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Contributions in: Simulations and Simulators, Web-based Instruction and Evaluation, Cooperative Learning, Assessment, Curriculum Design and Integration, Sustainability, Creativity, STEM Learning, and International Experiences

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- Joel D. Hewlett and Bogdan M. Wilamowski** 217–224 SPICE as a Fast and Stable Tool for Simulating a Wide Range of Dynamic Systems

This paper introduces a generalized method for simulating dynamic systems in SPICE. The proposed method is useful for students in that the necessary software is free and only an elementary knowledge of SPICE is required. The method uses a netlist description of the system that comprises little more than a set of state equations. In comparison with many of the more commonly used tools, such as MATLAB/SIMULINK, the presented method is less involved, allowing the student to stay focused on the problem rather than the software. The method is not limited only to electrical systems: it can be applied to virtually any dynamic system, making it accessible to students from other backgrounds.

Keywords: SPICE; system dynamics; state-variable analysis; computer aided analysis

- T. J. Mateo Sanguino and J. M. Andújar Márquez** 225–237 3D-RAS: A New Educational Simulation Tool for Kinematics Analysis of Anthropomorphic Robotic Arms

The present work launches a new educational simulation tool aimed at making kinematic analysis of anthropomorphic robotic arms more attractive and practical. This work focuses on the development of a new educational simulation tool for the “Robotics” subject in the third year of the “Computer Engineering” and “Electronic Engineering” degrees at the University of Huelva (Spain). The developed tool (3D Robotic Arm Simulator, 3D-RAS) is aimed at engineering practices and demands students no programming knowledge. Its highly graphic interface allows easy and simple definition of both parameters and geometry in serial arms with up to five degrees of freedom (DOF). Therefore, this work focuses on an innovative graphic environment designed for teaching professionals which allows them studying D-H conventions, mapping both forward and joint workspaces, evaluating surface and volume trajectories applied to anthropomorphic robotic arms, and visual observation of the movement of serial robotic manipulators. This process is much simpler than the analytical interpretations of results.

Keywords: engineering education, kinematics, robotic arm, virtual instrument, trajectory planning

- Fermín Sánchez, David Megías and Josep Prieto Blázquez** 238–247 SiMR: A Simulator For Learning Computer Architecture

This paper presents SiMR, a simulator of the Rudimentary Machine designed to be used in a first course of computer architecture of Software Engineering and Computer Engineering programmes. The Rudimentary Machine contains all the basic elements in a RISC computer, and SiMR allows editing, assembling and executing programmes for this processor. SiMR is used at the Universitat Oberta de Catalunya as one of the most important resources in the Virtual Computing Architecture and Organisation Laboratory, since students work at home with the simulator and reports containing their work are automatically generated to be evaluated by tutors. The results obtained from a survey show that most of the students consider SiMR a highly necessary even an indispensable resource to learn the basic concepts about computer architecture.

Keywords: Distance learning environments; virtual laboratories; rudimentary machine; simulation software for processor architecture

- Victor R. L. Shen and Cheng-Ying Yang** 248–256 Intelligent Multiagent Tutoring System in Artificial Intelligence

An Intelligent Multiagent Tutoring System (IMATS) in Artificial Intelligence (AI) is presented in this paper. The authors describe ways of improving the quality of teaching AI through the use of agent technology. An interface agent, an authorization agent, an SQL agent, and a student agent can be integrated into the intelligent learning environment. These agents can guide and assist students as needed, probe their understanding, and promote learning and retention. They also exploit the natural human tendency to respond socially to computing systems. Here a brief historical perspective of intelligent learning environments is discussed and followed by an explanation of the IMATS framework. Next, a detailed description of the intelligent tutoring system, IMATS, is given. Then the results of usability evaluation, effectiveness evaluation, and satisfaction level evaluation of the software system are presented. The IMATS framework incorporates an incremental approach to obtain the dynamics of knowledge accumulation in the domain of interest and the learned knowledge content over time.

Keywords: agent technology; artificial intelligence; intelligent tutoring system; web-based instruction

- Piroska Stanic Molcer and Vlado Delic** 257–265 Exploring the Effectiveness of Interactive On-line Exercises in Project Accomplishing in the Course: Intelligent Control Systems

This paper presents the experiences with web-based interactive exercises in fuzzy logic teaching. In addition to theoretical lectures, laboratory exercises and a project-based learning environment in 2010, at the College of Applied Sciences in Subotica, web-based interactive laboratory exercises were introduced into the Intelligent Control Systems course in the sixth semester. A set of MATLAB on-line exercises was developed as well as an on-line tool for student assessments and for the formative evaluation of the new web-based learning environment. The effects of the interactive on-line exercises on the success of the project-based learning were examined. The results show the benefit of giving students the opportunity to learn by exploring at any time and from any location. The results of the questionnaire on student satisfaction are also given.

Keywords: interactive learning; project-based learning; formative evaluation; on-line experiments; intelligent systems

This work presents a web-based platform that provides easy and intuitive remote interaction with a team of mobile robots through the Internet. It has been designed to allow students to train with mobile robots from their own home, with a flexible timetable, minimum installation requirements for their computer and independent of the operating system they use. The remote laboratory is devoted to a robotics and computer vision subject and it facilitates the understanding of several algorithms and control strategies in these fields. Several types of robots are available for monitoring and control tasks, using the same user friendly interface of communication. Along the paper we detail the architecture of the platform, the teaching and learning model we have adopted and the practical sessions we propose. Also, we analyse the academic results and the students' experiences we have collected. This tool has empowered the autonomy of the students to solve the tasks proposed and the students themselves highlight the flexibility of access. However, we have been aware of some issues that will help us to redefine some features for the near future.

Keywords: architectures for educational technology systems; distance education and telelearning; distributed learning environments; interactive learning environments.

Safety awareness has been identified by the College of Engineering at Iowa State University as one of the core student competencies tracked as part of the ABET accreditation process. However, engineering students, and their internship supervisors, were found to rank this competency low compared to other competencies. To increase competency and accomplish safer designs, engineers need to be trained in safety engineering fundamentals. However, it would be extremely difficult to add this content to already overflowing engineering curricula. Thus, an autonomous on-line safety awareness enhancing curriculum was developed and deployed. This work suggests utilizing a decision making simulation to assess the effectiveness of the proposed program on a level of safety awareness has merit. The results of the analyses of the simulation indicated a significant shift in safety awareness. The implementation of this approach for assessment of programs requires little effort on behalf of the instructor and quickly provides results to both the students and the faculty after students completed the program. This assessment process can replace current methods (e.g. feedback from graduates during exit interviews and from graduates' supervisors in the workplace), which are indirect measures that involve a more tedious process. Ultimately, the suggested methodology can be automated and provide assessment almost instantaneously.

Keywords: safety awareness; competency; decision making simulations; program assessment

The aim of this research was to design and implement a learning methodology based on continuous assessment in group-based learning in a blended learning environment with a view to improving design skills and identifying the attitude of learners toward this methodology. This was achieved through a case study of the Industrial Plants course of the Degree in Industrial Scheduling at the School of Industrial and Aeronautical Engineering of Terrassa (ETSEIAT) of the Universitat Politècnica de Catalunya (UPC) during the 2008-2009 academic year. Qualitative and quantitative methods, including questionnaires, interviews and result analysis, were used in the case study. The findings show that the use of information and communication technologies (ICTs) for improving design skills in group-based learning is feasible and delivers good learning results. Students and instructors appreciated the opportunity for students to work in groups, in combination with face-to-face and ICT sessions, and to study using the written material and the correction protocol that was provided.

Keywords: cooperative/collaborative learning; distributed learning environments; teaching/learning strategies; evaluation methodologies

Many studies have shown that cooperative learning results in a notable improvement in the learning performance of team members. In the present study the relative performance of the high-, medium- and low-ability students within cooperative learning teams is compared with that of students with an equivalent ability working using an individualistic learning method. A series of experiments are performed in which forty-two mechanical engineering sophomore students are randomly assigned to one of the two learning modes and are put into mixed-ability three-member groups. The experimental results show that the relative benefit of cooperative learning depends on the academic ability of the individual members within a cooperative team. Furthermore, the presence of dysfunctional teams may well account for the ambiguity in the results presented in the literature regarding the potential benefits of cooperative learning for students with differing levels of academic ability.

Keywords: ability-condition interaction; cooperative learning; heterogeneous teams; individualistic learning

This paper presents an analysis of the peer assessment data used to derive individual marks for teamwork projects assigned in four petroleum engineering courses. The collected data represents a wide range of groups composed of international and local students, male and female students. The analysis emphasises peer assessment as a viable tool for evaluating individual contributions, as long as human bias is adequately minimised for fair assessments. We applied the normalisation factor technique to address biases. The study demonstrates that poorly performing students in the groups can be identified by utilising peer assessment. However, to be successful additional judgement is required from the lecturer, based on the observation of team dynamics. It was determined that a significant number of students (about 40%) gave the highest marks to peers for all assessment criteria; in particular a high proportion of the international students in our study were more generous than the local peers. In four groups out of 22 groups, all team members gave the highest rates to each other for all criteria thus severely undermining the peer assessment process. All these observations underline the necessity to give students adequate training in the method when using peer assessment; and care needs to be taken when groups are formed to enable effective group dynamics.

Keywords: peer assessment; teamwork; petroleum engineering; learning styles; international students

There is a need for engineering and technology curricula which balance analytical and theoretical knowledge with integrated physical facilities that offer students authentic and relevant hands-on experiences. In this paper, this need is addressed with focus on the field of manufacturing. It has been established that fabricating a simple functional mechanism is an effective way to give students realistic hands-on manufacturing experiences. A consortium of five departments in four institutions was formed, and a consortium-wide curriculum writing process was undertaken, in which a core set of common course-level learning outcomes was developed. A statistical analysis was carried out to ascertain those outcomes that contributed most to meeting institutional educational objectives. This resulted in a common core of learning outcomes serving the needs of all participating institutions.

Keywords: engineering curricula; competency gap; hands-on experience; learning factory

A nanotechnology learning module was implemented into a freshman engineering course at Virginia Tech. The novelty of our approach is that an established spiral curriculum model has been employed, for the first time to the best of authors' knowledge, to design the nanotechnology option. The module was piloted in a freshman class (180 students) during spring '08. The key components included (1) a prior knowledge survey, (2) a 40-minute in-class presentation on basic nanotechnology concepts, (3) an activity that involves nanoscale image analysis and the plotting of molecular forces using LabVIEW software, and (4) a post-module survey. Lessons learned from the pilot implementation were incorporated appropriately to expose roughly 1450 freshmen to nanotechnology basics in fall 2008. The module was further refined in spring 2009 when pre- and post-tests were administered to assess the learning outcomes. Based on the prior knowledge data from about 1800 freshmen, we found that they had misconceptions about nanoscience fundamentals, e.g., regarding the (1) role of gravity at the nanoscale, and (2) behavior of intermolecular forces. Exit surveys revealed that approximately 18% of students had an interest in pursuing a nanotechnology option and approximately 65% believed that nanotechnology was relevant in their intended engineering majors. The LabVIEW provided an appropriate environment to implement the hands-on analysis of nanotechnology concepts, but we caution that such hands-on exercises should place greater emphasis on nanotechnology concepts than on LabVIEW skills.

Keywords: nanotechnology; freshman engineering; spiral curriculum

P. Ortíz, J. Montoya, C. Hernández, 354–363 Thermodynamic Approach in Chemical Plant Design: Teaching Chemical Engineering in the First Year
A. Manrique and W. Nieto

This work describes and discusses an educational experience developed in a first year course of a chemical engineering program. Student teams are guided through the ideal design of a chemical plant from basic thermodynamic concepts, so that they can identify the differences between their designs and real processes and to establish relationships between what they have done and specific areas of chemical engineering knowledge. The design project had an integration curriculum approach and involved the assisted use of process simulation software and some specialized bibliographic resources. The learning process was assessed by surveys and interviews, and by a rubric-guided analysis of students' reports. The project and its methodology are intended to be a mechanism to promote a wider vision of the curriculum from the early years and to foster students' motivation.

Keywords: chemical engineering education; curriculum integration; learning cycles

C. Depcik, A. Hausmann, J. Lamb, 364–379 Incorporating Sustainable Automotive and Energy Design into the Engineering Curriculum using Remote Control Cars
B. Strecker, C. Billinger, W. Pro and M. Gray

The Engineering Education and Centers wing of the National Science Foundation has undertaken the task of re-structuring engineering education. The objective is to make it more effective, quality conscious, flexible, simpler and less expensive. A novel capstone design project at the University of Kansas addresses these concepts using Remote Control (RC) cars. RC cars are an effective teaching tool as they help to focus the analysis of the ideas while increasing the relevance to current social topics. It produces better engineers by creating a curriculum-wide methodology that merges theory with practice, generating better quality designs. The flexibility of the program is evident in the six different designs created in the first year alone using varying levels of technology. Small-scale building is inherently simpler as parts are easier to manufacture and mistakes can be readily eliminated and components remade. Finally, at around \$1200 per 1/8th scale car, the costs of the program are significantly reduced, making the project feasible for all universities, community colleges and even high schools of various sizes.

Keywords: sustainability; automotive; capstone; mechanical; energy

Shun Takai 380–388 Pre-Post Assessment of Creativity Methods in an Experimental Course

This paper compares performance and creativity of design projects before (pre) and after (post) students apply creativity methods taught to them in an experimental course. Design projects are evaluated by numeric performance scores and qualitative Creative Product Semantic Scale (CPSS) scores. A preliminary pre-post analysis of design projects indicates that the creativity of the projects improves after applying creativity methods; however, a more creative project does not necessarily improve performances after applying creativity methods. CPSS 'resolution' scores and 'elaboration and synthesis' scores are good measures of project performance; however, CPSS 'novelty' scores do not have significant associations with performance scores. Projects with simpler designs perform better, which is suggested by a significant negative association between part counts and performance scores.

Keywords: creativity; evaluation; decision making; design education

Lyn D. English, Peter Hudson and 389–398 Perceived Gender Differences in STEM Learning in the Middle School
Les Dawes

Women are underrepresented in science, technology, engineering and mathematics (STEM) university coursework, reflecting long-standing gender issues that have existed in core middle-school STEM subject areas. Using data from a survey and written responses, we report on findings following the introduction of engineering education in middle school classes across three schools (grade level 7, $n = 122$). The engineering experiences fused science, technology and mathematics concepts. The survey revealed higher percentages for girls than boys in 13 of the 24 items; however there were six items with a 20% difference in their perceptions about learning in STEM. For instance, despite girls recording that they have been provided equal or more opportunities than boys in STEM, they believed they do not do as well as boys (80% boys, 48% girls) or want to seek a career in STEM (39% boys, 17% girls). The written responses revealed gender differences across a number of themes in the students' responses, including resources, group work, the nature and type of learning experiences, content knowledge, and teachers' instructional style. Exposing students to STEM education facilitates an awareness of their learning and may assist girls to consider studying STEM subjects or STEM careers.

Keywords: middle-school engineering; student perceptions; gender differences

Shi-Jer Lou, Yi-Hui Liu, Ru-Chu Shih, 399–410 Effectiveness of On-line STEM Project-Based Learning for Female Senior High School Students
Shun-Yuan Chuang and Kuo-Hung Tseng

This study aimed to develop an interdisciplinary on-line learning project for female senior high school students and to explore their participation process and its learning effectiveness. The topic for the project was 'The creative design of a cup speaker'. The five-stage model comprised preparation, implementation, presentation, evaluation and revision (PIPER). The model was used for the integrated learning of science, technology, engineering, and mathematics (STEM). Throughout the project, the students were able to discuss and share knowledge about their projects via the STEM on-line platform. The study involved 40 volunteers from a girl's senior high school in Taiwan, grouped into ten teams of six students. Textual analyses, survey questionnaires, and interviews were used to collect data. The findings of the study show that the female students were engaged in the project and were able to combine theory with practice effectively to create cup-speakers according to the five stages of PIPER. In addition, this project created a new opportunity for female Taiwanese senior high school students to experience the joy of engineering design as well as to enhance the effectiveness of the STEM knowledge application. Therefore, the design of interdisciplinary and hands-on projects is seen as an important issue for future curriculum design.

Keywords: female senior higher school student; learning effectiveness; project-based learning (PBL); STEM

This paper examines the obligatory but often contentious relationship that exists between contemporary second level education and the choice of undergraduate course by students within an Irish context. A survey of 1723 students from across four second level schools and all year groups was conducted asking students to elect a career that they would most like to pursue in the future. The results of this survey served to highlight the declining allure of engineering as a future career for students as they progress through second level. Focus groups were held in all four schools in order to identify the current motivations behind students' course choice, as well as students' perceptions regarding the decline in undergraduate engineering numbers. Students frequently highlighted future career prospects, as well as current matriculation requirements as factors to be taken account of in the uptake of undergraduate engineering degree programmes. Finally this paper also compares and contrasts the perceptions and motivations of current second level students with those of existing undergraduate engineers.

Keywords: course choice; engineering; education; student perceptions

Little is known about why students choose to enrol in post-graduate studies. Going through a Ph.D. degree is often seen as a risky decision. This study offers responses' analysis of two groups; the first consists of 274 graduate students enrolled in various engineering programmes in Lebanon and the second consists of 187 working engineers. Both groups of participants completed a survey investigating the factors that may impact on their decision to pursue a Ph.D. Based on the Theory of Reasoned Action, the Likert-scaled items aimed to identify the attitudinal and normative factors leading to the intention of enrolling in Ph.D. An independent t-test revealed no significance between students and engineers' intention. An exploratory factor analysis provided four factors: professional attitude, social attitude, financial attitude and subjective norm. Using multiple regression technique, the professional attitude appeared to be the main contributor to students' and engineers' intention. The findings are discussed and recommendations for future studies are offered.

Keywords: engineering education; Ph.D. enrolment; Theory of Reasoned Action; Middle East

This study was conducted to clarify the relationship of student attitude, subjective norm and perceived behavioral control to the intention of university student's use of innovative information technology for learning and their thoughts about integrating innovative information technology into instruction in Germany. Research subjects were 270 students pursuing different academic degrees at Ilmenau University of Technology. The data were collected by web-based questionnaires. Quantitative analytical methods, including descriptive statistics, reliability analysis, one-way ANOVA, regression analysis, confirmatory factor analysis and a structural equation model were employed using SPSS and AMOS statistic software. The results show that the perceived behavioral control variable has a relationship to students' behavioral intention. Attitudes toward the behavior and perceived behavioral control can predict the intention of the use of innovative IT and for learning in TU Ilmenau students. In addition, most students have positive attitudes toward the use of innovative IT in their tuition, and believe that university instructors and students should be trained to use integrating innovative IT in teaching.

Keywords: behavioral intention; instruction with innovative information technology; theory of planned behavior

This paper presents the experiences and observations of a Taiwanese scholar teaching engineering students in Norway for one semester. Many important cultural differences were found both in terms of student behaviour and academic practices. This qualitative study focuses in particular on the teacher's formal meeting with the students in the classroom, informal meetings with the students outside the classroom and examination practices. The observations presented here can give Eastern educators a better insight into the current educational situation in Northern Europe. Moreover, the observations can also be useful to North European educators as an observer's view of current educational practices.

Keywords: internationalization; culture differences; testing; classroom teaching

There is a global need to implement modern educational pedagogies. For developing nations, class size, utilities infrastructure, and a deeply entrenched lecture-based teaching paradigm are additional challenges. Our fundamental hypotheses are that classroom logistics in a transport class can be modified to use a novel pedagogy incorporating a Desktop Learning Module (DLM) for effective Hands-on Active Learning (HAL) in a developing nation and that enhanced learning will take place. HAL was compared to Lecture in a 127-student, 300-level Chemical Engineering (CHEN) class and assessed through multiple-choice quizzes and survey questions based on the Seven Principles for Good Practice. Follow-up faculty interviews were conducted to explore additional impact related to the introduction of HAL. For side-by-side comparison of the two pedagogies the class was split into two groups. These studies revealed there was significant but equal improvement in conceptual understanding for both the HAL (n = 59) and Lecture (n = 68) groups. However, surveys reveal HAL is in better alignment with Principles for Good Practice in undergraduate education. Faculty interviews add supportive evidence that students who experience the new pedagogy do better than those who do not. There is also an apparent spread effect suggesting that the introduction of cooperative learning strategies influenced faculty teaching and student learning behaviors. Also, the DLM device has features that encourage its adoption such as fast response, portability, and suitability for interfacing with a student group. The introduction of HAL pedagogy has important implications and holds strong promise in challenged learning environments as found in Nigeria. The DLM is found to be well suited for this environment.

Keywords: educational pedagogies; hands-on active learning; global; challenged environment; principles for good practice