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Special Issue
Engineering Education for All
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The path to the future requires the best possible trained engineers for further developing and mentoring the technological advances that are reshaping the present. Such advances may be the keys for facing the challenges ahead, including the population outgrowth, the climate changes and a global need for sustainability and responsible management, which probably will not come from traditional politics, but from people capable of building bridges between the mentioned advances and of handling them ethically. All this brings us to the topic of ''Engineering Education for All''. If the ''engineers of the future'' are to be key players in solving current challenges of Mankind, we will need the most talented and motivated ones, regardless of their social background and economical status. In this study we try to methodically analyze the main strategies for the promotion of ''Engineering Education for All'', mainly linked to actuations which directly affect students or teachers (and teaching methodologies) and which take advantage of the environment and available resources. From an initial list of 60 strategies, we focus on the 10 drivers of change considered more important after an initial evaluation. Subsequently, a systematic analysis of the typical problems linked to these main drivers of change, enables us to find and formulate 10 major and unsolved problems. After selecting these typical problems, we put forward 24 different solutions, for short-term actuation, and discuss their effects, while bearing in mind our team's experience, together with the information from the studies carried out by numerous colleagues.

Keywords: engineering education; continuous improvement strategies; education for all

The globalisation of manufacture has forced many developing countries in Asia to respond to the exacting requirements of quality and interchangeability that involve complex and diverse conventions for graphical and geometrical product specifications. Competing pressure for international recognition of engineering qualifications has reduced the time available in Malaysian universities to teach a range of practical skills, including those of reading and interpreting engineering drawings (RIED), although Malaysian industry has identified inadequacies in the RIED skills of recent graduates. This paper reports the deliberate use of incidental learning to increase RIED skills in groups of undergraduate engineering students by replacing the familiar line illustrations of parts and machines in the learning tasks of a conventional analytical subject with sets of formal engineering drawings. Participants who were engaged for 14 hours of practical problem solving work in the subject and a parallel CAD-modelling subject, gained measurable skills in RIED. Since the increase in participants' RIED skill did not require alterations to the existing educational objectives of the subjects, the time allocated to problem-solving within those subjects or additional RIED teaching expertise, an expansion of the approach is recommended.

Keywords: incidental learning; graphics education; engineering drawings; problem based learning

Specialty courses bridge a student's university education and future occupation. This paper discusses an integrated pedagogy to cultivate a broader, global engineering perspective among Chinese students to enhance their critical thinking and research skills. Two kinds of pedagogies based on the curriculum order are integrated with traditional lectures: English language literature review and Project-Based Learning (PBL). This integrated pedagogical approach was applied in three different kind of engineering courses at three different schools in three different Chinese universities. Student feedback and self-evaluation shows that the literature review method helps them improve their specialty area English level, as well as gain a better grasp of textbook theories and concepts. Meanwhile, PBL helps students develop process-oriented approaches to real-world problem solving and collaboration. Findings show that Chinese students experiencing the integrated pedagogy accept the method, and report a better understanding of textbook content than through passive lectures alone.

Keywords: integrated pedagogy; Chinese higher education; collaboration; evaluation

The main goal of this paper is to present an introductory course in chemical engineering based on analogies and research-based activities. The use of analogies can be a very helpful tool used to build a strong engineering foundation for freshmen with weak high school scientific background. To help students shift from the imaginary of the five analogies utilized in the course to the real pictures of some engineering concepts, the similarity to the analogy is followed by simple lab experiments or class activities. The final chapter of this course is related to energy efficiency to demonstrate to freshmen who lack scientific background that their attitude could make them more efficient and lead them to success.

Keywords: analogies; research-based learning; transport phenomena; thermodynamics; energy efficiency

This paper presents an innovative experience applying PBL methodology simultaneously to eight different subjects in a Master's Degree on Technology for Human Development of the Technical University of Madrid run by the Innovation and Technology for Development Centre (itdUPM). Students are encouraged to work on a real project considering multidisciplinary aspects but always working on the same project, in real and developing context, demanding intense and critical coordination between professors.

During the experience, the following competencies are strengthened: communication, team working and ability to analyse different socio-technical alternative based on economic, social and environmental aspects. The paper presents methodology, assessments, results, difficulties found and new challenges, as an example for potential replicability in other universities.

Keywords: project based learning; technology for human development; holistic and experiential learning in different areas of engineering

This paper presents an experience in developing technical skills and personal competences by an approach that integrates a group of teaching methodological tools and assessment coherently. It has been implemented for students of Engineering Project Management subject in the Industrial Technologies degree program of the Technical University of Madrid. The study shows how the authors face the new challenges that are caused by the adverse economic context by adopting effective countermeasures in the classroom. The results show that the specific teaching-learning strategy that we introduce enables the reinforcement of four competences simultaneously and the acquisition of subject knowledge at a high level, eventually guaranteeing the inclusive engineering educational system of the institution.

Keywords: engineering education; project based learning; ABET competences; project management competences; inclusive education

The capstone course in colleges of engineering is participant-directed learning (PDL) based on project-based learning (PBL) and is one of the most important courses for students aiming to become competent professional engineers capable of solving real industrial problems. Thus, the course has attracted much attention and involves participation of students as well as teaching staffs and employees in diverse enterprises. Based on users' experiences, assessment and improvements of existing web-based project management system (PMS), this study aims to establish an online capstone course support system available via wired and wireless Internet connections. To support PDL, a knowledge utilization system (KUS) is developed as an open system utilized by internal students as well as external participants from diverse industries and also as a self-proliferation system enabled collection and accumulation of information from internal and external sources. The established system represents an efficient and effective system that facilitates PDL in capstone course.

Keywords: capstone course; participant-directed learning (PDL); project-based learning (PBL); capstone course support system (CCSS); knowledge utilization system (KUS); industrial engineering (IE)

The design and implementation of a Virtual Electric Power Transmission Line Lab for undergraduate curricula is introduced in this paper. The aim of the virtual laboratory is to enhance learning and teach students the basis and characteristics of the power transmission line model under different conditions in a virtual interface before entering the field. The user can realize various tests, such as short circuit, no-load, load and fault tests, to develop an understanding of the model behaviors, effects of changes in the model parameters, load and connections. The proposed Virtual Electric Power Transmission Line Lab is developed in the MATLAB graphical user interface (GUI) environment. The proposed virtual lab has been implemented in the Power Systems Lab taught at the Department of Electrical and Electronics Engineering at Karadeniz Technical University as part of the undergraduate curriculum. A survey of the students who took the lab course has been conducted, and the responses are included in this paper.

Keywords: transmission line; computer aided education; virtual laboratory

This paper presents and describes the opportunities for new technologies applied in the field of technical education. Specifically, it introduces VMLab system characterized by implementing tools of new Internet trends in measurement technology. Because this system is available to anyone who has an Internet connection, it belongs to the top ways of obtaining practical education. Student using this VMLab system for e-Learning is to be helped to create simple or complex electrical connections. He/she selects the individual devices and components from a previously defined library. These allow users to compose various electric schemes and to make their measurements according to the teacher's instructions. From the educational point of view there is a great benefit for students that they can learn to work with real devices even without having them physically available. Therefore, this system can be used without time, space and economic limitations. It means it is very useful for the education of all motivated and talented students, regardless of their social background.

Keywords: VMLab; variable topology; e-Learning; Internet; technical education, for all

Massive Open Online Courses (MOOCs) have emerged as disruptors to higher education bringing the possibility to access learning contents to thousands of students from all over the world. MOOCs are a new way to design and deliver online learning. Learners become part of an on-line community where they can participate as reviewers, collaborate with each other and are engaged in watching videos and other multimedia resources. However, MOOCs are also generating a huge debate around three different aspects: the learning process including evaluation and certification criteria, the lack of skills among instructors to design and plan MOOCs and the technical and security issues of MOOC platforms. More specifically, institutions are currently making a great effort to become part of main facilitators' platforms. They are creating a good number of methodologies, guidelines and best practices to equip instructors with the necessary skills to produce high-quality learning resources that can encourage learners' participation and decrease the dropout rate. On the other hand, engineering education is one of the main areas of interest in MOOC courses. In the software and computer engineering area it is possible to find a huge number of MOOCs in particular topics ranging from an introductory to a master level. However, just a few courses address a holistic view of a domain such as software

engineering due to the intrinsic difficulty of summarizing in a few weeks the main concepts of an engineering discipline. That is why, in this paper, authors introduce an Agile MOOC Development Lifecycle (AMDL) to address the challenge of designing a MOOC from scratch. Afterwards, the framework is applied to create a MOOC course about software engineering for a non-technical audience and developed by a large and multidisciplinary team of 18 instructors. This experience is also reported as a case study to validate the proposed development lifecycle. Finally, some discussion, lessons learned and future research lines are also outlined.

Keywords: software engineering; agile; MOOC; on-line education; e-learning

Nowadays, experiences with massive open online courses (MOOCs) are being part of modern engineering degrees, thus providing practical interactive activities to improve teaching-learning strategies with online courses and social community learning with peers from different countries. Additionally, this MOOC movement is being identified as a valuable tool to provide engineering education to all students, including students with disabilities that for different reasons cannot be part of a face-to-face session and, naturally, have the rights to make use of this myriad of teaching-learning strategies. In this sense, if a teacher wants to develop a MOOC course or to recommend a course to his students, it is imperative to identify the best accessible platforms in order to provide inclusive learning strategies. The aim of this study is to analyze the accessibility of a selection of eight popular MOOC platforms: Coursera, edX, Udacity, MiriadaX, UNED COMA, Udemy, Futurelearn and NovoEd. To this end, three automatic accessibility evaluation tools have been used: eXaminator, FAE and Tingtun. Hence, it has been checked the degree of conformance of these platforms with the Web Content Accessibility Guidelines (WCAG) created by the World Wide Consortium and adopted by ISO as an international standard. The study has been complemented with a heuristic evaluation by experts in order to have a holistic perspective of MOOC accessibility. The idea behind this study is that the stakeholders in the teaching-learning process will be able to identify and select the most inclusive platform based on the international standards. Moreover, the technical staff in educational institutions will be provided with a procedure to identify accessibility issues in other platforms and engineering teachers will be aware of the potential obstacles that students with disabilities may experience. The results of this study identify edX and Futurelearn as the best MOOC platforms. Finally, conclusions and future work ideas are presented.

Keywords: web content accessibility; usability; disability; WCAG 2.0; MOOC

In this paper an innovative experience developed by seven Universities (six European and one non-European) to teach a two weeks summer course in a non-conventional, remotely way is presented. The course is developed using a Project Based teaching-learning methodology and it is also designed to have a deeper knowledge of the relationship between sustainable development and the economic and financial conditions. The experience is innovative because the technology used, allowed students to share knowledge and participate from countries all over the world. Competences of students in this context are measured and strengthened. The most interesting issues, challenges and difficulties are presented here. Conclusions help professors to propose actions to improve the methodology in order to strengthen students' competences.

Keywords: project based learning; sustainability; global economy; remote learning experience

Metal Casting Technology Station-University of Johannesburg (MCTS-UJ) is managed through The Technology Innovation Agency (TIA), and it works closely with the School of Mining and Metallurgy and Chemical Engineering, UJ. MCTS-UJ submitted a proposal for Research and Innovation in Foundry Technology (RIFT) programme to The Department of Science and Technology (DST) in 2011 to address government's localisation plan. The proposal addressed the Human Capital Development aspect in the advanced foundry technology for the South African foundry industry. As part of the RIFT programme, MCTS-UJ, an initiative of DST partnered with the Technische Universität Bergakademie Freiberg, Germany to develop a programme to train and retain Masters students from South Africa. We used qualitative interviews as part of the case study to explore how MCTS-UJ succeeded in retaining the female students and why some students decided to leave or stay back. The semi-structured interviews were conducted with four female students who participated in the RIFT programme to understand their experiences during their study in Germany. At the end of the RIFT programme the students completed an equivalent programme to our Masters in South Africa that is Dipl. Ing in Foundry Technology. We compared all interview data with archived information in many documents based on RIFT programme to determine if they draw the same conclusions. We felt that satisfactory progress of the students should be monitored throughout the Engineering programmes and adequate funding is necessary to attract and retain female students in Engineering We make recommendations for Foundry Engineering programme for localisation and explore the impact of RIFT programme on skills development. Interviews with MCTS staff helped to explore the impact of RIFT programme on technology localisation. We also developed a model for the retention of female students in foundry Engineering.

Keywords: engineering programme for technology localisation; foundry students' experiences; a model for retention of female students in engineering

Teaching fundamentals of programming is a complex task that involves student acquisition of diverse knowledge and skills. It is also well known that programming often requires a certain degree of creativity. There are some studies on how to foster creativity with programming, but few of them have analyzed the influence of students' creativity on their performance as programmers. In this paper we present the results of such a study, with a sample of 89 freshmen engineering students. Our results suggest ($p < 0.01$) that a high level of creativity is correlated with achieving excellence in programming. Creativity is a soft skill which is not currently covered within most engineering curricula, and we conclude that it should be taken into account. Female, diverse thinking students and some disadvantaged groups may benefit from a free-thinking environment in the classroom, in particular during their first-year in college.

Keywords: creativity; programming; computing engineering; equal opportunities; soft skills; professional skills

This work presents a comparison of two universities: one public, and the other private. Two competency-based Master's degree programs will be compared in terms of the strengths and weaknesses identified by their coordinators. The faculty's perceptions of the development/acquisition of said competencies by the students will be presented, as well as their impressions of the entire competency-based teaching/learning process.

Keywords: generic competencies; teaching/learning process; methodologies; assessment tools; feedback

Engaging a representatively diverse (across class, race, gender, and cultural lines) population in a future of engineering continues to be a struggle for many countries. This paper presents a study from the U.S. context, where racial and ethnic minorities and women are significantly underrepresented in engineering. The interview study asked diverse pre-college students about their personal and career interests and how they defined engineering. These responses were coded using Holland's Career Theory framework of six interest dimensions (realistic, investigative, artistic, social, enterprising, and conventional) to categorize students' personal and career interests to see how they may or may not correspond to their understandings of what interests an engineering future may appeal to. The results illustrate that the students' personal interests map to the full spectrum of Holland's dimensions. However, students' understandings of engineering map to a more stereotypical view of engineering that does not always match to their personal interests. The paper argues for introducing engineering in ways that highlight how engineering pervades a wide array of domains and interest areas.

Keywords: diversity; personal interests; career theory; pre-college