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Special Issue

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In this study, the Delphi method is used to establish a series of course modules based on the decisions made collectively by the Delphi experts for a graduate institute of cultural and creative design in Taiwan. The fuzzy logic theory is then used to build an assessment model to quantize the development of the students' core professional competencies and assess the efficacy of the education in the graduate school.

Keywords: cultural and creative design; cross-disciplinary; Delphi method; fuzzy logic theory; assessment model

Kuang Sheng Liu, Yen Ting Liao and Chun Ta Tzeng	283–290	TBEE Model for Green Design Courses to Evaluate the Indoor Environment Health of Existing Buildings in Taiwan
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In recent years, great importance has been attached to environmental protection-related issues in Taiwan. In addition, courses of green building, ecological construction, environmental quality and low-carbon development have been included as required courses in the Department of Architecture. This study selected the decision-making key factors for improving existing buildings from the perspective of "Environmental Quality" and reducing "Environmental Load," to establish the TBEE (Taiwan Building Environment Efficiency) model for evaluating indoor environment health and the improvement of existing buildings in Taiwan. This TBEE model has also become an important curriculum in the current Green Design Courses in Taiwan. This model is used to teach students how to calculate the values of indoor environmental health before/after the improvements of existing buildings. It uses an objective scientific calculation method, which can help improve the indoor environment health and the evaluation of the quality (Q) and the load (L). This TBEE model has been used as a reference for evaluating the indoor environment efficiency of existing buildings by the authorities in Taiwan.

Keywords: environmental quality; environmental load; green design courses; indoor environment health; existing buildings; TBEE model

Alex Maritz, Gerrit Anton de Waal and Shieh, Chieh-Jen	291–301	Educating Engineers: A Postgraduate Entrepreneurship and Innovation Perspective
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The aim of this paper is to clarify the educational methods that effectively educate and develop engineers in entrepreneurship in specific postgraduate programs. The purpose is to provide a framework by which entrepreneurship educators may develop and implement programs that are unique to engineers and postgraduate entrepreneurship education programs. The paper integrates two prominent frameworks and a strand of recent literature on entrepreneurship education to develop a conceptual model for engineers in a postgraduate entrepreneurship education setting. Findings include unique theoretical and applied initiatives in all dimensions of postgraduate entrepreneurship education programs, including the addition of a new dimension: community and outreach. The result is a conceptual framework, highlighting components and initiatives within the context of ontology, learning, audience, objectives, outcomes, assessment, content, pedagogy, community and outreach. The predominant theoretical implication is the need to consider entrepreneurship education in a postgraduate context targeted at engineers. We add to the body of knowledge by identifying education insights unique to this context. Limitations include applicability to the contextual scenario provided. The main practical implications concern program developers, educators, teachers and trainers in postgraduate entrepreneurship education for engineers. The paper sheds new light on the design and implementation of such programs. A conceptual framework is proposed for postgraduate entrepreneurship and engineering education, adding to the body of knowledge in scant literature in this domain. Dimensions of entrepreneurship education programs are demystified within the context provided.

Keywords: engineering education; entrepreneurship education; postgraduate entrepreneurship education programs

Jyh-Rong Chou	302–311	Applying TRIZ and Life Cycle Engineering to Eco-innovation Product Design: A Practice Case
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Environmental concerns have become strategically important to product design and engineering education. This paper presents a practice case to illustrate how students apply TRIZ and life cycle engineering (LCE) to eco-innovation product design. An eco-innovation product design method that integrates TRIZ and LCE into a holistic methodology was proposed, which can be used to assist students in developing eco-innovative products based on informed procedures. Functional modeling and analysis are implemented through the technological relationship diagram of the target product. TRIZ methods are used for generating product ideas, which are then arranged and combined to produce a set of design concepts using morphological analysis. An eco-innovation ideality is also proposed to evaluate alternative concepts as well as to determine the optimal design concept. The practice case shows that the proposed method has the potential to help students generate radical design concepts for eco-innovation of products.

Keywords: eco-innovation; product design; design methodology; TRIZ; life cycle engineering

The main particularity of gesture-based learning is that users interact in the learning process in the same way as they interact in the non-digital world. It can also support kinesthetic pedagogical practices to benefit users with strong bodily-kinesthetic intelligence. However, without proper assistance or guidance, the performance of gesture-based learning is usually not satisfied. To cope with this problem, the aim of this paper is to propose a concept map-oriented approach with a gesture-based learning system in the basic engineering circuit course. There were ninety-three participants in the experiments designed with the three learning approaches: concept map-oriented gesture-based learning, conventional gesture-based learning, and traditional e-book learning. The experimental results showed that the concept map-oriented learning approach with the gesture-based learning system increased the learning performance of the students in the basic engineering circuit course more than traditional e-book learning and the conventional gesture-based learning approach did.

Keywords: gesture-based learning; concept maps; embodied interaction; basic engineering circuit course

Min-Wei Hsu, Tsai-Yun Lo, K. C. Liang, Wi-Kuan Lin and Wen-Hao Yang 319–325 Exploring the Impact of Surrounding Factors on Design Imagination

Designing is a problem-solving process, which the professional designers need for higher imagination and creativity to carry on the problem-solving. In the research, we aim to develop a training program which helps designers to enhance the mechanism of imagination during industrial designing. First, imagination and creativity theories, design cognition and thinking, design methods and techniques are being explored by way of a literature survey in order to gain a deeper understanding of the structure and mechanism of human imagination. Research methods for design thinking, the pattern of imagination, the factors that affect the imagination, and developing techniques and teaching methods for imagination, have then been inducted for further studies. We then explored the forty international professional designers using secondary interview data. The data was analyzed based on the abstract and concrete, the activities, location, etc., the source of imaginative inspiration for the designers were categorized. The results showed that two designers using an abstract way of generating an imagination and inspiration mode accounted for 58%, using concrete objects to achieve the source of inspiration accounts for 42%. Indoor activities accounted for 64% inspiration of the factors of environmental stimulation, 36% were outdoor activities. Therefore, for the learning strategy, we conclude that enhancing the cognitive and experience-driven skills to gain insights from a variety of life experiences, expands the implicit design knowledge for the cognitive activities to trigger the imagination in the design thinking of designing.

Keywords: imagination; design thinking; industrial design; experiential

Chieh-Jen Shieh, Su Zhifang and Shang-Pao Yeh 326–332 Key Success Factors in Cultivating Students' Learning Motivation

Engineering Education focuses not simply on the theories and principles in the curriculum, but stresses the instructional application and practice. In this case, with a designed curriculum the students in Engineering Education often precede learning and acquire the necessary knowledge. In the learning process, many students have reduced learning motives because of the passive learning and they can even become learning-dodgers. Nevertheless, there are some students who keep their learning motives. Looking at the difference between such motives and the learning process, this study aims to understand the approach of the students in Engineering Education who keep their learning motives and the factors involved in their motivational regulation strategies. Aimed at the factors in Learning Motivation, the AHP criteria established with the Delphi Method are organized by the consistent opinions of experts with repeated enquiry, conclusions, and revision. The instructors in the Department of Electronic Engineering in the national universities in Taiwan have distributed 110 copies of the questionnaires. A total of 83 valid copies have been retrieved, a retrieval rate of 75%. According to the overall results of the evaluation criteria, among the key success factors in the students' Learning Motivation acquired from the questionnaire data, the top five emphasized criteria. Amongst 20 evaluation criteria, are the Teaching Approach, Commendation and Concern, the Control of Learning Strategy, Goal Setting, and Family Care and Support.

Keywords: learning motivation; Delphi Method; key success factors; learning behavior; learning belief

Section II

Contributions in: Gender and Minorities Issues, STEM, Reading Abilities, Communications, Global Preparedness, Teaching Methodologies, PBL, Engineering Design, Assessment, Lego Mindstorms, Supply Chain, Simulators, Remote Labs, Quality Control, Control Systems, RFID, Sensors, Water Quality

Candice E. Stefanou, Susan M. Lord, Michael J. Prince and John C. Chen 333–342 Effect of Classroom Gender Composition on Students' Development of Self-Regulated Learning Competencies

Success in any field depends on a complex interplay among environmental and personal factors. A key set of personal factors for success in academic settings are those associated with self-regulated learners (SRL). Self-regulated learners choose their own goals, select and organize their learning strategies, and self-monitor their effectiveness. Behaviors and attitudes consistent with self-regulated learning also contribute to self-confidence, which may be important for members of underrepresented groups such as women in engineering. This exploratory study, drawing on the concept of "critical mass", examines the relationship between the personal factors that identify a self-regulated learner and the environmental factors related to gender composition of engineering classrooms. Results indicate that a relatively student gender-balanced classroom and gender match between students and their instructors provide for the development of many adaptive SRL behaviors and attitudes.

Keywords: critical mass; engineering students; gender differences; role models; self-regulated learning

Justin Bond, Yichuan Wang, Chetan S. Sankar, P. K. Raju and Qiang Le 343–359 Female and Minority Students Benefit from Use of Multimedia Case Studies

Students need to acquire professional skills before entering the workforce in order to achieve career success and this is particularly important for female students and minorities. This article draws upon engineering education literature and student learning theories to understand the interconnected relationships among student characteristics (gender and race), instructional methodologies and gains in Higher-Order Cognitive Skills (HOCS) and the achievement of learning outcomes using the 4-P model of student learning. The model was tested for students enrolled in an undergraduate introduction to engineering course at a southeastern U.S. university and a historically black college and university (HBCU) for five semesters, where students participated in experimental (multi-media case studies) and control (round table discussions) sections. Both female and minority students achieved better learning outcomes, particularly in grade performance, after working on multimedia case studies. All students perceived

improvement in HOCS and learning outcomes in a multimedia case study learning environment. These results support the use of multimedia case studies in classrooms to increase students' engagement in learning and exposure to real-world experiences, thereby building their professional skills. The widespread adoption and implementation of multimedia case studies is also likely to encourage more female and minority students to pursue careers in engineering.

Keywords: 4-P (presage-pedagogy-process-product) model; professional skills; higher-order cognitive skills (HOCS); engineering education; multimedia case study pedagogy; achieving learning outcomes

Gillian M. Nicholls, Harvey Wolfe, Mary Besterfield-Sacre and Larry J. Shuman 360–377 Defining the Majors that Comprise “STEM”: An Analytical Method for Looking Beyond the Classical Acronym

There is no universally agreed-upon definition for “STEM.” Research in STEM education would be aided by developing a convention for how to categorize students' potential college majors. This study develops and tests a definition of STEM and a method for verifying the definition's validity and usefulness. A classification scheme is developed from reviewing prior educational research; examining the National Science Foundation's categorizing of fields of study; and constructing a predictive model. Demographic, attitudinal, experiential, and standardized test score variables from the National Educational Longitudinal Study of 1988 (NELS:88) dataset are used to predict which students will earn a STEM degree vs. another educational outcome. The predictive model tests the classification of majors into different four year degree outcomes. It tests the inclusion of majors beyond the classic “bench” sciences, engineering, and mathematics. Models were fitted to predict whether students had a STEM vs. other outcome, and the predicted outcomes were compared to actual outcomes. The models with more divergent outcomes had greater accuracy. Students earning a degree involving significant quantitative coursework in a field not generally considered STEM had more factors in common with students earning a Non-STEM degree. A narrow definition of STEM focusing on the bench sciences, engineering, and mathematics produces more accurate predictions. This method for classifying educational outcomes allows researchers to precisely define which majors or non-degree outcomes are included in the analysis. The method is flexible enough to accommodate a mutually exclusive and exhaustive set of outcomes.

Keywords: STEM definition, STEM persistence; NELS:88 Longitudinal Study; Logistic Regression modeling

A. Sucena, J. Falcão Carneiro and F. Gomes de Almeida 378–387 Assessing Reading Abilities of Mechanical Engineering College Students: A Prospecting Study

Reading is a basic competence that students have to master to be successful. Despite this fact, recent studies show that there may be a significant decline in the reading abilities of college students, one of the most educated segments of any population. This work is a prospecting study regarding the assessment of reading abilities of college students, namely in the context of Engineering education. Based on an existing screening test for assessing reading difficulties of children and teenagers, this work presents the results obtained by administering that test to students at a top engineering institution in Portugal. An outcome of this study is the determination of a time range suitable for a massive, time limited, use of the previously mentioned test to assess college students, thus enabling a basic tool that will permit, in future works, to screen reading abilities in wider college populations. This work also shows evidence that ca. 20% of college students present a poor reading performance, revealing a strong need for monitoring college students' reading abilities along different generations.

Keywords: engineering education; reading abilities; non-technical skills

G. Medina-Sanchez, E. Torres-Jimenez, P. Romero-Carrillo and R. Dorado-Vicente 388–399 Teaching Technical Communication in English to European Engineering Students

The European student mobility programme has enriched the academic life during the last two decades, contributing to create networks where people and institutions share experiences and ideas. Moreover, this programme reflects the present globalisation of the labour market, which is strongly present in the engineering field where actual complex projects are usually performed by multidisciplinary international teams. Despite the increase of mobility students, many times the receiving (host) university just offers individual tutorial sessions and assessments in English, and in general, little attention is paid on supporting the interaction between students from different countries. An opinion survey among engineering students motivates the proposed methodology that faces two goals: to teach international team-working skills and to improve the technical English of incoming and local students. Different teaching strategies have been combined: glossaries, wikis and multimedia material implemented within a Learning Management System, and group activities. The results of a test about engineering concepts in English and a final opinion survey point out an increase of technical communication skills and a high level of students' satisfaction.

Keywords: international students; engineering education; multi-lingual work teams; globalisation

Gisele Ragusa 400–411 Engineering Global Preparedness: Parallel Pedagogies, Experientially Focused Instructional Practices

With advances in technology and blurring of national boundaries, colleges and universities worldwide are increasingly required to prepare their graduates for global workforces. Importantly, engineering industries are seeking graduates with globally focused communication and leadership skills. Additionally, graduates are sought after who have interdisciplinary research and professional abilities that enable them to work effectively in diverse engineering environments that cross national boundaries. The presented research responds to an emergent challenge of engineering global preparedness. Specifically, it represents a study that measures the impact of formal and informal experiences and socio-demographic factors that impact students' global preparedness in engineering. In this study, graduate and undergraduate engineering students were assessed using an engineering global preparedness index that measured the role that experiential and socio-demographic factors played in their global preparedness. The results indicated that students' internationally related pedagogical experiences and precursing life experiences positively impacted their preparedness for global workforces. Additionally, diversity in preparedness and socio-demographic factors among students was noted, revealing that students with diverse socio-demographic profiles had diverse preparedness indices. The study provides engineering educators with future directions as to the importance of providing globally focused experiences for their students in engineering education to assist them in becoming fully prepared for global engineering workforces.

Keywords: engineering education; global workforces; engineering preparedness; global experiential education

Kàtia Gaspar, María Amparo Núñez, Juan José Rodríguez and Francesc Jordana 412–423 Adaptation of the EHEA Standards in Degree Programs

In Spain, the model of education proposed by the European Higher Education Area (EHEA) represents a change in teaching methodology and planning that affects all involved in a degree course. The question is where this change really leads. To find answers, the UPC's (Universitat Politècnica de Catalunya) Escola Politècnica Superior d'Edificació Barcelona (EPSEB) organised surveys for teachers, students and administration staff after a year of implementation of the EHEA. The students had completed at least an academic year in both pre- and post-EHEA courses. We also examined changes in academic results in both models. This article presents the results of both analyses and provides conclusions that may differ from general expectations.

Keywords: EHEA; higher education; teaching methodology; academic outcomes; stakeholders' perceptions

David Díaz, Teresa J. Leo, Eleuterio Mora 424–437 Mixed Assessment Methodology in Engineering Higher Education based on Quality Control Concepts
and **José Andrés Somolinos**

This paper outlines the adaptation of an assessment methodology in several courses in an engineering studies syllabus to the context of the new European Higher Education Area, through focusing on the best set of assessment methodologies that can be used, in order to improve learning processes without losing quality in the content. This is called a “mixed assessment methodology” and includes the implementation of different continuous assessments using virtual, manual or mechanical procedures. It allows teachers to manage large student numbers as well as to give them the required feedback. The paper classifies subjects into groups, based on their content and separates students by whether they are repeating the course or not, it addresses different assessment methodologies, incorporates engineering quality control concepts, and discusses the results achieved. The main contribution is to establish the best mixed assessment methodology for each subject in higher engineering education.

Keywords: assessment; evaluation; engineering education; early reorientation; quality control

Kyungmoon Jeon, Olga S. Jarrett 438–448 Project-Based Learning in Engineering Education: Is it motivational?
and **Han do Ghim**

This preliminary study explores the feasibility of incorporating the ARCS (Attention-Relevance-Confidence-Satisfaction) model of motivation into project based learning (PBL) in a college engineering course on Functional Fibrous Biomaterials. The project involved design of wearable computers and consisted of five stages, orientation, identifying and defining, planning, implementing, and reporting and evaluating. The students worked in self-selected small single-gender groups to design their projects. According to the authors, it was feasible to incorporate ARCS into PBL, and the instructor was satisfied with the quality of the projects. An ARCS-based assessment tool, the Instructional Materials Motivation Scale (IMMS), found that the lowest scores were on confidence. Men rated attention, relevance, and satisfaction as above neutral but that women’s ratings were below at least slightly below neutral on attention, confidence, and satisfaction and lower than men on all four aspects of motivation. Educational implications are discussed.

Keywords: project based learning; ARCS; confidence; gender

Young-Tae Lee and Sung-Hee Jin 449–457 Rolling Discussion Technique for Facilitating Collaborative Engineering Design Activities

The purpose of this study was to develop the Rolling Discussion Technique and to validate the developed technique process and principles. This technique is based on the concept of collective intelligence, which facilitates creative problem solving activities by sharing the ideas and thoughts of a large group of members within the class. An expert review and usability test were conducted as an internal validation method, and a field evaluation was used as an external validation method to partially confirm the feasibility and educational rationale. The results showed that the Rolling Discussion Technique suggested in this study can be applied as a useful discussion technique in engineering design education courses such as capstone design courses.

Keywords: Rolling Discussion; engineering design; knowledge sharing; collective intelligence; project-based learning

Seungkeun Kim, Hyondong Oh, 458–470 Using Hands-on Project with Lego Mindstorms in a Graduate Course
Jiyoung Choi and Antonios Tsourdos

The aim of this paper is to propose an educational hands-on project using inexpensive subsystems for learning guidance and control. A Lego Mindstorms NXT, a low-cost web camera, and tractable tools are used for searching for and mapping of an obstacle in an indoor environment. In order to provide the Lego robot with navigation information indoors, visual tracking is implemented by using color marker detection and an extended Kalman filter. Furthermore, spiral-like search, command-to-line-of-sight guidance, and motor control are applied to sensing and mapping of an unknown obstacle. The experimental results from a short-term group project verify that the proposed hands-on work is an efficient educational tool for learning vision processing and estimation as well as guidance and control with a low-level burden of time and cost.

Keywords: educational hands-on project; guidance; control; visual tracking; obstacle mapping; color marker detection; Lego Mindstorms

Ray Y. Zhong and George Q. Huang 471–482 RFID-enabled Learning Supply Chain: A Smart Pedagogical Environment for TELD

The supply chain is very important in the industrial field, thus Supply Chain Management (SCM) is becoming one of the key parts in engineering education since this sector needs a large number of professionals to take charge of various interconnected business transactions. However, the teaching and learning of SCM are facing several challenges, like a lack of up-to-date training materials, limited demonstrative facilities, and a passive education mode through listening and watching. This paper introduces a smart pedagogical environment for Teaching by Examples and Learning by Doing (TELD), which is an RFID-enabled learning supply chain (LSC) based on advanced Internet of Things (IoT) technologies to address these challenges. The RFID-enabled LSC uses RFID technology, wireless communication standards, and service-oriented architecture (SOA) to create a smart environment of the supply chain, adopts a number of games in each supply chain echelon, such as manufacturing, distribution, and retailing to demonstrate the key principles in global SCM, as well as integrating problem-based learning, experience-based learning and collaborative E-learning to realize TELD. A case study from the Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong shows the working mechanism and efforts of the RFID-enabled LSC in terms of rationalized user activities and quantitative improvements.

Keywords: Radio Frequency Identification (RFID); Learning Supply Chain (LSC); TELD; smart pedagogical environment; engineering education; Logistics and Supply Chain Management (LSCM)

Miodrag Zivkovic, Bosko Nikolic and Ranko Popovic 483–494 eWISENS: Educational Wireless Sensor Network Simulator

The basic features of a software system developed to support the teaching of Wireless sensor networks, and the experiences gained in using it in the Wireless sensor networks course at the School of Electrical Engineering, University of Belgrade, have been presented in the paper. The system has been used for a few years by students for the self-learning and laboratory work. It allows users to design and simulate adequate networks. The paper finally gives the overall benefits of its usage.

Keywords: wireless sensor network; wireless network; visualization; simulation software; software for education

Raúl Antón Gabriel Ayala, Francisco Mouzo and Tomás Gómez-Acebo 495–504 Power Plant Optimisation Simulator Using Catalogues: A Case Study with Student Assessment

A study was carried out using a power plant simulator with optimisation and catalogues to teach Rankine cycles to undergraduate engineering students. To do this, a classic textbook power cycle problem and the tools to optimise it were created. The aim was to bring real world problems closer to students by giving them problems where there is not always a solution and they have to adapt. One of the means used to achieve this was to include real devices as inputs (i.e. catalogues by Siemens Turbine and Carver Pumps). After using the simulator, students provided a thorough assessment. The conclusion of this article is that the simplicity and clear objectives of this multimedia laboratory exercise were effective in teaching thermodynamic cycle optimisation.

Keywords: simulator; Rankine cycle; optimisation; catalogue use

In this paper the design process of a real-time water monitoring system developed to enhance water sustainability education is discussed. This system, called the LabVIEW Enabled Watershed Assessment System (LEWAS), is a real-world application extension of a set of data acquisition modules that were successfully implemented using LabVIEW in the first freshman engineering course, Engineering Exploration ENGE 1024, at Virginia Tech. The system measures water quality and quantity data including flow rate, pH, dissolved oxygen, conductivity and temperature—as indicators of stream health for an on-campus impaired stream—in real time. In addition, weather parameters (temperature, barometric pressure, relative humidity and precipitation) are measured at the LEWAS site on Virginia Tech campus. The LEWAS is solar powered and uses the campus wireless network through a high-gain antenna to transmit data to remote clients in real-time. Pilot applications of the LEWAS have been implemented into ENGE 1024 to address issues related to water sustainability education. Students have given positive feedback regarding the impact of real-time monitoring on increasing their environmental awareness.

Keywords: remote labs; real-time systems; sensor systems; water pollution; student motivation