the skills that all engineering professionals must develop extensively during their training is the mental handling of this three-dimensional reality. This competence is called a Spatial Skill, a cognitive skill that, with the proper training, may be improved. Teachers of Graphic design must therefore develop a series of learning activities that enable students to acquire, develop and improve their spatial skill levels. For this purpose, we have developed training using several technologies, such as Virtual Reality (VR), Augmented Reality (AR) and PDF3D. In this paper we have compared these three technologies with the intention of finding which one(s) of them yields the best results as a training tool and improves the academic results of students in the subject of Engineering Graphics.

Keywords: virtual reality; augmented reality; PDF3D; spatial skill; rate of return; success rate

Á. Fidalgo-Blanco, D. Leris, 829–838 Monitoring Indicators for CTMTC: Comprehensive Training Model of the
M. L. Sein-Echaluce and F. García Teamwork Competence in Engineering Domain

This paper proofs three initial hypotheses in relation with the teamwork competence, Firstly, the new university students access to the University without enough knowledge about teamwork competence because they have not been trained or evaluated in this competence. This justifies the use of our Comprehensive Training Model of the Teamwork Competence (CTMTC) method, which allows individualized training and assessment of teamwork competence in all the stages, including the outcome of this teamwork too. Secondly, the realised fieldwork for obtaining indicators that allow evaluate the required effort in order to use CTMTC, focusing on aspects of monitoring (formative evaluation) and outcomes (summative evaluation) and also the enormous effort in time for the teachers to carry it out, are shown. Thirdly, the final evaluation grades obtained by the teams and by their individual members, with the CTMTC method, justify the need of applying that personalized evaluation method and the search of technological tools, such as learning analytics, to help its implementation.

Keywords: teamwork; competences; learning analytics; white-box testing

Carlos López, Raúl Marticorena, 839–850 Acquisition of Transferable Skills Associated with Software Maintenance
José Francisco Díez-Pastor and and Development Using Tools for Versioning and Task Management
César Ignacio García-Osorio

Tools for version control and task planning allow monitoring and collecting information on the software development and maintenance processes. This work describes the use of these types of tools in subject modules related to these fields. Instead of simply describing the tools as part of the subject content, the idea is to use them to promote and evaluate the acquisition of certain generic skills related to the subjects. After selecting the skills, this paper surveys the possible tools and their field of application at different levels of mastery, and concludes with an analysis of the impact of selected tools in the acquisition of those skills. This analysis was conducted through surveys of students from different courses in the knowledge area of software engineering.

Keywords: software engineering education; software configuration; management tools; transferable skills; organizational skills

Antonio Balderas, Juan Manuel Dodero, 851–862 A Domain Specific Language for Online Learning Competence Assessments
Manuel Palomo-Duarte and
Iván Ruiz-Rube

Learning outcomes in higher education are defined as competencies, which are either specific or generic. The former refers to those skills specific to the subject studied. The latter, also known as transferable skills, refer to other capabilities that a capable professional has to put into practice to work in real-world. Generic competencies are usually shared amongst most science fields, and include teamwork, leadership and self-criticism. These skills are inherently difficult to assess, as they are not usually considered in traditional engineering assessment procedures. As a result, lectures usually have to assess them using subjective information. This is especially problematic when the number of students increases. In this paper, we introduce Simple Assessment-Specific Query Language (SASQL), a Domain Specific Language (DSL) to alleviate this issue. It is a formal language that can be automatically processed to execute SASQL sentences using an assessment-specific vocabulary. SASQL has a simple syntax, oriented to learning assessments. Using our proposed workflow, a course coordinator can extract different objective indicators to assess competencies defined in the syllabus using simple queries. Such indicators are automatically extracted from the activity logs generated by the Learning Management System (LMS). Two case studies with Moodle LMS-based courses are carried out to explain how such indicators can be obtained and how to interpret the results obtained for student assessments.

Keywords: online learning; competence assessment; technological support in online education; domain-specific languages; learning analytics

Project oriented courses became a global trend among best engineering universities around the world in the past decade. They teach students not only core academic knowledge, but face students with real problem solving situations, where they need to express and develop their other virtues and skills, e.g. working in multidisciplinary teams, time and task management, problem solving, different presentation and communication skills, etc.

In this paper we investigate (multi-) cultural background of virtual team members from two different aspects: how it influences the team's creativity and how various cultural backgrounds of creative team members could lead into different perceptions of particular design features. Multi-cultural background of NPD teams is a complex challenge, which—if not addressed properly—could cause multi-level problems. The results of our first described research clearly indicate how these differences could affect the forming of virtual NPD creative teams and suggest guidelines how to build effective NPD teams. The second research shows that the same design features can trigger different responses in different cultural background. The designers, who design a product for a particular market, should be aware of these differences, which must be addressed with a special care if we want the product to be properly accepted at the desired target of a global market.

Keywords: interdisciplinary virtual teams; creativity; shape perception; multicultural influences

María José Casañ, Nérida Hierro, 874–883 Improving the way to Communicate Learning Activities to an Informal Learning Collector
Nikolas Galanis, Enric Mayol and Marc Alier

Lifelong Learning has been a growing interest in e-learning research communities, in a similar way as other related kinds of learning (formal, non-formal and informal) already had. In fact, the Tagging Recognition and Acknowledgment of Informal Learning Experiences project proposes a framework to manage these types of learning, giving special attention to informal learning. This project gathers informal learning activities with an Informal Learning Collector. The main way for registering informal learning activities data into the Informal Learning Collector is using push mechanisms where the user explicitly introduces such information. In this paper, we present some evaluation of user opinions about this push communication mechanism, and propose an alternative way to communicate informal learning activities data, by using a pull mechanism. Using the pull mechanism, the Informal Learning Collector collects data directly from external applications. After the introduction of the pull mechanism, Informal Learning Collector users have confirmed that usability has been improved significantly.

Keywords: lifelong learning; informal learning; knowledge management; usability; e-learning

M. Á. Conde, F. García, 884–892 The Application of Business Process Model Notation to describe a Methodology for the Recognition, Tagging and Acknowledge of Informal Learning Activities
C. Fernández-Llamas and A. García-Holgado

Learning is a process that takes place anywhere and at any moment of our life. That means that not all learning happens linked to an institution. However, that kind of learning, known as informal learning, is usually invisible for people in charge of organizations. This is because either the learner is not aware of having learned something or because he/she is not able to show or make visible this type of learning to other. In order to facilitate the exploitation of this knowledge, TRAILER project poses a methodology supported by a technological ecosystem. This methodology is quite complex; it involves different stakeholders and components. For defining the methodology, a flexible and understandable notation was used, Business Process Model Notation. It helps in the designing and implementation of the solution and it also has been used to guide experts during the methodology testing.

Keywords: Informal learning; methodology; model; business processes; learners

Enayat Rajabi, Miguel-Angel Sicilia, 893–900 Interlinking Educational Data: An Experiment with Engineering-related Resources in GLOBE
Salvador Sanchez-Alonso and Juan Manuel Dodero

Linking different kinds of engineering learning resources on the Web of Data enables enrichment, ease of navigation, casual discovery and improves resource seeking. This is performed by many tools and approaches built to discover similarities between the entities on the Web. In this paper we present a report primarily focused on evaluating the interlinking of engineering-related resources of a significant educational repository (GLOBE) to one of the most important datasets (DBpedia) on the Linked Open Data (LOD) cloud. After considering various interlinking approaches for link discovery, the paper focuses on the use of one of the interlinking tools (LIMES) and outlines the number of resources linked to the DBpedia dataset. In this empirical study, we report that almost 40,000 engineering resources were matched to the DBpedia concepts. Our findings are also examined as well as classified in various categories by human experts.

Keywords: engineering resources; linked data; interlinking; educational data; GLOBE; LIMES

Miguel Morales Chan, Rocael Hernández Rizzardini, Roberto Barchino Plata and José Amelio Medina 901–911 MOOC Using Cloud-based Tools: A Study of Motivation and Learning Strategies in Latin America

This study describes the motivational and cognitive learning strategies used by students of the large-scale MOOC titled “Cloud-based Tools for Learning,” which consists of using free Web 2.0 tools for learning. It is intended to be used by teachers and training professionals who want to innovate their educational practice. A sample of 230 students (11.2% of the 2045 total students enrolled) participated in the study. They answered the motivated strategies for learning questionnaire (MSLQ). The MSLQ has questions about motivation and cognitive learning strategies used by students in a course. The mean scores of the 5 subscales are classified as low, medium, or high. Students ranked motivational strategies high, with relevance to highlight task value, intrinsic goal orientation, and self-efficacy for learning performance, all of them with a “high” classification. The cognitive learning strategies were also classified “high” but slightly lower than motivational section, which had higher ranks in elaboration, organization, and metacognitive self-regulation. Furthermore, we found a correlation between motivation and cognitive strategies. We provide results from a MOOC given by the Telescope project (an initiative with a similar objective as Coursera or EdX) at Galileo University, Guatemala, a technological university with the longest tradition of computer science within the region. The Telescope project is an initiative carried out by the Galileo Educational System (GES) Department, which is in charge of Educational Technology R&D at the University. We examine the importance and relation between the two components, motivation and learning strategies. Hence, such results contribute to a better understanding of the learning process in this particular MOOC and will enable further discussion and insights to improve didactic strategies and the use of innovative cloud-based tools in future MOOCs.

Keywords: massive open online course, cMOOC, xMOOC, MSLQ, cloud-based tools, learning activities

ACM classification Keywords: K.3.1. K.3.2.