

# The International Journal of Engineering Education

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<b>Chiu-Wing Sham, Siew-Chong Tan, Kin-Man Lam and Charles Surya</b>	515–522	Raising the Interest of Students in Engineering with an Integrated Summer Programme

In this paper, we describe how a two year summer programme is conducted for high-school students to stimulate their interest in engineering and allow them to understand how engineering can improve people's living standards and contribute to society. In this programme, thirty-four students participated in a series of activities including lectures, visits to plants, a guided hands-on project, and a four-day voluntary service trip to P. R. China, applying their engineering knowledge. The objective of the programme is to expose high-school students to engineering at an appropriate level. The voluntary service trip can help to instil a sense of compassion in high-school students. In the presentation and reports submitted, most of the students stated that they found the programme meaningful, it can enhance their knowledge of engineering, that they could apply the engineering skills to real-life applications to improve the living standard of people, and that and they would like to consider choosing the field of engineering as their future career option in order to contribute to society based on their interest. According to the survey, the integrated summer programme can raise the students' interest in engineering.

**Keywords:** engineering education; outreach activities; high-school students; P. R. China, Hong Kong

<b>Igor M. Verner, Alex Polishuk, Yona Klein, Dan Cuperman and Ronen Mir</b>	523–533	A Learning Excellence Program in a Science Museum as a Pathway into Robotics
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There is growing interest to the use of robots in science museums for demonstration of technological innovations and introducing the principles of human-robot interaction. This paper considers the educational robotics programs developed at MadaTech in collaboration with the Technion, aimed to promote public understanding of robots, motivate young people to study robotics, and foster excellence in technology and science education. The robot theatre performances and the OlympiYeda competition of the MadaTech 2010 Robotics Year are analyzed. The characteristic features of the programs such as learning in a rich environment, learning through interactive robot demonstration, and learning in a diverse community are evaluated.

**Keywords:** science museum; educational robotics; human-robot interaction, learning excellence program, multi-cultural education

<b>Brian P. Dejong and Joseph E. Langenderfer</b>	534–544	First-Year Engineering Students in Newly Accredited Programs: Enrollment and Persistence Demographics
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This paper examines enrollment and persistence trends among first year students in recently accredited electrical and mechanical engineering programs at a predominantly undergraduate-oriented non-research intensive university where the programs grew from existing technology programs. Data analyzed in this longitudinal study includes transcript information and student surveys for students enrolled in an introductory engineering course during a six-year period. Until now, the programs have relied on a convenience sample of students with minimal program promotion or recruitment. Quantitative analysis was performed on the distributions of student interest and math preparedness upon enrollment in the introductory course. Additionally, within-program and within-university persistence was quantified and compared to math level and grade earned in the introductory course. Enrollment in the introductory course is growing at an acceptable rate. However, demographics are shifting towards students who are unprepared to complete Calculus I simultaneously. Furthermore, for the unprepared math students, persistence is very poor (10% of trigonometry and algebra students, 27% of Precalculus students), but for students on-track in math, persistence is much better (28% of Calculus I students, 63% of post-Calculus I students). Lastly, A Precalculus co-requisite with the introductory course may reduce enrollment by 18%, but should only reduce number of majors by 5% or less. Results of this study may be informative for universities looking to begin engineering programs.

**Keywords:** freshman retention; persistence; enrollment; new programs

<b>Thomas Bjørner, Lise Busk Kofoed and Jon Ram Bruun-Pedersen</b>	545–553	Creativity in Project Work—Students' Perceptions and Barriers
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In this paper, we will present case study results from a cross-disciplinary education named Medialogy, which is taught in the Technical and Science Faculty at Aalborg University. The aim of Medialogy is to facilitate creativity within technical solutions, and thus the intention of this paper is to answer the following: What is the Medialogy students' perception of creativity and in which part of the process of problem solving do they view themselves as being creative? In Medialogy, the education explicitly focuses on the little-c creativity and communicates the everyday life and evolutionary creativity to the students. The Medialogy students also perceive creativity as the little-c creativity that contains something interpersonal and intrapersonal, and by means of which products can be developed. They do not regard creativity as focusing on interaction and social context. They perceive that they are creative during all stages in the project work. However, it is also significant that the Medialogy students believe that they are more creative in the beginning of their projects and during the design and implementation stages, whereas the analysis is a less creative part. In general, the Medialogy students request further tools for creativity as well as more support for the creative process from the supervisors.

**Keywords:** creativity; problem based learning; project work; engineering education; perception

Project-based learning (PBL) follows an inductive learning approach by which students are taught to undertake a materials self-study after the need has been identified through a project's context. It has been used in many senior capstone and freshman design courses to enhance students' competences in design and other outcomes required by ABET. In most engineering programs, engineering analysis is still taught mainly through sequences of traditional lecture-based courses. Is it possible to use an independent project course to effectively teach engineering analysis and the challenging technical concepts that it involves? This paper presents the results of a study on the effectiveness of teaching engineering analysis of mechanical systems through a stand-alone project course. Our approach introduces the technical topics in the traditional academic manner prior to introducing the students to the project details. The model-rocket project was carefully and very specifically designed such that the technical topics of the pre-project lectures had direct and meaningful applications and were essential to its success. Based on this approach, the results demonstrated that the predictive success of the students' theoretical models of their rocket systems' behavior reached as high as 92%. Identical pre- and post-project tests showed consistent performance improvement reaching as high as 35%. This data suggests that it is possible to effectively utilize the PBL approach to teach the challenging technical subjects associated with engineering analysis. The main ingredient is the specific design of the projects such that the predictive capability of theoretical models is essential in evaluating students' project success.

**Keywords:** Project-Based Learning; engineering analysis; modeling

**Rached Dhaouadi, Yousef Al-Assaf and Habib-ur Rehman** 563–571 Introducing the Guided Design Experience in Control Engineering Education

The design skills of engineering students can be best achieved using an integrated learning approach which consists of a sequence of structured, guided, and open-ended design experiences throughout the undergraduate curriculum. This paper presents the implementation of the guided design experience through an introductory core course in the area of control engineering at the undergraduate level in the department of electrical engineering at the American University of Sharjah. The objective and implementation mechanism of the delivery of guided design experience is demonstrated through a class project in this course at the junior level. The effectiveness of the teaching methodology is assessed for a group of students by conducting a survey before and after the execution of the course project. The survey results show that the control class project is very successful in enhancing the critical thinking of students, developing students confidence in their design skills, and preparing them for the open ended design experience.

**Keywords:** engineering education; design skills; control systems; integrated approach

**Fakhteh Soltani, David Twigg and John Dickens** 572–578 Setting up University-Industry Links through Sponsoring Undergraduate Engineering Programmes

Although there has been a reduction in demand in the current recession, it has been widely reported that the UK has been facing an increasing shortage of high quality engineers entering industry. Industrial sponsorship of students and degree programmes is one way of contributing towards the developing University-Industry (U-I) links. This study highlights the issues of the relationship between employers and students during their undergraduate study from the perspective of students, employers and academic staff. It takes a mixed-method approach to assess the attitudes and perception of individuals from these parties and identify the barriers which limit further engagement in order to propose guidelines for further improvements. Data were collected from the undergraduate engineering students, companies, and the academic staff of engineering departments at Loughborough University using questionnaires, interviews and documentary analysis. The results show that greater awareness of the details of sponsorship schemes, including how they work and what is involved, would make employers more likely to offer sponsorship and encourage more students to apply for sponsorship. Conclusions are drawn on recommendations to develop sponsorship schemes in the way that the parties' expectations are met and their benefits maximized.

**Keywords:** industrial sponsorship; employers-students links; engineering education; professional skills

**Hakan Guler and Necati Mert** 579–587 Evaluation of Internship Programs for Educational Improvements: A Case Study for Civil Engineering

The main goal of this paper is to evaluate civil engineering internship programs for educational improvements by doing statistical analyses on comprehensive survey data gathered from inquiry sheets. A web base online survey tool was prepared and 251 inquiry sheets were statistically analyzed. Univariate analyses were performed to describe the interns' population and their needs. Levene's test was used to test equality of variances and the *t*-value was used for equality of means. The One-Way ANOVA procedure was used to test the hypothesis that the means of groups are not significantly different. Finally, binary logistic regression was conducted to identify factors that predict the students' satisfaction level. A positive, statistically significant relationship was identified between internship satisfaction level, future carrier planning, multidisciplinary team working, learning theoretical and practical applications, food service during the internship period and worksite internship. This study proved that the civil engineering students are keen to participate in practical training programs during their period of education and also that civil engineering departments should update the theoretical courses taking into consideration the practical applications.

**Keywords:** engineering education; civil engineering internship; statistical analyses; logistic regression

**C. C. Franklin, A. Mohan, D. Merle, J. K. Lannin and S. S. Nair** 588–598 Perceptions of Professional Skills by Graduate Students—A Comparative Study between Engineering, Education and Biology

College graduates are increasingly expected to collaborate across disciplines in the modern workplace. In addition to possessing content knowledge, this requires them to be adept in professional skills, including written and verbal communication skills, team building and leadership, and to have an understanding of relevant global issues. A growing awareness exists among educators for the need to better equip students with professional skills for the changing workplace. Student perceptions related to the importance of these topics, and to their coverage in the formal curriculum have, however, not been examined. A comparative study between graduate students from three disciplines (Engineering, Education and Biology) is reported that quantifies these perceptions. A Likert survey was administered to graduate students in Engineering, Education and Biology, to determine their perceptions of the importance of professional skills to their careers, and whether such skills were addressed in their undergraduate and graduate curricula. Students from all disciplines rated professional skills as very important, and they also emphasized the lack of attention to these topics in their formal curricula. Interestingly, Engineering students rated pedagogy and interpersonal communication skills and proposal writing lower compared with students in Education and Biology. Engineering should investigate how the other disciplines incorporate content related to some of these important professional skills into their curricula. Other implications of the study for engineering students and educators are also discussed.

**Keywords:** professional skills; engineering education; global workplace; proposal development

**Wen-Jye Shyr and Tsung-Chin Lo** 599–605 The Working Competency Items for Energy Technology: A Three-Stage Empirical Method

This study employed a three-stage empirical method to establish a set of working competency items considered important for energy technology based on industrial requirements. Stage I was conducted to develop an initial list of competencies, comprised of Behavioral Event Interviews (BEI) with three energy technology field engineers. In Stage II the Delphi Technique involved three

rounds of questionnaire surveys of ten field experts and scholars followed by the Kendall Coefficient of Concordance Analysis examining the consistency of respondent opinions to check to see whether they reach a level of significance. A list of 45 competencies in 3 domains was then developed. In Stage III these competencies and domains were verified quantitatively by surveying 32 learners studying energy technology followed by a nonparametric Mann-Whitney U Test. The research findings reveal the practical competency requirements for students in a technology university program.

**Keywords:** Delphi technique; competency analysis; energy technology

**Susan M. Lord, Michael J. Prince, Candice R. Stefanou, Jonathan D. Stolk, and John C. Chen** 606–620 The Effect of Different Active Learning Environments on Student Outcomes Related to Lifelong Learning

Calls for educational reform emphasize the need for students to develop a capacity for lifelong learning. Lifelong learners may be characterized as curious, motivated, reflective, analytical, persistent, flexible, and independent—traits that are critical for success in today's globalized economy. Stakeholders in engineering education recognize that students' development of the capacity for lifelong learning is vital for their success and that instructors play a critical role in influencing such outcomes. However, there is a critical lack of research in this area. This research investigates how instructor choices of active learning pedagogies affect student outcomes related to their development as lifelong learners at four institutions. We measure student self-regulated learning (SRL) in response to a range of active learning pedagogies and suggest that SRL is a proxy for lifelong learning in the context of the formal classroom. We consider the research question 'In what ways do pedagogical choices made by engineering instructors assist students to develop attitudes and behaviors associated with self-regulated learners?' The results of this mixed-method design suggest that students' development as self-regulated learners involves a complex interplay between many factors that are influenced by faculty choices in the course design.

**Keywords:** autonomy; lifelong learning; self-regulated learning; self-directed learning

**I. Ngambeki, M. M. Habashi, D. Evangelou, W. G. Graziano, D. Sakka and F. Çorapçı** 621–632 Using Profiles of Person—Thing Orientation to Examine the Underrepresentation of Women in Engineering in Three Cultural Contexts

Personal interests are a key element in encouraging careers in engineering. Evidence suggests that a lack of interest may contribute to the underrepresentation of women in engineering. The purpose of the current research was to examine differential orientations to people and things among college students and their relations to academic majors and career choices across cultures; to explore the effects of sex differences among these orientations and the relation to major and career choices; and to examine the predictive validity of the instrument used to measure these orientations across cultural contexts. Data were collected from 511 engineering and non-engineering university students in Greece, Turkey and the United States regarding their current and prospective majors, their intention to pursue careers in various fields, their endorsement of gender role, and their differential orientations to mastery of objects or interpersonal interaction. Thing orientation was a predictor of the interest in engineering majors and careers in all three cultural contexts. When only engineering majors were considered, thing orientation was a stronger predictor of interest for women than for men, suggesting that women may need special focused motivation to pursue a career that is not in accordance with traditional gender roles. The manipulation of messages about engineering to describe it as being both person and thing focused may make it more attractive to women.

**Keywords:** interest; person–thing orientation; underrepresentation in engineering; vocational choice

**Andrej Jodko and Josifas Parasonis** 633–641 Curricula of the World Architectural Engineering Undergraduate Programs

The purpose of this article is to carry out a comparative analysis of the curricula of 33 Architectural Engineering (AE) undergraduate programs around the world that are labeled in the same way but present different perceptions of the label concept. We applied various types of analysis and evaluated the absolute and relative value of curricula by comparing: study length, number of credits, courses, electives, etc. We discuss our figures, findings, and conclusions in this paper. Not all regions of the world are represented equally, and interpretation of the curricula may be subjective, based on the selected approach. The findings reveal a large spectrum of opinions in academia regarding what constitutes Architectural Engineering, as demonstrated by differing study program contents around the world. Our data and analysis provide valuable insights and a springboard for academia, researchers and curriculum developers in the field of Architectural Engineering to reach consensus.

**Keywords:** architectural engineering; undergraduate; engineering study program; multiple objective analysis

**Ryan Arlitt and Katie Grantham** 642–650 A Hybrid Problem-Based and Just-in-Time Inductive Teaching Method for Failure Analysis Instruction

Risk in Early Design (RED) is one method for preserving expert risk analysis knowledge. The purpose of this paper is to propose and perform steps toward verification and validation of the RED methodology and implementation. Evaluation metrics were developed, and several of these evaluation metrics were gathered in a case study. This case study was performed in a sophomore level lab class at the Missouri University of Science and Technology in the fall of 2010. The lab was designed to assist in teaching mechanics of materials, and was composed of approximately 200 students. Lab questions and a questionnaire were used to determine the students' ability to assess and mitigate risk both with and without this teaching method. The questionnaire was also used to prioritize and uncover usability issues with RED, and initial improvements were made to the RED application based on this feedback. While students were unlikely to produce an accurate failure mode assessment with or without the teaching method, results showed that students were using RED to aid their failure assessments.

**Keywords:** problem-based; just-in-time; risk in early design; failure analysis

**Jose de Jesus Rangel-Magdalen, Jesus Rooney Rivera-Guillen, Rene de Jesus Romero-Troncoso, Hayde Peregrina-Barreto and Jose Pedro Sanchez Santana** 651–662 Open Core Hardware Description Practices for DSP Masters Degree Course

Nowadays, the industry is widely using embedded systems to match the requirements of low cost and high performance. Consequently, there is an increasing demand of engineers with high-level knowledge in software and hardware development. The contribution of this work is to propose a hardware signal processing course based on the pedagogical methodology known as design experiments, in which theory and practice are linked. The course covers the main topics of signal processing and includes the main hardware designs used in industry. The work focuses on the open core design used in those hardware descriptions through proposing several lab practices intended to get students trained in the hardware software co-design. MATLAB and field programmable gate arrays (FPGA) are used as the design tool and the synthesis platform, respectively. The work presents an easy-to-follow structure that can be easily understood by the students. The proposed course was validated from both pedagogical and industrial point of view through two surveys.

**Keywords:** Field Programmable Gate Arrays; education; Hardware Signal Processing; Hardware Description Language; MATLAB

**Egoitz Sierra Uribe, Mikel Garmendia Mujika and Lander Barrenetxea Apraiz** 663–673 Solving the Problem of Interpreting Views: Teaching the Part Visualization Process

Part visualization is a fundamental skill in engineering. It comprises the reading, interpretation and creation of industrial technical drawings, interpreting the different views of a part represented in them. However, engineering students show certain learning

difficulties and a high failure rate in subjects such as Technical Drawing and Industrial Design. This paper presents a proposal to provide a learning method in this specific knowledge. In order to solve visualization problems in any kind of industrial part, comprehension indicators have been defined analyzing the student's difficulties, the expert's knowledge and literature review. The main lack founded in the traditional teaching method has been the inexistence of a systematic resolution process and not taking into account the factor of spatial visualization in learning. An activity programme has been developed to assimilate the process which puts these comprehension indicators to work together. With the help of dynamic images as well as physical models the visual factor was considered. The programme proposes specific tasks which work through the theoretical contents and procedures involved in part visualization as well as taking into account the students' main difficulties and deficiencies when faced with this kind of problem. After testing the method in the classroom, the results which have been obtained from experimental and control groups have been contrasted, showing a higher improvement in the experimental group. The main conclusion is that it is necessary to work with the student on the process of solving visualization problems, teaching the specific strategies and forms of reasoning which are associated with part visualization, in a continuous feedback.

**Keywords:** part visualization; teaching strategy; problem solving process

**Javier Rodríguez-Falces, Javier Navallas** 674-685 A New Way to Describe Intra- and Extra-cellular Electrical Potentials and their Generation by Excitable Cells  
and **Armando Malanda**

A fundamental aspect of bioelectricity studies is the process by which activation of an excitable cell results in the generation of a transmembrane voltage (the intracellular action potential) and an extracellular electrical potential in the surrounding medium. Traditional methods for teaching how to calculate the potentials do to provide biomedical engineering students with a means to appreciate the progressive nature of the generation of the extracellular potential as the intracellular potential propagates along the fiber. The objective of this paper is to propose a new approach, based on electrostatic theory, to teach students the basics of the formation of the intra- and extra-cellular potential around a fiber. The paper reports on the application and testing of this approach, which is demonstrated to enhance the ability of students to predict the shape (waveform) of the extracellular potential at different electrode positions relative to the fiber. In addition, the new approach helps students to create a mental picture of bioelectrical potentials in the context of the biological structures in which they occur and interact. The paper also emphasizes the necessity of considering the spatial profile of the intracellular potential, in conjunction with its temporal profile, for a correct interpretation of the amplitude and temporal characteristics of extracellular potentials.

**Keywords:** biomedical engineering; bioelectricity; excitable cell; electrostatic theory; intracellular potential; extracellular potential

**Dazhi Yang, Ruth A. Streveler, Ronald L. Miller, James D. Slotta, Holly M. Matusovich and Alejandra J. Magana** 686-700 Using Computer-based Online Learning Modules to Promote Conceptual Change: Helping Students Understand Difficult Concepts in Thermal and Transport Science

Misconceptions about engineering and science concepts persist among engineering students, and some are resistant even to direct instruction. This paper reports on a unique form of computer-based online learning module, designed to help engineering undergraduates learn difficult concepts in the thermal and transport sciences (specifically, heat transfer, mass diffusion, and microfluidics). The design of these modules has been informed by relevant research on cognitive psychology and technology-enhanced learning. Specifically, the modules are based on the prior work of Chi and Slotta, which focuses on helping students understand the emergent properties of complex physical systems, thereby providing a means for promoting conceptual change within these challenging domains. The modules were designed and hosted in a Web-based learning management system, where a variety of interactive materials and inquiry prompts were incorporated to help students better understand the concepts and visualize the phenomena. Engineering students' perceptions of computer-based online learning are reported along with learning outcomes that resulted from their use of the modules. This was the first study to provide a discipline-based example in engineering education for how to use computer-based online learning and emergent properties of complex systems to help undergraduate engineering students learn difficult concepts. It has implications for (1) designing effective online learning environments to help students learn difficult science and engineering concepts; and (2) developing effective instructional strategies for promoting conceptual change.

**Keywords:** engineering education; online learning; conceptual change; misconceptions

**Bugrahan Yalvac, Mehmet C. Ayar and Firat Soylu** 701-712 Teaching Engineering with Wikis

In this paper we discuss the nature of five university professors' use of wikis in education and their personal epistemologies pertaining to wikis. A group of students collaboratively authoring a wiki article is an epistemologically different practice from students writing individual papers. A wiki-supported learning environment cultivates more student-centered pedagogies by distributing the power of knowing towards the students, which in turn may lead to a formation of a community of practice. How and why professors use wikis in teaching are critical to explore for the efforts to cultivate more student-centered teaching practices in higher education. Study data are collected through individual interviews. Analyses revealed that participants used wikis to improve student collaboration, to reach an optimal solution to a given problem, to form an asynchronous and egalitarian learning medium, to have students negotiate and construct knowledge, and to have students work collectively. According to our participants, wikis provided a medium for communities of practice to begin emerging. However the communities did not fully develop because of the limited time within the course of a semester. We recommend any future studies investigate the ways to cultivate more sustainable wiki-supported learning communities.

**Keywords:** wiki; student-centered; personal epistemologies; knowledge construction; communities of practice

**Okan Bingöl and Serdar Paçacı** 713-723 A Virtual Laboratory for Neural Network Controlled DC Motors Based on a DC-DC Buck Converter

DC-DC converters have a wide usage as the driver circuit of direct current (DC) motors. This has necessitated sensitive speed controls to be made on DC motors. Classical controllers have lower performance due to the non-linear features of DC motors, such as saturation and friction. The Neural Network Controllers (NNC) are widely used in controlling poorly-defined, nonlinear and uncertain systems. NNC courses are now being offered by several universities at the bachelor's and master's degree levels as a result of NNC's successful applications in these fields. However, the training of an NNC driver circuit in a laboratory environment is a time-consuming and expensive task. In this study, an NNC training set of the DC converter-fed Permanent Magnet Direct Current (PMDC) motor, which is part of the electrical machinery courses, was prepared. The set has a flexible structure and a graphical interface. Thanks to this set, it has become possible to change the PMDC motor and controller parameters, and monitor the system's reaction under various operational conditions in graphics. This training set can also guarantee effective learning and comprehension of Artificial Neural Networks (ANN).

**Keywords:** DC-DC converter; DC motor; artificial neural network; virtual laboratory

**Paul D. Schreuders and Matthew D. Lammi** 724-733 Student Attitude and Achievement with Computer-based Instrumentation

This quasi-experimental research studied the cognitive and affective domains of achievement in engineering laboratories while employing computer-based and traditional oscilloscopes. 61 students from two courses, electrical engineering for non-majors and electronic fundamentals, were randomly assigned into treatment and comparison groups. The students' knowledge and attitudes were gauged using assessment instruments and an attitudinal survey. These results were statistically analyzed and conclusions are discussed. The results suggest that computer-based instruments are viable in engineering laboratories.

**Keywords:** educational technology; engineering education; laboratories, user-interface; human factors

This paper presents a feasibility study of using a manufacturing activity simulation board as a teaching tool for product costing. The manufacturing activity simulation board has been developed for teaching product costing in a virtual manufacturing setting. This setting and goal of the board has been designed to appeal to engineering students based on the basic principles of cost accounting. Hands-on manufacturing activities are incorporated in order to enable the user to be familiar with cost accounting between manufacturing activities and their costs. In this research, we tested the feasibility of introducing the use of the simulation board in the regular cost engineering course. Preliminary evaluations indicated that the board could be successful in achieving these objectives.

**Keywords:** simulation board; manufacturing activity; manufacturing cost; cost accounting; learning activities; engineering education

In this study a new framework especially designed for educational data mining has been proposed and named as Visual Cluster Exploration Framework (VCEF). It differs from existing alternatives such as parallel coordinates and icon based projections in terms of dealing with the curse of dimensionality, parameter free design and ease of use. The visualization subsystem of the VCEF employs a novel visualization technique which is called as SD-plots. The results in both synthetic and real life data sets demonstrate that the approach is highly effective and helps educators to discover clusters easily. The results could be used to organize well-balanced student groups to improve the active learning in engineering classes.

**Keywords:** data mining; visualization; clustering; educational data mining

