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Contents

Contributions in: E-Learning, Simulators, Teaching Methods, Active Learning, Assessment, Creativity and Innovation, Student Identity, Recruitment and Retention

This study evaluates the effectiveness of an on-line adaptive training system aimed at improving students' abilities to solve physics problems. The system displays a set of multiple-choice problems along with the correct answer and several carefully designed distracters. The distracters correspond to typical mistakes that undergraduate students make according to the authors' teaching experience. Depending on students' choices, the system provides them with appropriate, timely feedback and prompts them to solve other problems to practise their problem-solving skills further. In this way students solve a different set of problems of different difficulty levels according to their particular learning needs. The system also has the capability of providing other didactic resources such as tutorials or virtual learning environments, such as active simulators, to enhance student learning. Owing to its flexible structure, the system allows for the sharing of test banks and didactic resources between different courses and professors. It also keeps track of student performance and generates specific reports. The software was tested using a sample of 169 undergraduate engineering students taking physics courses. Using a pre-test/post-test assessment tool, it is found that students using the software (the focus group) have a larger average integrated learning gain than students who did not use it (the control group). This conclusion is supported by a statistical analysis based on Z tests.

Keywords: engineering education; physics problem-solving; adaptive on-line training; learning gain

This paper demonstrates the results of our research activities in which we validated state-of-the-art theory of technology acceptance (Unified Theory of Acceptance and Use of Technology—UTAUT) in the context of a specific e-learning system—Moodle. This research was performed because there is little research reported in the area of e-learning acceptance and there are only a few validations of UTAUT in the context of e-learning. Research objectives were achieved with an online survey in which we included Likert-based statements related to UTAUT concepts and concepts specific to e-learning systems. The survey was performed on a random sample of undergraduate students, who were asked about their level of agreement or disagreement related to their acceptance of Moodle. The answers from 235 students were primarily analyzed using structural equation modeling (SEM) which demonstrated the validity of concepts and the level of causal relationships between concepts. We found that performance expectancy, social influence and facilitating conditions have a direct effect on students' attitudes towards using Moodle, where performance expectancy was the strongest determinant of student attitudes. Students' intention for using Moodle is caused by social influence and facilitating conditions. Behavioural intentions were shown to be a strong indicator for the actual use of Moodle. The implications and limitations of the present study are also discussed.

Keywords: e-learning; acceptance; UTAUT; SEM; on-line learning

This paper presents a straightforward and economical approach to the development of a fuzzy control remote laboratory using the MATLAB Web Server tool. The objective of the laboratory is to offer students and professionals a valuable tool for improving their fuzzy design abilities, and to test the performance of fuzzy controllers in a real DC motor. The advantages of using this approach are: cost reduction, with regards to the training of industrial operators in new techniques, and an increase in time and space flexibility in the use of limited resources at regular educational institutions. This laboratory was incorporated in a multilingual control repository and some evaluation results of the experience are shown here.

Keywords: educational technology; laboratories; fuzzy control; DC motors

This paper describes an efficient method of teaching power quality, to senior undergraduate and postgraduate students of power system groups in electrical engineering departments, as a part of a power quality course. The paper shows a MATLAB-Simulink based simulator in order to teach students the power quality and to practice analysing the simulation results. In this paper, first the theoretical aspect of simulation and simulator are described, and then the results are presented. Evaluation of the simulations using more than 40 students is very positive in terms of their developing confidence in and understanding of simulations.

Keywords: MATLAB-Simulink; power quality; simulator; impulse; wavelet

Using simulators in engineering disciplines is widespread. Memory Hierarchy is no exception. However, the process of its design and analysis as an educational resource has not been sufficiently explored. On the one hand, student motivation in the course could improve if they were invited to take part in the design of the simulator. On the other hand, this participation implies a deeper knowledge in the topics of the course. In this paper, this process is described about a simulator called MNEME, which includes a complete vision of memory hierarchy topics. This simulator has been validated and improved using feedback from students during three academic years.

Keywords: student's motivation; memory hierarchy; simulation

Deborah Moore-Russo, Katie Grantham, Kemper Lewis, and **Susan M. Bateman** 1378–1390 Comparing Physical and Cyber-Enhanced Product Dissection: Analysis from Multiple Perspectives

Product dissection has evolved into a versatile pedagogical platform useful across the engineering curriculum. Simulation technologies have recently broadened the opportunities to implement cyber-enabled product dissection, but its effectiveness on achieving educational outcomes must first be studied. In this paper, we carefully delineate the difference between physical, virtual, and cyber-enhanced (a blend of physical and virtual) dissection considering the advantages and limitations of each type of platform. We then study and report on the impact of variations of cyber-enhanced dissection across two populations of sophomore engineering students at two universities using a number of exercises and data collection methods. We found that students perceived the cyber-enhanced dissection exercises to be relevant to the students' own professional preparation, to facilitate easier dissemination, to better align with emerging industrial practices, and to provide unique experiences not available in other courses the students had taken. Some potential drawbacks of cyber-enhanced dissection were also reported by students, including technology distracting them from the core educational objectives and over-reliance on historical data of unknown origin. Although there are important tradeoffs between physical and cyber-enhanced dissection that need to be considered, using a blend of physical and virtual instructional tools may provide an effective platform to teach a wide range of engineering concepts across a curriculum.

Keywords: product design; product dissection; digital tools; cyber-enhanced dissection; student perceptions

Javier Rodriguez, Javier Navallas and **Armando Malanda** 1391–1404 Teaching a Master Student how to Model the Electrical Potentials Produced by the Muscle

In Electromyography studies, the motor unit is considered as the anatomical and functional unit responsible of the electrical activity related to the contraction of the skeletal muscle. This paper is aimed at showing biomedical engineering master students how to model and study the electrical potentials produced by the activation of the motor unit. The proposed model is based on a mathematical concept familiar to engineers, the convolution. By using computer simulations based on this model, the effects of changes in the motor unit parameters on the characteristics of generated electrical signal are illustrated. The paper is useful in showing the students how to identify the different aspects involved in the analysis of biological phenomena.

Keywords: motor unit; muscle fiber; computer simulation; single fiber action potential (SFAP); motor unit action potential (MUAP)

Juan A. Mantecón, Manuel Gómez and **José Rodellar** 1405–1413 Teaching Control of Irrigation Canals to Non System Engineers

This paper presents an experience of teaching automatic control within the master course Real-time Control of Irrigation Canals. It is part of Semester 3, focusing on Decision Support Systems, offered by the Technical University of Catalonia (UPC) in the framework of the Erasmus Mundus Master Program Hydro-Informatics and Water Management (EUROAQUAE). After some insights into signals, systems and control theory, the students are introduced to the operational management of irrigation canals and to the mathematical models needed for simulation and control purposes. PI and predictive control are taught and used to design irrigation canal control systems. MATLAB-Simulink and Real Time Workshop environments are extensively used to provide explanatory exercises along with lectures, student homework tasks and a final design project on a laboratory canal. A visit to a real canal installation is organized during the course.

Keywords: automatic control; irrigation canals; water management; control education; course design; course evaluation; teaching strategies

Victor R. L. Shen and **Cheng-Ying Yang** 1414–1420 A Special Approach to Teach Artificial Intelligence

Problem-Based Learning (PBL) is a promising and student-centered teaching method. This paper discusses the methodology and its application to teach Artificial Intelligence (AI) in detail. Also, it aims to construct a web- and problem-based (PBL) system for students at the department of computer science and information engineering. The central bases on the instructional theory, learning theory, and PBL activities are applied to this paper. Given this, the authors intend to educate students with team working, data analyzing, and problem-solving capabilities. The learning experiences in the two course forms including the PBL approach and the traditional one are compared by using a questionnaire response and examination scores. Moreover, the ability of technological innovation can enable students to enhance their competencies. The research results obviously show that the PBL approach can help students learn more about Artificial Intelligence (AI). Additionally, in the PBL course with an interaction in small groups, students learn how to present what they thought, how to clarify and define what a problem is, and how to precisely grasp what the relevant information is.

Keywords: Artificial intelligence (AI); problem-based learning (PBL); web-based instruction system

I. C. Jong 1421–1427 Determining Deflections of Elastic Beams: What Can the Conjugate Beam Method Do That All Others Cannot?

An elastic beam on a simple support can be in neutral equilibrium under a variety of loading conditions. Is it possible to ascertain the deflections of such a beam? The answer is: yes—by the conjugate beam method propounded by Westergaard in 1921, and no—by all other methods. It is recognized that support conditions, rather than boundary conditions, are what the conjugate beam method requires in finding deflections of loaded beams; and more support conditions than boundary conditions are usually known for beams in neutral equilibrium. The objective of this paper is to share with engineering educators the pedagogy of the conjugate beam method and the solution for the deflected configuration of a loaded elastic beam in neutral equilibrium by this method. The feasibility of obtaining such a solution via this method is unmatched by other methods. The conjugate beam method, missing in most current textbooks in mechanics of materials, is as good as (or even better than) other methods when it comes to the analysis of deflections of beams. Once well revived in textbooks, or otherwise, for teaching and learning, this method is expected to significantly impact the favored way beam deflections are analyzed.

Keywords: beam; slope; deflection; neutral equilibrium; conjugate beam method

S. S. Moor and **P. R. Piergiovanni** 1428–1444 A Multimodal Approach to Classroom Instruction: An Example from a Process Control Class

The use of active, cooperative and inductive learning approaches has been shown to be beneficial to student learning. Traditional engineering activities of projects, simulation exercises and laboratories provide cooperative and active experiences outside the classroom. By bringing these traditional engineering activities into the classroom a multimodal approach to education can be used where a variety of activities enhance the classroom experience. A process control course has been developed that integrates the use of experimental kits, simulations, problem solving exercises and instructor content delivery in a single setting. In this setting any of the above modes of instruction can be used as is appropriate to the progress of the course. Multiple assessments have been used to evaluate and refine the modular kits and the multimodal approach of this class. These assessments include observations by different instructors, anonymous student surveys, student focus groups, and observed student problem solving sessions. Overall the kits and the integrated approach have had a positive effect on the class. Student focus groups brought up all of the approaches used when asked what helped them to understand and remember the material. Students like the integration of kits and simulation in the classroom setting and have shown a particular preference for class sessions where a short activity is used to raise an issue and then followed up with detailed content on the issue. For these sessions students have suggested returning to the experimental kits at the end of the section—encouraging instructors toward a learning cycle approach.

Keywords: inductive learning; cooperative learning; process control; cycles; classroom experiments; simulation

X. Lladó, J. Freixenet and **A. Oliver** 1445–1454 Linking Research and Teaching through an Applied Computer Vision Course

In this paper we present our experience of designing a course shared between the European Erasmus Mundus Master's Degree in Computer Vision and Robotics (VIBOT), and the local Master's Degree in Industrial Computer Science and Automation, both of which are official qualifications at our university. The main aim of the course is to integrate a number of different subjects, such as computer vision, computer programming, perception systems, databases and computer engineering, by using an open research platform called PASCAL. We aim to demonstrate the effectiveness of such a practical course that integrates technology and research into educational methods. We describe this integration, by presenting and evaluating the methods used and identifying the links between research and teaching techniques. As a practical approach, the majority of educational activities are developed in our university labs, where we work with students from all five continents, mixing national and foreign students into different workgroups. The students are greatly motivated by working in such an environment and on this research platform, which permits them to consolidate their existing knowledge and extend their curricula.
Keywords: course design; computer vision; integrating research and teaching

Joaquín Castelló, Dolores Lerís, Vicente Martínez and **María Luisa Sein-Echaluce** 1455–1463 The Mathematical Communication Competency in the Engineering Degrees: a Tool to Assess the Starting Point

In 2006, the authors of this article designed a survey to assess the mathematical profile of students beginning engineering degrees. The study presented here is the result of the idea of validating part of the questionnaire as a tool for measuring skills in the use of mathematical language. Thirteen questions have been considered, and the hypotheses tested were whether any questions were redundant and therefore could have been excluded, and whether correctly answering the questions classified beforehand as requiring a higher level of knowledge was related to correctly answering questions at lower levels.

The chi-square test was used to study the dependence of pairs of related items, and logistic regression was used to determine whether the results for some simple items conclusively explained the results in other more complex items. The study essentially confirmed that eleven of the thirteen questions are a useful instrument for measuring skills in communicating mathematical content among students beginning an engineering degree.
Keywords: assessment, first-year students, mathematical competency in engineering

Tuncay Aydogan and **Ozlem Can** 1464–1471 Identifying Students' Misconceptions in Data Structures and Algorithms

Data Structures and Algorithms (DSA) is one of the core courses of Computer Science (CS) education. The course has several abstract concepts. In this study, misconceptions made by students relating to the Lists, also known as Linked Lists (LL), have been identified. The main and sub-problems were first identified, and then a three-tier multiple-choice conceptual understanding diagnostic test (or three-tier test) was prepared and administered to 291 students. The results were analysed and information about 14 misconceptions were obtained.
Keywords: misconceptions; data structures; three-tier diagnostic test; linked lists

Hurevren Kilic, Murat Koyuncu and **Mohammad Rehan** 1472–1483 Designing Senior Graduation Project Course for Computing Curricula: An Active Learning Approach

This paper proposes an active learning-based design approach to senior graduation project courses for computing curricula. The proposed approach focuses mainly on course requirements including increasing the interaction between instructor and project team members; providing better and fair student/team performance assessment; encouraging students to practise life-cycle driven development; preparing students for role-based team-working; motivating students to communicate with experts from industry and supporting cooperation between students. It is observed that implementation of the proposed approach increases the student course satisfaction level while higher quality student projects are achieved.
Keywords: senior graduation project; active learning; project-based learning; computing curriculum; undergraduate education.

Jorge Enrique Pérez-Martínez, Javier García, Isabel Muñoz and **Almudena Sierra-Alonso** 1484–1492 Active Learning and Generic Competences in an Operating Systems Course

The Bologna Declaration and the implementation of the European Higher Education Area are promoting the use of active learning methodologies. The aim of this study is to evaluate the effects obtained after applying active learning methodologies to the achievement of generic competences as well as to the academic performance. This study has been carried out at the Universidad Politécnica de Madrid, where these methodologies have been applied to the Operating Systems I subject of the degree in Technical Engineering in Computer Systems. The fundamental hypothesis tested was whether the implementation of active learning methodologies (cooperative learning and problem based learning) favours the achievement of certain generic competences ('teamwork' and 'planning and time management') and also whether this fact improved the academic performance of our students. The original approach of this work consists in using psychometric tests to measure the degree of acquired student's generic competences instead of using opinion surveys, as usual. Results indicated that active learning methodologies improve the academic performance when compared to the traditional lecture/discussion method, according to the success rate obtained. These methods seem to have as well an effect on the teamwork competence (the perception of the behaviour of the other members in the group) but not on the perception of each students' behaviour. Active learning does not produce any significant change in the generic competence 'planning and time management'.
Keywords: active learning; cooperative learning; problem based learning; generic competence.

Wilmar Hernandez, Jorge Bonache, Carmen Cousido, Javier Palmero, Manuel Labrador and **Antonio Alvarez-Vellisco** 1493–1502 Statistical Analysis of Academic Results Before and After Four Years of Bologna

In this paper, a statistical analysis of the performance of telecommunication engineering students who were majoring in electronic systems in the subject Analysis of Circuit I is conducted. Here, the marks of the students before and after four years of being subject to a student-centered teaching and learning approach, implemented as part of the changeover to the Bologna model, are compared. In this research, the statistical population (i.e., marks of the students in 2005 and 2009) were analyzed in detail in order to identify the specific changes after four years of 'Bologna'. Mann–Whitney and proportion tests were used to analyze the effects of the implementation of the Bologna process, which resulted in an improvement in the academic results of the students. In addition, models for the marks of the years 2005 and 2009 were constructed. These models were very different from each other. A mixture of Gaussians was used to model the 2005 marks, and the 2009 marks followed a Gaussian distribution. Thus, before the start of the educational experiment, in the year 2005, the statistical population was heterogeneous, consisting of two subpopulations, and at the end of it the data resulted in being homogeneous. Therefore, the Bologna process has represented a passing from an unsatisfactory model for the 2005 marks to a more 'reasonable' model for the 2009 marks.
Keywords: non-parametric tests; proportion tests; statistical modeling; Gaussian mixture models

Frederick C. Berry and
Patricia A. Carlson

1503–1507   Assessing Engineering Design Experiences using Calibrated Peer Review™

We report on the assessment of the design experiences that students have in their electrical or computer engineering programs. Calibrated Peer Review™ (CPR) is the tool used for this assessment. CPR is an online-tool with four structured workspaces that perform in tandem to create a series of activities that reflect modern pedagogical strategies for using writing in the learning process. The learning materials that were developed for guiding students through an engineering design experience serve as the data for assessment.

Keywords: engineering design; peer-review; technical communication

**Andrés Díaz Lantada, Pilar Lafont
Morgado, Javier Echávarri Otero,
Juan Manuel Munoz-Guijosa** and
José Luis Muñoz Sanz

1508–1523   Listening to Students as a Way of Improving Teaching: Application of QFD-Based Techniques to a Final Year Subject

The use of techniques based on 'QFD-Quality Function Deployment' approaches has some major, outstanding teaching applications that are closely linked to the work of individualising teaching, improving student–teacher relations, and optimising the services offered by educational institutions, by actively listening to what students want. In particular, in the current context of the implementation of the European Higher Education Area, through which it is intended to focus the teaching–learning process on students and their individual work, it is very important to consider students' opinions and their ideas concerning their future professional development. This work sets out the application of QFD techniques for assessing teaching quality, perceived through student satisfaction in the course called 'Design and Manufacturing of Plastic Products' taught on the 5th course of the Machine and Manufacturing specialisations as part of the Industrial Engineering degree of Madrid Polytechnic University. The power of the method used has enabled 60 students' needs to be analysed as well as their relationship with 30 teaching tools, services and processes that are available in any university and that can be used to find out which issues need strengthening according to the 1800 relationships integrated into the model. It has also been compared to a Blitz QFD® based approach that lets this type of quality analysis be performed and proposals for improvement be made more directly. After these systematic QFD and Blitz QFD® analyses several improvements have been introduced within the subject, so as to tackle the main student needs that were detected. Such actions have promoted the knowledge acquired by students and the quality of teaching, as can be seen from the comparison made between final results from the 2008–2009 course and those from the 2009–2010 course.

Keywords: teaching quality; quality function deployment; quality assessment; students' needs.

**Chun-Fang Zhou, Ling-Ling Luo,
Xiang-Yun Du,** and **Anette Kolmos**

1524–1535   Factors Influencing Group Creativity in Project-organized Teams in Engineering Education in China

In China, project-organized learning is regarded as a strategy to foster creative engineers. This study explores the link between project-organized learning and group creativity. We regard group creativity as a socio-cultural concept, influenced by factors from a social and cultural context. Relating this point to project-organized learning in engineering education in China, this paper focuses on which factors influence group creativity development in project-organized teams. Multiple methods including questionnaire and interview were employed. A CCQ (Creative Climate Questionnaire) survey was conducted among 126 members from 25 teams at seven universities. Interviews were carried out with eight team leaders. Research findings show that a series of factors such as task challenge, group diversity, conflict, group size and membership change etc. influence group creativity interactively; however, risk taking is not encouraged in these teams, which could be the potential barrier to creativity. Therefore this paper has contributions to implications for engineering education innovation.

Keywords: group creativity; project-organized team; engineering education; Chinese culture

**Maria Catalina Ramirez Cajiao,
Javier Alejandro Carvajal Diaz** and
Jose Tiberio Hernandez Peñaloza

1536–1549   Innovation and Teamwork Training in Undergraduate Engineering Education: A Case of a Computing Engineering Course

In the last few years a computing engineering course has been taking form at the Universidad de los Andes (Bogotá, Colombia). The course brings students and entrepreneurs together with innovation projects centered around the productive sector. This paper presents the experience of the course "Innovation with Communication and Information Technologies" in which, within the CDIO (Conceive—Design—Implement—Operate) framework (with an initial observation stage), a group of entrepreneurs from the ICT sector act as coaches for teams of students who, in an autonomous way, propose innovative and sustainable projects. Based on an evaluation process based on the Cybersyn methodology of indicators and indexes, evidence is generated of a growth in innovation and teamwork abilities as well as student development during the last year of undergraduate studies. This paper is structured in three parts: (1) a review of the literature associated with the development of abilities and innovation and teamwork in engineering schools with an emphasis on the phases of CDIO; (2) a detailed description of the process and evaluation of the proposed course in computer engineering; and (3) the main results obtained during the last year that will enable the proposal to be replicable in other engineering courses. A conclusion is presented with recommendations and a view of future work.

Keywords: active learning; innovation training; teamwork training; alliance with entrepreneurs; engineering education

**Kerry L. Meyers, Matthew W. Ohland,
Alice L. Pawley** and
Cody D. Christopherson

1550–1560   The Importance of Formative Experiences for Engineering Student Identity

The motivation for the current study was to examine the experiences that contribute to engineering identity both in terms of educational and professional pathways; this was accomplished through both qualitative and quantitative means. A cross-sectional study of undergraduate engineering students was conducted at a medium-sized Midwestern private university. A large-scale survey of all undergraduate engineering students, ~1100, yielded responses from ~700 students during the spring of 2009. Survey questions were based on a study approach defining adulthood by Jeffrey Arnett, but specifically applied to engineering identity as a parallel but unique instrument. Engineering identity from a student perspective was assessed, both in terms of self-identification (do engineering students consider themselves to be engineers?) and identifying factors that are "necessary" to be considered an engineer. A qualitative inquiry followed to better inform the quantitative survey results. Individual student interviews across class levels and engineering self-identifications were conducted as a collection of case studies. While it was not surprising to find that individual student experiences contribute to an overall sense of belonging to the college, it was interesting that key experiences such as internships and undergraduate research were not found to be statistically significant predictors of engineer self-identification. Student interviews offered insight into this finding; those experiences were formative, but there is a bi-directionality to these experiences–they can be either affirming or discouraging. Students cited experiences that were positive, challenging learning opportunities as reaffirming their engineering identity as it relates to future career plans. Conversely, negative student experiences were also formative but were related to non-identification and dissuaded students from future engineering related career plans. Finally, the implications for an institution's curricular structure as it relates to engineering identity are discussed as are suggestions for promoting multiple student experiences before graduation and formal assessment of those experiences.

Keywords: engineering education; identity; professional persistence; student experiences

International students account for 3.5% of graduate students in the US with 17% enrolled in engineering programs in 2008. Recruiting and retention of International Graduate Students (IGS) is an essential and important consideration for US universities with increased competition from other countries. Understanding concerns and preferences influencing the IGS's decision to choose a school in addition to factors affecting decisions to continue advanced degrees at a university will help schools effectively recruit and retain better quality students and thus increase research productivity. This paper addresses the design of comprehensive online survey to find preferences and influential factors affecting the decision of IGS in choosing a graduate school. IGS and alumni at US schools were invited anonymously to participate and complete the survey. Survey results were analyzed and interpreted both quantitatively and qualitatively. Results indicate that preferences of IGS to choose a school depend on their nationality, gender, age and several other factors. The paper concludes with recommendations to improve recruitment and retention, considering preferences and concerns of different groups of IGS and strategizing the efforts in view of diversity of IGS.

Keywords: International graduate students; recruitment; retention; online survey