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Special Issue

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Guest Editor

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1311 Editorial

**Antonio Ramalho de Souza Carvalho,
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1312–1321 University Satellite Project—ITASAT: Creating Technological Capabilities

In order to meet the demand for future generations of micro satellites, as well as to build and to accumulate technological capability, the Brazilian Space Agency has established a Government Action which intends to strengthen its space program, mainly through the ITASAT Project (University Satellite). One of the objectives of ITASAT Project, maybe the most relevant one, is to contribute to the human capital improvement by involving university students in the design and development of a small satellite. Thus, this research seeks to understand how capabilities were developed at an individual and a team level, through a process of teaching-learning-teaching, involving a learning-by-doing and learning-by-experiencing support. The methodology used on this research is qualitative, in which the subsystems teams were observed by the researcher during 2010 and 2011. In order to complement and corroborate conclusions based on the observation method, a questionnaire survey was developed, which was applied to a representative sample, aiming to capture students' perceptions regarding learning process and building technological capabilities within the project. Thus, it was observed that students' teams acquired technological knowledge through a teaching-learning method supported by learning-by-doing and learning-by-experiencing processes. The knowledge and skills developed by those teams go beyond the walls of the academy, impacting the Brazilian society and its space industry. Finally, it was concluded that ITASAT Project was a successful learning experience in the field of complex system integration, project management and technical developments accomplished by subsystems teams.

Keywords: technological knowledge; skills; team knowledge

**Fernando Martini Catalano and
Micael Carmo**

1322–1330 The Scientific and Technological Projects Developed Between University of Sao Paulo and Embraer and its Impact on Engineering Education

This work will describe the programs of science and technology development between the Brazilian aircraft industry and the academy particularly those programs developed in aeronautical engineering. It will focus on the Brazilian Silent Aircraft Program which is an initiative of six Brazilian Universities and Institutes with Embraer to develop studies, methodologies and solutions for the aircraft external noise problem. The impact of this initiative in both Industry and academy will also be discussed. As expected both institutions has beneficial spin-offs from this kind of R&D project. For the academy, besides of the incremental of the research laboratories, publication increase and others, the behavior in face of the industry need and time scale is among the most important impact in the whole academic community from under-graduation and graduation students, to faculty researchers and professors. This will better prepare the graduates to cope with the market needs.

Keywords: academy-industry funding; R&D programs; aeronautical engineering education

**Alcinea Z. Sampaio, Daniel P. Rosário,
Ana Rita Gomes and Joana P. Santos**

1331–1347 Virtual Reality Applied on Civil Engineering Education: Construction Activity Supported on Interactive Models

Besides the constant updating of training in the new graphic resources available to engineering and architecture professions, and in widespread and frequent use, the school should also adapt its teaching activities to the new tools of visual communication. In Civil Engineering, the capacity to visualize the construction, management and maintenance of buildings can be added through the use of three-dimensional (3D) models, which facilitate the interpretation and understanding of target elements of maintenance and construction and of 4D models (3D + time) through which the evolution of construction steps and deterioration of materials can be visually demonstrated and understood. Furthermore, the possibility of interaction with the geometric models can be provided through the use of Virtual Reality (VR) technology. The text presents a new perspective of introduction an innovative technology in school. The VR technology is used as a tool to create interactive applications as a part of a research work. The students

involved in this research had to learn advanced software of geometric modeling and visualization and to explore the capacities of a VR technology system. Also, programming skills had to be adapted to establish the integration needed for the creation of virtual prototypes. Moreover, the structure of different kind of databases had to be studied and implemented, integrating diverse types of information, needed to develop the interactive virtual model. The VR technology was introduced in school in order to prepare Civil Engineering students to consider this knowledge as an important support, later in professional activity, and also to facilitate the link between engineering theory and its implementation. The VR applications were developed to be used in the construction activity.

Keywords: research in education; virtual reality; construction activity; interactive model

Y. Gene Liao, Kwo Young and Gregory F. Moss 1348–1361 A University-Industry Partnership for Developing a Learning Environment for Advanced Energy Storage

The escalating demand for energy and the increasing concerns over the environment have called for clean and sustainable energy development. Generating electricity from renewable and clean energy sources such as solar and wind power as well as driving highly efficient vehicles are promising solutions to the energy development strategies. There is a great need for electrical energy storage for the effective commercialization of renewable energy resources, load-leveling, and maintaining a constant supply of electrical energy. Another important factor related to the need of electric energy storage is transportation electrification. The electric energy storage, such as battery and ultracapacitor, is a major electric drivetrain component for vehicle electrification. This paper describes a university-industry partnership in the establishment of learning environment for advanced energy storage that responds to critical need through the creation of laboratory-based undergraduate courses in advanced energy storage systems, tailored with an emphasis on the vehicular and stationary sectors.

Keywords: electric energy storage; energy storage; renewable energy; vehicle electrification

F. Bosi, E. Mazzocchi, I. Jatro, F. Dal Corso, A. Piccolroaz, L. Deseri, D. Bigoni, A. Cocquio, M. Cova and S. Odorizzi 1362–1370 A Collaborative Project Between Industry and Academia to Enhance Engineering Education at Graduate and PhD Level in Ceramic Technology

Results of an intensive and effective industry-academia partnership are presented, demonstrating that barriers to inter-sectoral mobility have been overcome, achieving an enhancement in the quality of both graduate and doctoral programmes in engineering.

The industrial and social needs of improving the ceramic production process and of developing novel advanced ceramic multifunctional materials and structures were essential for the creation of a synergetic cooperation between a world leader industry for Ceramics (SACMI), a medium enterprise specialized in Virtual Prototyping (ENGINSOFT) and an academic research group in Solids and Structural Mechanics of the University of Trento. The research collaboration has lasted several years producing a continuous inter-sectoral and inter-disciplinary transfer of knowledge among the partners and maximising in this way their performance, in particular in terms of added value generated through human capital improvements. An additional impact of the above mentioned cooperation has been the award of a Marie Curie—Industry Academia-Partnership & Pathway four years grant focused on boosting skills exchange between the commercial and non-commercial sectors through secondments of academic staff and PhD students to industry and vice-versa. Moreover, the partnership has led to a significant enhancement in the teaching results, together with an increasing motivation of the students, crucial in the Engineering Education.

Keywords: ceramic industry, transfer of knowledge, FP7-PEOPLE-2011-IAPP Marie Curie Action.

Denis P. Dowling 1371–1376 Impact of a University Spin-In Company on Academic Research: A Case Example

This paper provides an example of how a collaborative research engagement with an advanced technology start-up company has had considerable research and educational benefits to the host academic institution. The start-up company had developed a novel microblast based coating technology for use in the medical device and aerospace sectors. After an initial collaborative research project, the company relocated into the university, renting space in a business incubator unit and also in an engineering laboratory specialising in Surface Engineering. This paper provides an overview of the student impact of the collaborative research activities and details how Irish Government supports facilitated this engagement. As a result of this collaboration to-date 5 post-graduate students are working on projects directly associated with the start-up company and 6 journal papers have been published.

Keywords: industry academic collaboration; research-led; entrepreneurial environment

Imanol García, Enrique Soriano, Higinio Rubio and Jesús Manuel García 1377–1386 Simulator Training for Employees in the Field of Production: A Robert Bosch Gasoline Systems Case

As a result of market globalization and increasing demand of products, companies have to improve their production processes and modify their operations to adjust to changes and be competent. This context is being steadily accentuated in the manufacturing sector, where many companies are conducting research on formative methods that allow engineers and operators, whether newly hired or transferred from other plants of the company, reach the standard production level quickly, thereby achieving and maintaining the necessary level of market competitiveness.

In this paper, we introduce a case of formative software development at the Robert Bosch Gasoline Systems Company (Aranjuez, Spain) that has just begun the implementation of a Lean Transformation project, performed in order to standardise production according to their global benchmarks and thereby improve the productivity of the filter manufacturing lines. During a previous evaluation of production lines, we decided that cultivating employees based on parameters of machine management and the knowledge of their influence on the final product is the key area of concern since it significantly influences production losses and the productivity indicator of each line. In order to achieve this, we focused on the production of diesel filters; a master's student at the company was designated to analyse various formative methods. Finally, we developed a decision-making simulator of the manufacturing parameters. The resultant software was implemented in Visual Basic and Excel, which allowed the integration of the tool in the company's work culture. The simulator was then tested with plant employees, observing the general improvement of knowledge about the production processes of diesel filters. Finally, it was implemented at the factory. We realised that time reduction on technical and on organizational losses led to an increase in the productivity.

Keywords: decision-making; simulator; employee training; manufacturing; filters

A. L. Helleno, A. T. Simon, M. C. O. Papa, W. E. Ceglie, A. S. Rossa Neto and R. B. A. Mourad 1387–1399 Integration University-Industry: Laboratory Model for Learning Lean Manufacturing Concepts in the Academic and Industrial Environments

In the current production scenario, with a globalized economic environment, companies increasingly need to become more competitive to face up to the global market. This means production systems are constantly changing in the direction of the replacement of the low productivity equipment, rearranging the plant layout, the redirection of the transport stream from the supplier to the end customer and adding new models to plan and control production. All these changes aim to improve product quality and to reduce production lead time by eliminating waste, reducing costs and increasing competitive advantage through the process flexibility. For these changes to happen effectively is necessary that the current employees and the future production engineers are inserted and fit in this new reality. Currently, the Lean Manufacturing concepts are applied in an industrial environment to optimize production flow eliminating the waste found in the process. However, there is a challenge to put these

concepts effectively in the industrial environment and in the university environment. The traditional learning process based on teacher, classroom, non-integrated theoretical and practical concepts, case studies with static production characteristic (controlled variable) has been shown to be ineffective in the consolidation of these concepts in a dynamic production environment. In university, this same model applied in the production engineering course and fragmented into different disciplines makes production engineers not fully prepared for the challenges of the new industrial environment, requiring an adjustment period. This adaptation will result in low competitiveness of the company in front of global competitors. Thus, this article aims to present a laboratory model for integrated learning of the Lean Manufacturing concepts based in practices able to reproduce the dynamic production environment, thus speeding the process of training employees of the industrial environment and the learning of future production engineers.

Keywords: engineering education; production engineering; lean manufacturing; learning factory

Antonio Souto-Iglesias, Israel Martínez-Barrios, Mirko Toman, Aaron Fernández-Coracho and Rafael Guadalupe-García 1400–1409 Integrated Learning of Production Engineering Software Applications in a Shipbuilding Context

A course focused on the acquisition of integration competencies in ship production engineering, organized in collaboration with selected industry partners, is presented in this paper. The first part of the course is dedicated to Project Management: the students acquire skills in defining, using MS-PROJECT, the work breakdown structure (WBS), and the organization breakdown structure (OBS) in Engineering projects, through a series of examples of increasing complexity with the final one being the construction planning of a vessel. The second part of the course is dedicated to the use of a database manager, MS-ACCESS, in managing production related information. A series of increasing complexity examples is treated, the final one being the management of the piping database of a real vessel. This database consists of several thousand pipes, for which a production timing frame is defined connecting this part of the course with the first one. Finally, the third part of the course is devoted to working with FORAN, an Engineering Production application developed by SENER and widely used in the shipbuilding industry. With this application, the structural elements where all the outfittings will be located are defined through cooperative work by the students, working simultaneously in the same 3D model. In this paper, specific details about the learning process are given. Surveys have been posed to the students in order to get feedback from their experience as well as to assess their satisfaction with the learning process, compared to more traditional ones. Results from these surveys are discussed in the paper.

Keywords: project management; database, production engineering; mind map; FORAN; MS-ACCESS; MS-PROJECT; erection diagram; ship production.

Kirti Ruikar and Peter Demian 1410–1419 Podcasting to Engage Industry in Project-Based Learning

The value to teaching and learning of industry engagement in engineering education is difficult to dispute. Industry partners provide real-world cases which place in context the theoretical content conveyed by the instructor. Unfortunately, the time and effort required of the industry partner wishing to contribute projects and expertise to a learning programme make it challenging to bring this contribution to fruition. Podcasting offers an opportunity to facilitate this contribution and make it less resource-demanding. Multimedia podcasting content can accommodate the different ways in which students learn (e.g. VARK—Video, Aural, Read/write and Kinesthetic sensory modalities for learning). Multimedia content also addresses the problem of student engagement. This paper describes a case study of an application of podcasting to a final year design module at Loughborough University. The students were assigned a master-planning project on which to work. An industry partner (i.e. the lead architect) was engaged to record an audio-visual session in which he gave an account of the key design considerations and the rationale for the master-planning project. Later, in a dedicated module lecture session, the audio-visual podcast was played. This was the first time the students were introduced to the master-planning project. The students were briefed about the scope of the podcast content in order to ensure that students clearly understood the context and purpose of the podcast. To further contextualise the podcast content, a real scenario directly relevant to the module's intended learning outcomes (ILO's) was selected. The design focus of the module meant that the podcasting project included the architect's account of the design and development processes. The results show that most learning styles were accommodated. The students performed very well in the test and rated the podcast very highly in a questionnaire which solicited their subjective reaction to the experience. It is concluded that podcasts offer genuine value in terms of convenience for industry partners to contribute. The significant value of podcasts to the teaching and learning experience is in the improved engagement and motivation of students, accommodating most learning styles, facilitating self-paced learning and encouraging active participation and learning. Podcasting leverages and augments synergy between industry and academia bringing strong benefits to both.

Keywords: audio-visual podcasts; academia–industry collaboration; project-based learning environments

Yanben Wang and Jurong Bai 1420–1428 A Training Model of Out-standing Engineers: Exploration of School-Enterprise Cooperation Based on Technology Competition

University can build practice platforms by cooperating with enterprises, and carry out technology innovation activities through technology competition. This is an effective way to promote the personnel training system reform and to implement the “Out-standing Engineers education and training plan”. The article analyzes the domestic and international research status, and puts forward a novel competition model based on school-enterprise cooperation, which includes: building technology competition platforms through school-enterprise cooperation; opening proposition around the industry/enterprise requirements; enterprises participating in the evaluation of technology competition; enterprise-oriented talent pool construction; and the industrialization of outstanding works. Through a case of “Up-tech Cup” National Undergraduate Embedded Design Contest, the application of the above model is elaborated. We analyzed the effect of technology competition based on school-enterprise cooperation from the satisfaction survey of students, enterprises, and university. Technology competition based on school-enterprise cooperation effectively promotes the reform of personnel training system and the implementation of “Out-standing Engineers education and training plan” in China. It has certain academic value and application value for holding technology competition and implementing the “Out-standing plan”.

Keywords: Out-standing Engineers education and training plan; technology competition; competition model; school-enterprise cooperation

Kahina Lasfer, Art Pyster and Tal Ben-Zvi 1429–1439 Broad Partnership of an Engineering Program with Industry: A Success Story

As part of its overall strategy, the Systems Engineering (SE) graduate program at an Engineering School has adopted a broad partnership with industry, which consists of sponsorship of professional students to complete a Masters and/or PhD degree in SE. The main objective of the present study is to evaluate the impact of a Graduate Systems Engineering Program (GSEP) of this small university in the workplace through assessment of the program sponsors' satisfaction and the performance of the program's professional student graduates in their jobs. Qualitative and quantitative data were collected for the period 2004–2010 to assess and evaluate GSEP through survey questionnaires, interviews, and course evaluations.

The results of this study revealed that overall up to 95% of the program sponsors and its students are satisfied with the program. The main reasons for partnering with the present studied institution were stated by the program sponsors to be tailoring the program and its courses to their needs and offering the program at the sponsors' sites. Through its broad partnership with industry, GSEP corporate partners were able to successfully deploy SE concepts and understand the value that SE brings to their organizations.

Section II

Contributions in: Cooperative Learning, Retention, Research Based Instructional Strategies, Sustainability, Psychometrics, Web Based Intelligent Tutoring, Simulations, Games, Remote Laboratories, Virtual Laboratories, Multimedia Learning, Project Based Learning, accreditation, STEM Applications, Control Engineering, Electrical and Computer Engineering, Computer Networks, Mechanical Engineering, Production Engineering, Engineering Dynamics, Design Projects

Michael C. Loui, Brett A. Robbins, Erik C. Johnson and Niranjana Venkatesan 1440–1455 Assessment of Peer-Led Team Learning in an Engineering Course for Freshmen

In ECE 110, a required course for freshmen (first-year students) majoring in electrical or computer engineering, students may attend optional supervised study sessions, which implement peer-led team learning. Small, permanent teams of students met weekly in 90-minute sessions, under the supervision of graduate teaching assistants, undergraduate teaching assistants, or undergraduate volunteers. In these sessions, student teams worked on difficult problems adapted from examinations given in previous semesters. We hypothesized that students who attended the study sessions would earn higher scores on examinations, and they would persist at higher rates in engineering. We also sought to describe the affective benefits that students perceived from attending the study sessions. For three semesters, we recorded students' study session attendance and final exam scores. We surveyed students to obtain their average hours each week spent on ECE 110 and to gauge the perceived benefits of the sessions. We performed linear regression and analysis of covariance tests on the numerical data to analyze student performance. To analyze retention (persistence), we used data about the courses that students took immediately after ECE 110 to form two-way contingency tables. In all three semesters, regular session attendees did not have significantly higher persistence rates, but they scored significantly higher on final exams. Regular attendees reported that they improved their understanding of the material, and made new friends. Some students began to see peers as helpful sources of knowledge. In summary, regular attendance in peer-led team learning sessions benefits students both academically and socially.

Keywords: cooperative learning; peer-led team learning; workshop; first-year students; retention

Maura Borrego, Jeffrey E. Froyd, Charles Henderson, Stephanie Cutler and Michael Prince 1456–1471 Influence of Engineering Instructors' Teaching and Learning Beliefs on Pedagogies in Engineering Science Courses

This study explored how academics' beliefs about teaching and learning influenced their teaching in engineering science courses typically taught in the second or third year of 4-year engineering undergraduate degrees. Data were collected via a national survey of 166 U.S. statics instructors and interviews at two different institutions with 17 instructors of engineering science courses such as thermodynamics, circuits and statics. The study identified a number of common beliefs about how to best support student learning of these topics; each is discussed in relation to the literature about student development and learning. Specific recommendations are given for educational developers to encourage use of research-based instructional strategies in these courses.

Keywords: engineering science; faculty beliefs; research-based instructional strategies; statics

Ranjani Rao, Alice L. Pawley, Stephen R. Hoffmann, Monica E. Cardella and Matthew W. Ohland 1472–1489 An Ecofeminist Grounded Analysis of Sustainability in Engineering Education: Skill Set, Discipline, and Value

Sustainable engineering has been highlighted in many national reports as a key component of the education of engineers of the future. Yet faculty perceptions of sustainable engineering as 'soft' and outside the boundaries of engineering prevent its widespread inclusion in the engineering undergraduate curriculum. In this paper, we demonstrate how ecofeminist theory could be used to understand the inferior status that sustainable engineering currently occupies in the disciplinary hierarchy. To characterize the ongoing debates and tensions underlying acceptance of sustainability as part of the engineering process as well as of engineering education, we have closely analyzed 42 out of 150 articles published in the area of engineering education using inductive grounded theory, and we relate our themes and sub-themes to ecofeminist theory. The first theme considers sustainability to be a challenging skill set for the future engineer; the second emphasizes the disciplinary aspects of sustainability; and the third theme looks at the normative aspect of sustainability as value-based engineering. We found it helpful to use ecofeminism as a framework for thinking how sustainability's marginalization in engineering education could be related to its 'soft' ness, its chaotic and system-level character, as these aspects align it not with the core of engineering but rather with the marginalized 'feminine.' This framing should help us reconceptualize how we talk about sustainability in engineering education to make it a more integrated and valued concept for future engineering students.

Keywords: sustainability; sustainability education; grounded theory; literature analysis; content analysis

Mary Kathryn Thompson, Line Harder Clemmensen and Beung-uk Ahn 1490–1502 Effect of Rubric Rating Scale on the Evaluation of Engineering Design Projects

This paper explores the impact of the rubric rating scale on the evaluation of projects from a first year engineering design course. A small experiment was conducted in which twenty-one experienced graders scored five technical posters using one of four rating scales. All rating scales tested produced excellent results in terms of inter-rater reliability and validity. However, there were significant differences in the performance of each of the scales. Based on the experiment's results and past experience, we conclude that increasing the opportunities for raters to deduct points results in greater point deductions and lower overall scores. Increasing the granularity of the scale can reduce this effect. Rating scales that use letter grades are less reliable than other types of scale. Assigning weights to individual criteria can lead to problems with validity if the weights are improperly balanced. Thus, heavily weighted rubrics should be avoided if viable alternatives exist. Placing more responsibility for the final score on the grader instead of the rubric seems to increase the validity at the cost of rater satisfaction. Finally, rater discomfort can lead to intentional misuse of a rating scale. This, in turn, increases the need to perform outlier detection on the final scores. Based on these findings, we

recommend rating scale rubrics that use simple 3 or 4-point ordinal rating scales (augmented checks) for individual criteria and that assign numerical scores to groups of criteria.

Keywords: engineering design; evaluation; rating scale; rubric; psychometrics

Ning Fang and Yongqing Guo 1503–1513 A Web-Based Interactive Intelligent Tutoring System for Enhancing Student Learning in a Foundational Engineering Dynamics Course

Extensive literature review shows that no intelligent tutoring systems (ITSs) were developed for engineering dynamics, a second-year core course that nearly all undergraduates majoring in mechanical, aerospace, civil, environmental, or biomedical engineering are required to take. This paper describes two innovative, web-based, interactive ITS modules that we developed for and implemented in an engineering dynamics course to help students learn how to apply the Principle of Work and Energy, one of the most important dynamics principles, to solve particle and rigid-body dynamics problems. This paper describes in detail how the two ITS modules were designed, and specifically such aspects as the determination of learning objectives, the design of corresponding dynamics problems that the ITS modules address, the selection of ITS authoring software, and the design of the layout of the interactive computer graphical user interfaces of the ITS modules. Two cohorts of engineering undergraduates during a control semester and a treatment semester participated in the present study. The results of pretests and posttests in the control and treatment semesters show that the two ITS modules increased class-average student learning gains by 36.8% and 43.0%, respectively. In an anonymous questionnaire survey that was administered at the end of the treatment semester, many students used the words “hints” and “step-by-step process” to describe how the ITS modules enhanced their learning. It is suggested that given their level of flexibility, intelligent tutoring systems should be used as a supplemental tool to enhance learning, rather than a tool to completely replace students’ experiences with human instructors and human tutors.

Keywords: engineering dynamics; interactive web-based intelligent tutoring system; student learning; conceptual understanding; procedural skills

Juthamas Choomlucksana and Toni L. Doolen 1514–1526 The Impact of Collaborative and Simulation Sessions on Learning Lean Principles and Methods: A Multi-institutional Study

Industrial experts have implemented lean methods globally since the late 1970s in response to difficult economic conditions, as well as to compete in an increasingly global and difficult marketplace. The application of lean methods has been used to eliminate non-value added activities from business and manufacturing operations. By eliminating non-value added activities, organizations have been able to reduce costs, improve process flows, and increase value for customers. The popularity and benefits of lean methods have led to a demand for an engineering curriculum that includes lean principles and methods. Engineering student learners often do not have experience in manufacturing operations at the point in which they are introduced to lean principles and methods in their studies, thus selecting appropriate teaching methods is important in ensuring that students develop a working knowledge of how to apply lean tools. Previous research has demonstrated the importance of learner perceptions specifically, the role of self-efficacy beliefs and attitudes in motivation and in academic performance. Moreover, researchers have found that the use of collaborative activities and simulation can positively impact learning. However, few previous studies have reported on the impact of interactive sessions on learner perceptions, including self-efficacy beliefs and attitudes, and the possible impact of these effects on learning. This study sets out to examine the impact of self-efficacy beliefs and attitudes, resulting from the use of collaborative and simulation sessions on the learning of lean principles and methods. Participants in this study were undergraduate students, primarily engineering students, from three universities. Data were analyzed using paired t-tests. Based on the analyses, it was found that the sequencing of sessions was an important variable. The findings also suggest that the use of collaborative and simulation sessions has a positive impact on learner self-efficacy and on some learner attitudes.

Keywords: lean manufacturing; collaborative learning; simulation; self-efficacy beliefs; learner attitudes

Biljana Cvetić, Dragan Vasiljević and Ivana Mijatovic 1527–1536 Design and Application of a Decision Support Tool for the Selection of Logistics and Supply Chain Management Games

The focus of this paper is on the design and application of a new original decision-making support tool for the selection of logistics and supply chain management (SCM) educational games. The design of a decision support tool for the selection of these games (hereafter, DST SLSCMG) was followed by a case study which demonstrates the application of the DST SLSCMG, and the evaluation of the use of the games. The proposed DST SLSCMG is based on the database of 55 identified logistics and SCM games and components, which enable performing a multi-criteria analysis. It is applied at an engineering school for the selection of the most suitable games for two logistics and SCM-related courses. The results of the evaluation of the use of the games showed that students were very satisfied with the games selected with the help of the DST SLSCMG. The new DST SLSCMG offered here can help interested educators to assess the available logistics and SCM games and select the most suitable ones.

Keywords: games; decision support tool; logistics; supply chain management; selection.

Pablo Gil, Francisco A. Candelas, Carlos A. Jara, Gabriel J. García and Fernando Torres 1537–1550 Web-Based OERs in Computer Networks

Learning and teaching processes are continually changing. Therefore, the design of learning technologies has gained the interest of educators and educational institutions from secondary school level to higher education. This paper describes the successful use in education of social learning technologies and virtual laboratories designed by the authors, as well as videos developed by the students. These tools, combined with other open educational resources that are based on a blended-learning methodology, have been employed to teach the subject of Computer Networks. We have not only verified that the application of Open Educational Resources (OERs) into the learning process leads to a significant improvement of the assessments, but also that the combination of several OERs enhances their effectiveness. These results are supported first by a study of both students’ opinion and students’ behaviour over five academic years, and, secondly, by a correlation analysis between the use of OERs and the grades obtained by students.

Keywords: educational technologies; computer science education; computer networks; virtual laboratories; e-learning

Arquemedes Barrios, Mauricio Duque, Michael Canu, José Luis Villa, Philippe Chevrel, Victor H. Grisales, Flavio Prieto and Stifen Panche 1551–1563 Academic Evaluation Protocol for Monitoring Modalities of Use at an Automatic Control Laboratory: Local vs. Remote

This article describes an Academic Evaluation Protocol (AEP) designed and implemented in order to monitor various modalities of using an Automatic Control Laboratory by analyzing the quality of work that can be obtained from a specific student group when the proposed experimental practice is being conducted according to a particular type of lab-work modality. To serve this purpose, the types of use-modalities associated to different lab-works are classified as follows: Local Real Laboratory (RL), Remote Laboratory (R@L) and Local plus Remote Laboratory (RL+R@L). To estimate how a specific lab-work modality impacts upon the development of an experimental practice, parameters such as average utilization time and the ABET-Indicators are used. The results obtained from this pedagogical instrument are analyzed by various means, namely the ANOVA Test, a Descriptive Statistical Technique and Wilcoxon Testing. The findings reveal that the student groups involved in experimental lab-practices following the RL and RL+R@L modalities achieve better performance (when conducting the automatic control laboratory) than the student groups served with the remote system only. The analysis performed indicates that there is no statistical difference

between working at the Local Laboratory (RL) or at a Local plus Remote Laboratory (RL+R@L). As a result, the use of the remote system combined with the local one does not improve significantly the ABET score, ruling out the idea that by placing special interest in using only the remote system, an improvement in students' comprehension is achieved.

Keywords: local laboratory; remote laboratory; Academic Evaluation Protocol (AEP); ABET Indicators

Joanna K. Garner and Michael P. Alley 1564–1579 How the Design of Presentation Slides Affects Audience Comprehension: A Case for the Assertion–Evidence Approach

Engineering educators often create slides for classroom presentations to instruct students. In turn, engineering students often create slides for classroom presentations to demonstrate what they have learned. Given how often presentation slides are projected and viewed by engineering educators and students, those slides should follow principles of multimedia learning to foster high audience comprehension. Unfortunately, Microsoft PowerPoint, which is the dominant program for creating slides, does not incorporate these principles into its defaults. As a result, most educators and students in engineering create slides that violate these principles. To determine the effect of this violation, we compared learning outcomes in 110 engineering students who viewed a technical presentation in which the slides either integrated or violated six multimedia learning principles. The presentation slides that adhered to the six multimedia principles followed the assertion-evidence approach, while the presentation slides that violated the six multimedia principles followed commonly practiced defaults of PowerPoint. Essay responses from the 110 engineering students revealed superior comprehension and fewer misconceptions for the assertion–evidence group as well as lower perceived cognitive load. In addition, stronger recall occurred in this assertion–evidence group at delayed post-test. These findings support the use of the assertion–evidence structure for presentations in engineering education.

Keywords: presentation slides; PowerPoint; assertion–evidence; multimedia learning

Douglas W. Stamps 1580–1590 A Vertically Integrated Design Sequence

A model of an integrated design curriculum is presented that features the vertical integration of topical themes and fully vertically integrated teams composed of freshmen through seniors working on common projects. The five-course integrated design curriculum is a degree requirement that consists of one course each spring for freshmen through juniors and a two-semester senior capstone sequence. Topics that are vertically integrated include learning design through project-based learning, learning a common software package for the design projects, and learning professional skills that are used to manage the projects and teams. The integrated design courses also provide scaffolding to develop a skill set for non-seniors to work on senior-led vertically integrated teams. The integrated design model was introduced into the curriculum to provide multiple opportunities for students to develop technical and professional skills as compared to the traditional two-semester capstone design course. Student evaluations show that, on average, the integrated design sequence had a greater impact on the development of technical and professional skills than the traditional senior capstone design sequence.

Keywords: vertical integration; engineering design; project-based learning; teamwork; senior capstone

M. Tunde Oladiran, Giuditta Pezzota, Jacek Uziak and Marian Gizejowski 1591–1603 Aligning an Engineering Education Program to the Washington Accord Requirements: Example of the University of Botswana

The accreditation systems of engineering education programs governed by the Washington Accord have evolved in order to respond to modern technological and scientific development. The principal purpose of the paper is to indicate that the process re-engineering model commonly employed in business environments can also be used in an educational system. In particular, the paper describes the process of re-engineering used for the transformation of the BEng (Mech) program in order to align it with the accreditation requirements. The study adopts a Business Re-engineering Process (BRP) in which engineering education is considered as a process. A modified McKinsey's re-engineering model was chosen as a tool to re-engineer the educational system. The model involves five broad phases, namely, identification, review & analysis, re-design, test & implementation and continuous improvement. The paper concentrates on the first two phases. The existing curriculum is mapped according to the graduate attributes, competency profiles and the Exit Level Outcomes of the Engineering Council of South Africa (ECSA). From the list of identified deficiencies it can be concluded that the major shortcoming of the program is not its content but its delivery. It is recommended that innovative flexible delivery methods should be used as teaching styles.

Keywords: accreditation; re-engineering; mechanical engineering program

Kuang-Chao Yu, Kuen-Yi Lin and Szu Chun Fan 1604–1614 How High School Students Apply Knowledge in Engineering Design Projects

This study examined how students applied conceptual and procedural knowledge when engaged in an engineering design project. A mechanical toy design project was used as a context for exploring how science, technology, engineering, and mathematics (STEM) concepts taught in an engineering module facilitated student performance. Study data were collected from 103 high school student participants and analyzed using correlation, variance, and simultaneous regression analysis. The major finding of the study was that the students' STEM conceptual knowledge was the key to success in engineering design, especially at the synthesis and evaluation levels, and for their process ability to analyze, and evaluate during the project. Three recommendations are made to improve high school engineering instruction. To facilitate in-depth learning about the process of engineering design, multiple approaches should be employed to develop the students' application of STEM conceptual knowledge and process abilities. Teachers need to enhance students' science and mathematics knowledge to establish mathematical analysis and systems thinking. Students' spatial and sketching abilities need to be improved to better facilitate engineering design work.

Keywords: conceptual knowledge; procedural knowledge; engineering design; STEM