

The International Journal of Engineering Education

Contents

Contributions in: Mechatronics, Robotics, Electric Machines, Civil Engineering, Computer Aided Design and Modelling, Multidisciplinary Teaching, Collaborative Learning, Teacher Training, Evaluation, Relationship with Industry, and Education Research

- A. Ibrahim** 1 Editorial
- G. Ostojic, S. Stankovski, L. Tarjan, I. Senk, and V. Jovanovic** 2–8 Development and Implementation of Didactic Sets in Mechatronics and Industrial Engineering Courses

The collaborative design process supports the development of successful systems and products with a many participating engineers from a variety of disciplines. This kind of working environment lays stress on obtaining such multidisciplinary knowledge. Such efforts became an important element of capstone projects for students from different departments. This paper describes research related to the use of didactic sets in a problem based classroom setting. These sets are designed and implemented by teams comprising students from the Mechatronics and Industrial Engineering departments. They are installed in the mechatronics lab at the Faculty of Technical Sciences in Novi Sad, Serbia. The sets are used by students who are enrolled on a number of courses as part of their lab practice in the Mechatronics and Industrial Engineering departments. These didactic sets enable the integration of knowledge gained from various courses. They help the students to understand the connections between different engineering fields. Some of the lab topics that can be delivered with this kind of equipment are: electric motors, frequency controllers, Programmable Logic Controllers (PLC), fieldbus systems, and Supervisory Control and Data Acquisition (SCADA) systems. The students are involved in problem-based learning during hands-on activities such as making mechanical connections or wiring. Each didactic set consists of: an asynchronous three-phase electric motor, a frequency controller, a PLC, different relays, pushbuttons, indicators, and wiring. Some of the most important learning benefits are obtained through scenarios that simulate real industrial tasks and conditions.

Keywords: mechatronics; laboratory; didactic set

- D. Guerra-Zubiaga, E. Ramón-Raygoza, V. Lara-Prieto, R. Parkin and M. Jackson** 9–17 A Systems Approach to a Final Year Mechatronics Design Course

Mechatronics is the science that studies the holistic design process in which intelligent machines are created to develop efficient and complex processes and products. Mechatronics integrates mechanics, electronics and computer sciences to achieve control and automation. The effective integration of these different components is a complex task that should be accomplished in the design phase. This work presents a systems approach to a mechatronics design course at ITESM, México. In their final year, engineering students are taught a methodology to design a mechatronic product. The methodology includes: the early stages of clients' needs identification, process characterization, literature review, and ideas generation, which lead to both the design and simulation of the mechanical, electronic and control stages. This series of steps is inspired in a number of different design methodologies, which are available from the literature and can be adapted to the available tools and circumstances at the university. This paper describes a practical way to integrate the existing specialised techniques and tools to generate an efficient design of a mechatronic product. Some of the virtual tools that are available to design, evaluate and integrate the different parts of a mechatronic design are also discussed. The systems approach was applied by the students to different mechatronic projects in industry, thus creating good links between university and manufacturing companies with satisfactory results. One of the numerous case studies is described in this paper as well as its outcomes, to provide evidence of the educational value of the methodology.

Keywords: design methodology; mechatronics education; product design

- R. Abiyev, D. Ibrahim and B. Erin** 18–29 EDURobot: an Educational Computer Simulation Program for Navigation of Mobile Robots in the Presence of Obstacles

In engineering education different experimental exercises are provided to students in order to improve the teaching level and provide better understanding of theoretical materials. These exercises might be implemented using educational software tools. In this paper, an educational software tool called EDURobot has been developed to enhance the understanding of robotics for undergraduate and graduate students in computer and electrical and electronic engineering departments. The software tool mainly teaches students the navigation problems of a mobile robot avoiding obstacles in a static environment using different algorithms. The simulation environment is of a menu-driven variety where students can draw obstacles of standard shapes and sizes and assign the starting point of the mobile robot. The robot will then navigate among these obstacles without hitting them and reach the goal point given by the user. Parameters associated with the different algorithms may also be changed to observe their effects which will further enable comprehension of characteristics of different path planning algorithms. The program is developed in Visual C# for Windows platforms. Different algorithms employed in the software are potential field, vector field histogram plus and local navigation.

Keywords: robotics education; robot navigation; obstacle avoidance; path planning

- S. Mistikoglu and I. Özyalçin** 30–39 Design and Development of a Cartesian Robot for Multi-disciplinary Engineering Education

This paper presents a teaching approach based on hands-on learning. The details of the approach presented here cover the theoretical aspects and the practical implementation of the engineering study. The study provides details of a model for a multi-disciplinary engineering education approach that provides the students with fundamental theoretical and practical knowledge. Furthermore, the results of the study reveal that the method is in compliance with the Accreditation Board for Engineering and Technology (ABET) criteria for education in engineering. Moreover, the benefits of the approach and the related results, which indicate that graduating students do benefit from the education provided, are also presented.

Keywords: cartesian robot design; engineering education; multi-disciplinary study; project based learning; accreditations criteria

F. Blázquez, J. R. Arribas, C. Veganzones, C. A. Platero and D. Ramírez 40–51 Adaptation of the Electric Machines Learning Process to the European Higher Education Area

In this paper the basic lines of a complete teaching methodology that has been developed to adapt the electric machines learning process to the European Higher Education Area (EHEA) are presented. New teaching materials that are specific to Electric Machines have been created (textbooks, self-learning e-books, guidelines for achieving teamwork research, etc.). Working in groups has been promoted, as well as problem solving and self-learning exercises, all of which are evaluated in a way that encourages students' participation. Finally, the students' learning process in the lab has been improved by the development both of a new methodology to follow in the lab and new workbenches with industrial machines that are easier to use and also enable the lab experiments to be automated. Finally, the first results obtained as a result of applying the proposed methodology are presented.

Keywords: electric machines; learning systems

R. Luna, R. Hall, M. Hilgers and L. Ge 52–58 GIS Learning Tool for Civil Engineers

A geographic information system (GIS) learning tool was developed using a series of learning objects. These learning objects were designed to support supplemental instruction in GIS and were integrated seamlessly into the course curriculum. Developed over one academic year and used in the next, this learning technology was part of a problem-based, open-ended, laboratory exercise. To evaluate the effectiveness of the GIS learning objects, the class was separated into two groups. The two groups were exposed to the same fundamental civil engineering curriculum. However, one of the groups also received supplemental instruction using the GIS learning objects. The students in the section who used the learning tool scored significantly higher on a quiz covering the basic curriculum elements. This paper summarizes the development process, testing and evaluation of one of the modules (topic: geotechnical engineering).

Keywords: GIS; web-based; learning system; scaffolding; usability

R. Dorado, R. López-García, E. Torres-Jimenez and F. Díaz Garrido 59–67 Teaching Turbochargers via Computer Aided Design Software

A computer 3D model helps one to understand mechanical systems such as combustion engines. Because of its wide range of applications, engine knowledge is one of the main issues for a mechanical engineer. A turbocharger is a quite common engine component because it increases machine power. To show a turbocharger performance and its parts, we built a 3D model using Computer Aided Design software. We used a web-based learning management system to test the students. The results of a test and a survey showed that this educational method is successful. The 3D model generated could be used in other areas of knowledge such as engineering design and engineering graphics.

Keywords: 3D model; turbocharger; web-based learning system

D. Abbot and K. Grantham Lough 68–86 Component-Function Templates To Aid Engineering Design Education

A new design instrument, component functional templates, has been developed to assist design engineering education. The templates attempt to link the functional basis and component taxonomy into one coherent visual form that can be used by novice designers as a functional modeling training tool. This paper presents the approach, derivation, and valid examples of template groupings that result from the analysis. Principal components analysis is used to extract historical data from consumer products whose information has been stored in an online repository. An application of the templates is presented where they prove to be sufficient to begin the modeling process that accurately describes the subsystem's functions.

Keywords: conceptual design; design education tools; product modeling

N. Fang and J. Lu 87–95 A Decision Tree Approach to Predictive Modeling of Student Performance in Engineering Dynamics

A decision tree model has been developed to predict student performance in Engineering Dynamics based on 750 data records collected from 125 students in two semesters. The predictor variables include a student's cumulative GPA and scores in four prerequisite courses: Engineering Statics, Calculus I, Calculus II, and Physics. The model generates nine decision rules and shows that a student's performance in Statics and cumulative GPA play the two most significant roles in governing the student's performance in Dynamics. The prediction accuracy of the model is more than 80%, which is at least 14% higher than that of the traditional multivariate regression model.

Keywords: decision trees; predictive modeling; multivariate regression; engineering dynamics

V. Mahnic 96–110 Teaching Scrum through Team-Project Work: Students' Perceptions and Teacher's Observations

In order to prepare students for the increasing use of agile methods in industry, teaching these methods is becoming an important part of the Computer Science and Software Engineering curricula. So far most of the attention has been devoted to Extreme Programming and its practices, but there is not much reported about teaching Scrum, in spite of the fact that Scrum is one of the most widespread agile methods. To fill this gap, a course was developed at the University of Ljubljana that not only teaches Scrum through a capstone project, but also serves as a study about the learnability and applicability of Scrum. This paper describes the course details and analyses students' perceptions and teachers' observations after running the course for the first time in the Spring semester of the Academic Year 2008/09. The student surveys showed that students were overwhelmingly positive about the course and confirmed the anecdotal evidence of Scrum's benefits as reported in the literature.

Keywords: software engineering education; agile methods; Scrum; capstone project

M. Čupić and Ž. Mihajlović 111–125 Computer-Based Knowledge, Self-Assessment and Training

We present the design, technical issues and use of a software environment for learning and educational assessment. Our proposed system offers individualized tasks for each student and allows variations and modifications of the tasks (with instructor supervision). The system is designed to support distance learning, but it can also support and enrich education in a traditional classroom. Using application-based computer graphics tasks, we present various potential uses of the proposed software environment. Computer graphics tasks are highly demanding for interactivity, visual presentation and simulation. The proposed design addresses the most demanding graphics challenges. We demonstrate that the proposed framework applies to different courses and that this mode of learning is highly motivating for students.

Keywords: educational technology; programming environments; unsupervised learning; computer graphics software

F. Jiménez and J. E. Naranjo 126–135 Multidisciplinary Practicals in Satellite Navigation Systems in Road Vehicles for Subjects Taught in Different Engineering Schools

Aimed at giving students training in transversal skills, such as multidisciplinary group work or putting acquired knowledge into practice, a series of practical sessions has been developed involving teachers and students from two different areas of expertise in two Schools of Engineering (School of Industrial Engineering and School of Computer Science of the Polytechnic University of Madrid). The ultimate objective of the practical sessions is to develop a driving assistance system (ADAS) based on satellite positioning. It is hoped that this integrative experience will make full use of each group's knowledge so as to be able to offer students a global view of both theory and

practice. In this way, a synergy will be promoted between mechanical engineering and computer science, a true technological reflection of the automobile sector where a fusion of disciplines is essential.

Keywords: multidisciplinary teaching; practicals; navigation system; road vehicle

V. Robledo-Rella, L. Neri and J. Noguez 136–140 Collaborative Learning for Physics Courses at Tecnológico de Monterrey, Mexico City Campus

This paper shows different collaborative learning activities implemented in physics courses for junior engineering students at Tecnológico de Monterrey, Mexico City Campus. The application of the Jigsaw Learning Procedure to physics courses is described in detail, and the results obtained show that the average grade of students working collaboratively using the Jigsaw Technique is about 10% higher than that of students working only individually on the same kind of assignments. It was also found that students improve their collaborative competences in later courses of their curriculum.

Keywords: physics education; collaborative learning

A. C. Estes, R. W. Welch, S. J. Ressler, N. Dennis, D. Larson, C. Considine, T. Nilsson, R. J. O'Neill, J. O'Brien and T. Lenox 141–154 Ten Years of ExCEEEd: Making a Difference in the Profession

In response to the need for faculty training, the American Society of Civil Engineers developed and funded the ExCEEEd (Excellence in Civil Engineering Education) Teaching Workshop, which was offered for the first time in 1999 and celebrated its tenth year during the summer of 2008. For the past decade, 21 ExCEEEd Teaching Workshops (ETW) have been held at the United States Military Academy, the University of Arkansas, and Northern Arizona University. ETW has realized 497 graduates from 198 different US and international colleges and universities. This paper summarizes the content of ETW, assesses its effectiveness, highlights changes in the program as a result of these assessments, outlines future directions, and assesses the effect this workshop has had on the quality of civil engineering teaching in the US. The assessment data were obtained from multiple survey instruments conducted during each workshop, surveys taken six months to a year after the workshop, and a ten-year longitudinal survey.

Keywords: teaching workshop; teaching assessment; ExCEEEd model; teacher training

A. Donnelly, C-Y Wu, P. Biswas, Y. Li, A. Denny and E. Hodge 155–161 Front-End Evaluation to Enhance the Usefulness and Adoption of Educational Materials: from Museum Education to Engineering Education

Summative and formative evaluation methods, adapted from the education evaluation literature, have been of tremendous value to engineering educators as they seek to assess educational materials. There is a third kind of evaluation that has a long history in the informal education realm that promises to further enhance engineering evaluation efforts. Front-end evaluation conducted in the beginning of a project provides information at the earliest stages of materials development to ensure that input from end users, faculty and students alike, is incorporated into the materials design. The benefits of front-end evaluation that have been utilized by museum exhibit evaluations and how they can be transferred across disciplines into the field of engineering education materials development are discussed. Front-end, formative, and summative evaluations combined increase the overall quality of the materials and facilitate dissemination.

Keywords: front-end evaluation; formative evaluation; summative evaluation; web-based design modules; aerosols

I. Ortiz-Marcos, M. J. Sánchez Naranjo and J. R. Cobo Benita 162–168 Evolution of Final Degree Projects at the Universidad Politécnica de Madrid

During recent years, it has been pointed out that the typology of Final Degree Projects (FDP) presented in engineering schools has changed. Just a few years ago, students presented predominantly classic engineering projects (installations, processing plants, etc.), whereas today they prefer theoretical-experimental works (research projects) or technical, organizational and economic studies (consulting projects). This paper shows a study analyzing the evolution of the typology of the FDP presented in the UPM ETSII (Industrial Engineers College in the UPM). As part of the research effort, more than 3,000 projects that have been presented during the last 25 years have been analyzed. This analysis has confirmed the preferences of the UPM engineering students for FDP. The results of this analysis will facilitate the identification of the competencies and skills that the students need to develop.

Keywords: final degree project; typology of projects

R. S. Evans and S. P. Nichols 169–177 Creating Links from Customers to Technology

This paper further develops the Technology Innovation Mapping (TIM) tool introduced in a previous paper. TIM assists activities in technology commercialization by allowing the technology/product development team to better understand the link to customer needs, the important elements of their intellectual property relative to customer interests, and the course of action necessary to improve the likelihood of successful technology commercialization. Use of the tool requires that the team describe and understand specific benefits and unique elements of the technology relative to a defined application. The tool facilitates a clear focus on specific customer needs. The paper provides an introduction to the TIM method, defines key terms used in the analysis, and provides a specific example of analysis.

Keywords: technology commercialization; innovation; function mapping

R. Žavbi, J. Benedičič and J. Duhovnik 178–194 Use of Mixed Academic-Industrial Teams for New Product Development: Delivering Educational and Industrial Value

Companies are interested in new products which will bring them financial benefits. One of the more difficult decisions, if not the most difficult, is to ascertain which and what kind of products will in fact accomplish this goal. Product development processes develop towards increasingly systematic approaches. We have developed a new method which introduces better systematics to the opportunity search process and also gives individuals opportunities to be creative and to produce eureka ideas. The method was implemented by a mixed academic-industrial team and supported by easily accessible ICT. The execution of this project was not only a way to expand the company's product portfolio (i.e. deliver industrial value) in cooperation with academia and the government, but also a way to provide simultaneous education for the company's engineers and students (delivering educational value, where the learning challenges are to become proficient in the use of the method and to acquire team work skills in mixed academic-industrial teams) and temporary replacement of human resources.

Keywords: Product development; interdisciplinary project; architectures for educational technology system; cooperative/collaborative learning

N. Triki, N. Gupta, S. Wamuziri and T. Rafik 195–204 An Investigation into the Role of Engineering and Technical Education in Providing the Skills Needed by Libyan Manufacturing Industry

The Libyan manufacturing industry has traditionally suffered from a shortage of skilled manpower. In 1990s, a network of Technical and Vocational Education and Training (TVET) institutions were introduced for the purpose of enhancing the supply of skilled manpower needed for the economic and social transformation plans. The aim of this study is to investigate the effectiveness of the Libyan TVET system in providing the skills needed by the national manufacturing industry. To achieve this goal a questionnaire has been designed to test the research hypothesis, and distributed to students in institutes of higher education; and engineers and technicians employed in manufacturing industry in Libya to explore their views in this regard. The study indicated a direct relationship between the

needs of the industrial sector and technical disciplines. The results of the research indicated that there is a substantial mismatch between the outcome of TVET and the exact requirements of manufacturing industry. The analysis of available statistics, however, suggests the unplanned nature of the link between the TVET and manufacturing industry. The results also indicated how to improve technical programmes which will help serve the community by providing students with adequate technical information.

Keywords: developing countries; Libya; TVET; partnership with industry

S. Y. Sohn and Y. H. Ju 205–217 Perceptions of Engineering Among Korean Youth

A lack of enthusiasm for engineering as a career choice is prevalent among young students in Korea, which may have negative effects on national competitiveness. As understanding students' perceptions of engineering is a first step toward designing strategies to boost interest in this area, we surveyed secondary school students to gauge their general knowledge about several engineering areas, their knowledge about application domains of various engineering fields, their thoughts about the status of engineers, the types of courses they prefer, the time of life during which they are likely to decide on future careers, persons/media affecting their career decisions, and other factors. We found significant differences in perceptions about engineering in different age and gender groups. Insights gained from the results of our study will be used to establish a youth engineering adventure program in Korea.

Keywords: K-12; engineering education; engineering perception; youth engineering adventure program

**M. L. Pertegal-Felices,
J. L. Castejón-Costa
and A. Jimeno-Morenilla** 218–226 Personal and Emotional Skill Profiles in the Professional Development of the Computer Engineer

The importance of generic skills in career success is a fact that nobody questions. The professional world requires universities to provide specific training so that future professionals can improve their job performance. Although proposals and recommendations have been made to include such skills in the curriculum, universities find such an idea hard to implement. One major barrier is the lack of an evaluation model in the acquisition of such skills, which are far more complex than those based on obtaining knowledge. This paper proposes a generic emotional intelligence and personality-based model with which to assess generic skills. This kind of model is evaluable and makes it possible to measure student competence. For this study, the model was applied to analyse the profile of computer engineers. The view of experts and professionals was taken into account for the study, and levels of competence were measured in a sample of Computer Engineering students through a series of tests. The results showed differences between student profiles and the opinion of the experts, as well as between the views of professionals and experts. However, a significant similarity was found between the views of professionals and the students' actual skill level.

Keywords: professional profile; computer engineers' skills; professional skills; generic skills; emotional intelligence

**H-L Jian, F. E. Sandnes, Y-P Huang,
Y-M Huang and S. Hagen** 227–235 Comparison of Taiwanese and Norwegian Engineering Students' Preferences for University Life

An insight into students' preferences and expectations of life at university is useful when trying to understand drop-out percentages and design study programs, especially in the global competition for students. This study focuses on Taiwanese and Norwegian students' preferences for life and activities at university. Hofstede's model was used to predict culture-related differences. A pair-wise decision questionnaire was used to conduct measurements. A universal trend is that teamwork was considered most important, and teachers were considered to be less important. The most noticeable culture differences were that Taiwanese students preferred non-curricular values and Norwegian students preferred curricular values. The study discipline had little impact on students' preferences.

Keywords: culture differences; curriculum development; extracurricular activities; student recruitment; student motivation