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A model is proposed based on the statistical concept of the overlapping distribution method (ODM). The model is then applied to estimate the number of students that can be expected to qualify for and to pass supplementary examinations. The ODM prediction model was validated using 19 sets of examination events involving 858 civil engineering students in two different universities. It was found that lowering the mark cut-off criteria from 45 to 40%, increases the number of students that qualify for supplementary examinations, by up to 75%. In turn, the number of students that successfully sit for supplementary examinations, increases by about 40%. The proposed model promises to be useful in informing policy on conflicting issues that arise from balancing the work load under large class sizes on one hand, and offering wider opportunity to as many students as have the potential to pass.

Keywords: overlapping distribution method; supplementary examinations policy; engineering assessments; throughput

This qualitative research employs interview techniques to understand behavioural evidence of early-career engineering leadership. Semi-structured interviews were conducted with nine engineering leaders from three large international engineering companies. Analysis of the interview data through constant comparative open and axial coding methods suggest that traditional notions of interpersonal competencies, such as extroversion and charisma, often may not reflect practicing engineers' preferences toward leadership. Instead, this research reveals four behavioural themes of interpersonal behaviours related to engineering leadership: technical forthrightness, positivity through sociotechnical constraints, builds interdisciplinary alliances, adaptive communication. Further, we view our results through Bartram's Great Eight competency framework, which outlines general competencies for leadership across settings. By mapping our interpersonal behavioural themes of engineering leadership onto the Great Eight competencies, we operationalize leadership behaviours manifest in engineering. We propose that by teaching engineering students—future engineering professionals—the interpersonal behaviours for successful engineering leadership, we encourage a reflective and person-centred approach to teaching the more general leadership competencies.

Keywords: engineering leadership; interpersonal; competency models; engineering education; early-career engineers

Current educational approaches in engineering education should provide students with attributes required in professional practice. Active learning, in the form of Problem-Based Learning (PBL) and Project-Based Learning (PjBL), as an educational approach, shows promise in engineering. The paper describes the attitudes of students towards the application of problem based learning element in the Mechanics of Machines course in a Bachelor of Mechanical Engineering programme. The Mechanics of Machines is a core course in Year 3 of Bachelor of Engineering programme in Mechanical Engineering. The PBL element of the course was an individual project on kinematics of planar linkages; a topic always challenging to students. The project was to help the students in visualizing the motion of mechanisms, to assist them with understanding the entire solution process, and to draw conclusions for relatively simple mechanism.

Two surveys were administered to students to assess their attitude towards the PBL element of the course; one before the commencement of the project, and the second just after they submission of the reports, but before marking. Out of 61 students registered for the course 54 responded to the first survey, and 50 to both. The aim was to observe the changes in students' response to the PBL element. The comparison between the results of the surveys shows improvement in students' attitude towards pedagogy. The students declare that the experience with PBL improved their ability in problem solving, critical reasoning, searching effectively for information and use technology as a learning tool. However, they were critical about their ability to negotiate a work load and to prepare and follow a schedule. Those did not improve while negotiating the project.

Keywords: engineering education; project-based learning; students' attitude; planar linkages

The objective of this paper is to present a critical literature review of the Building Information Modelling (BIM) methodology and to analyze whether BIM can be considered a Virtual Learning Environment. A conceptual framework is proposed for using BIM in a university context. A search of documents was carried out in the Core Collection of Web of Science; it was restricted to the last five years (2013–2017). A total of 95 documents were analyzed; all documents were written in English and peer reviewed. BIM meets all the characteristics of Virtual Learning Environments. The proposed framework has three dimensions (competencies, pedagogical approach and level of integration). It allows for the planning and analysis of future experiences of teaching BIM in a university context.

Keywords: BIM; higher education; construction engineering; computer-aided design; virtual learning environment

Women remain significantly underrepresented in engineering education, a cultural milieu which is stereotypically seen as a masculine domain. Laboratory studies and some questionnaire-based studies suggest being numerically under- or over-represented in student working groups may have an impact on the group work experiences of both female and male engineering students, however this has not previously been adequately explored in realistic engineering education team work settings. Using a quasi-experimental survey design with 217 participants, we document a number of micro-discriminations with respect to women in student work teams in engineering education. Both male and female students seem primed to anticipate potential difficulties arising for female students to a greater extent than for male students, even among high performing students. This suggests a cultural, implicit bias. As such, student group work in engineering programmes may need to be accompanied by teaching and learning strategies which seek to actively question such stereotypes and implicit biases.

Keywords: engineering education; gender; group work; tokenism; stereotype threat

In this work, two different evaluation methods are presented from laboratory sessions in the Fluid Machinery and Systems course of the Bachelor Degree Program in Mechanical Engineering: evaluation of technical reports (individual portfolio of the students) and final test (single objective assessment). The statistical analysis of the data during the last five academic years for 684 students reveals that the portfolio evaluation is less correlated with the final grade of the subject, showing overrated marks with narrow dispersions. On the contrary, the final test evaluation exhibits a higher correlation with the final grades, presenting a more representative distribution. The evaluation based in a final test is found to be more significant, unbiased, more coherent and able to reduce the subjectivity observed in previous years with the reports-based evaluation.

Keywords: laboratory evaluation; practicum test; final grade; mechanical engineering

Motivation and performance play an integral role in the success of engineering students at the collegiate level. Professors face challenges between the diversity of the students and diversity in engineering disciplines, creating the need to reform education in the field of engineering. The purpose of the study is to identify motivational changes and implement an intervention plan incorporating strategies, discussions, and approaches to adapt the educational system to work for an assortment of student populations. The study uses an adapted version of the Motivational Student Learning Questionnaire (MSLQ), to measure the motivation of two different cohorts of students throughout capstone design courses in comparison to their respective performance. The five motivation factors studied were: cognitive value, self-regulation, presentation anxiety, intrinsic value, and self-efficacy. Statistical Analysis was performed between the motivation factors and demographic populations of the students (male vs. female, domestic vs. international), as well as within populations. The first cohort of students were the control cohort, experiencing the typical senior design capstone requirements. The second cohort of students experienced the implementation of an intervention plan to better prepare them for the senior design capstone sequence. The intervention plan entailed changes made to Design Methodologies, a precursor course to capstone completed during the junior year. This research will evaluate whether these changes affected the students' initial motivational levels among different demographics. It is important to note that the changes made to Design Methodologies were not related to the content of the course; rather the changes were intended to better familiarize the students with their upcoming tasks and goals for senior design capstone.

The findings of the two-year longitudinal study comparing motivational factors and performance of the two mechanical engineering senior design capstone course cohorts are presented: the control cohort using the standard teaching methods for Senior Design Capstone at the university and the test cohort undergoing the intervention plan in the curriculum. The results show that the intervention plan made a positive impact on the student factors, especially for the international student population. More importantly, the intervention plan focused on promoting positive reinforcement regarding motivational factors rather than negative reinforcement.

Keywords: design education; senior design; capstone design; student motivation

The Computing Professional Skills Assessment (CPSA) is a method developed by the authors for assessment of the non-technical skills prescribed by ABET, the accreditation body for engineering and technology for computing students. These non-technical skills, referred to here as professional skills, include teamwork, communication and problem solving. With the CPSA, teams of five students analyse a complex, ill-defined problem over a 12-day period using an online, asynchronous discussion board. The discussion transcripts are subsequently examined using a rubric. This rigorous assessment evaluates all of the professional skills simultaneously and has been proven to be valid and reliable. As it is a demanding assessment running over a period of almost two weeks, the authors believe it to also be a very valuable learning activity representative of a learning oriented assessment. To ascertain the learning that occurs through use of the CPSA, it was implemented three times in three sections of a 3rd year computing course with a total of 56 students. The results which are presented here show that there was considerable learning and improvement in the students' targeted skills over the semester. The students were surveyed on their perceptions of the CPSA as a learning tool at the end of semester. They strongly believed that it is an effective teaching and learning method and that they benefitted significantly.

Keywords: ABET; online discussions; outcomes-based assessment; performance task; rubric; virtual teams

Engineering confidence and self-efficacy are key contributors to persistence in engineering. Hands-on, team-based engineering design projects can increase students' engineering self-efficacy, by providing mastery experiences. However, not all students benefit similarly from project-based learning in teams; students can take on different tasks and as a result, experience different changes in confidence or self-efficacy. In this study, we investigated the relationships between time spent on various project tasks and students' initial levels of and changes in confidence or self-efficacy. This study used a mixed-methods approach to data collection and analysis, focusing on 97 students between 2012–2015 enrolled in two different project-based learning contexts: at a small private engineering college and at a large public university. We found that engineering confidence and self-efficacy did not increase monotonically over the project experience for both contexts. Although there were no relationships between project tasks and related measures in confidence (for example, students who spent more time on building did not have a higher increase in tinkering self-efficacy), there were negative correlations between time spent on writing tasks and students' initial confidence/self-efficacy and changes in confidence/self-efficacy. Our findings indicate that time spent on task may not be a proxy for mastery experiences, and that changing self-efficacy or confidence may be highly individual and contextual. However, some recurring patterns suggest approaches for intervention that may better support a wide range of students.

Keywords: first-year engineering; project-based learning; self-efficacy; confidence

This study investigated the contemporary dimensions of engineering entrepreneurship education aiming at creating a landscape of the most important theories and trends found in the literature, mapping the most important authors, countries, and journals and the often-used research methods. The research methodology included a systematic literature review, combining bibliometrics, networks, and contents analysis. The sampling process was conducted in the Web of Science and Scopus databases, with two filters: research areas (engineering field) and document types (articles and reviews). The sample of 324 articles published from 2001 to 2017 was analyzed in-depth. The results show an exponential growth of interest in the study of engineering entrepreneurship education, with 74% of the samples published in the last 3 years. There is a trend of transition towards a more confirmatory research perspective. There is an increasing focus of the literature on the development of educational programs and methodologies and, consequently, on the evaluation of the results. Two dimensions of contemporary engineering entrepreneurship education stood out: the influence of entrepreneurship education on students' entrepreneurial intention and the definitions of entrepreneurship education. Finally, three main clusters of the literature were identified: entrepreneurial behavior and entrepreneurial intention; entrepreneurship education; and entrepreneurship education challenges, results, and best practices.

Keywords: entrepreneurship; entrepreneurship education; engineering education; systematic literature review; bibliometrics

Virtual reality offers vast possibilities to enhance the conventional approach for delivering engineering education. The introduction of virtual reality technology into teaching can improve the undergraduate mechanical engineering curriculum by supplementing the traditional learning experience with outside-the-classroom materials. The Center for Aviation and Automotive Technological Education using Virtual E-Schools (CA^2VES), in collaboration with the Clemson University Center for Workforce Development (CUCWD), has developed a comprehensive virtual reality-based learning system. The available e-learning materials include eBooks, mini-video lectures, three-dimensional virtual reality technologies, and online assessments. Select VR-based materials were introduced to students in a sophomore level mechanical engineering laboratory course via fourteen online course modules during a four-semester period. To evaluate the material, a comparison of student performance with and without the material, along with instructor feedback, was completed. Feedback from the instructor and the teaching assistant revealed that the material was effective in improving the laboratory safety and boosted student's confidence in handling engineering tools.

Keywords: virtual reality; online learning materials; engineering education; undergraduate laboratory, teaching methodology

The use of biobased materials for industrial and consumer products has received more and more attention because of the need for sustainability and to address the climate change. Biobased materials are renewable and derived from agriculture, silviculture, and terrestrial/aquatic microbial systems and have been used by humans for thousands of years in many aspects. To pursue technological edges and environmental benefits, the United States Government has been pushing for further development and applications of biobased materials. For further growth in this area, we have seen that there is a strong need for professionals from various backgrounds, including biology, chemistry, and engineering. However, to our knowledge, there are no exiting course series or degree programs on biobased materials in the US for engineering students and practicing engineers, as compared to the international counterparts. To address this issue, we developed and offered a new series of biobased materials courses to both college students and practicing engineers to provide them introductory information on biobased materials and potential opportunities. This series contains six courses including topics of biobased stock, bio-economy, bio-based materials and fuel, material properties and testing, as well as additive manufacturing and applications. These courses were taken in Fall 2015, Spring 2016, and Summer 2016 by more than 62 community college students (some of them have full time jobs) and 11 practicing engineers from General Motors. Four of the courses were integrated into a formal semester course delivered to Wayne State University students in Summer 2016. The participants in individual short courses obtained certificates of completion for potential career opportunities and advancements. In this paper, we present the contents and student feedback of this new series of biobased materials courses and discuss the future direction of this project.

Keywords: make it in America challenge; biobased materials; manufacturing engineering

Engineering educational and professional persistence are based on students making an informed selection of an engineering major. The purpose of this study was to explore the engineering major discernment process for First-Year Engineering students. It was hypothesized that students would become more certain of their engineering major selection over the course of their first year. This fully integrated mixed method study utilizes the survey responses of all students in the First-Year Engineering Program during the 2017–2018 school year (500+) in conjunction with the reflections of a subset of those First-Year Engineering students (300+) to qualitatively review students' experiences. Over 50% of the students changed their major from the engineering discipline they initially indicated they planned to pursue over the course of their first year. The certainty level of students with their engineering major selection increased over the course of the school year with over 80% of students indicating an increased level of certainty. The majority of first-year engineering students in the current study changed majors from their initial plans, thus First-Year Engineering programs offer an opportunity for students that do not have significant prior involvements with engineering related experiences to explore their interests without slowing their academic progress and increasing their certainty in engineering.

The current study found that: (1) performance outcomes were the most frequently cited factor for selecting engineering, this was true for all students regardless of intended engineering discipline or gender, (2) certainty levels in studying engineering increased for all students, although there were some differences by gender, and (3) the majority of major changes were for students that were initially not as clear on engineering professional pathways, and (4) the majority of students that decided not to continue in engineering initially indicated they were "just trying it out" and had lower certainty levels to begin with.

Keywords: major discernment; major selection; First-Year Engineering

Taking into account the global trends on job searching skills, particularly in IT sector, one should not neglect the significance of a lifetime personal and professional Web space. In order to answer the existing trends, the authors of the paper present the interdisciplinary joint work of the employees at their university to meet the needs of IT students and equip them to successfully enter the job market prior and/or upon their graduation. The paper presents an integrated experience of domain content and English language courses with the purpose to help students create a professional showcase via a visume (video resume), e-portfolio and LinkedIn account. The paper demonstrates the methodology developed and integrated into the curriculum of Computing and Informatics study programme at our university to scaffold students create and develop their e-portfolio on all three levels of studies: Bachelor, Master and Doctoral. The provided methodology helps students to demonstrate and organise the practical use of their academic knowledge acquired over the years. The e-portfolio data are further accompanied and linked to the visume and LinkedIn account. In order to evaluate the impact of the implementations made in our study programme, an online survey among 182 graduate IT students, who are part of University LinkedIn network, was conducted during December 2018. The results show that the collective experience is an excellent manner for future graduates to articulate their skills, abilities and achievements to their potential employers by placing them in a publicly accessible online space while at the same time the university displays higher teaching quality and gains better reputation.

Keywords: English for Science and Technology; professional showcase; e-portfolio; digital literacies; personal online space

This paper provides details of a study in which Learning Objects (LOs) have been designed and built for the field of Graphic Expression and then introduced into a university degree subject as a teaching aid so that their influence on students' approaches to learning can be studied. The study was carried out with 83 students in the subject "Engineering and Architectural Graphics Applied to Building Design", which forms part of the Degree in Building Engineering. Before starting the course, students show a "Deep Learning" approach but also very close to the "Surface Learning". Results, after using the LOs indicates that the use of LOs in Graphic Expression produces a statistically significant improvement in the Deep Approach adopted by students which is essential for more comprehensive learning. The type and intensity of approach learning was analysed by gender. Although there were no statistical differences, the data shows that women intensify their deep learning.

Keywords: learning objects; approaches to learning; graphic expression; R-SPQ-2F; online higher education

Conceptual understanding is critical for students' learning of many subject matters in science and engineering. This paper describes an educational intervention called enhanced hands-on experimentation (EHE). The goal is to reduce students' conceptual misunderstanding in engineering dynamics, a foundational second-year course that undergraduates in many engineering programs are required to take. Two case studies were conducted to compare the effectiveness of EHE in reducing students' conceptual misunderstanding with that of traditional textbook instruction (TTI). Pre- and post-tests were administered on EHE and TTI student groups in both case studies. A think-aloud approach was employed to collect qualitative verbal data generated by 48 students with 1,248 student responses. By quantifying qualitative verbal data collected, enhanced hands-on experimentation was found to be more effective than traditional textbook instruction in reducing students' conceptual misunderstanding in engineering dynamics.

Keywords: students' conceptual misunderstanding; enhanced hands-on experimentation (EHE); traditional textbook instruction (TTI); engineering dynamics

The purpose of this paper is to present and analyse the results, impact and scope achieved with Astursat, a software tool developed as a Final Degree Project in Telecommunication Engineering Masters' Studies. The aim of this tool is to encourage the interest of students in remote sensing and image processing. For this purpose, in-house meteorological and environmental raw data received at the Satellites Tracking Station installed at the University of Oviedo (Spain) is employed. With this data, a system with real functionality has been developed to foster professional skills. For this reason, Astursat represents the last logical block in a complex system composed of a remote sensing stage, a reception sub-system and the processing and visualisation of the corresponding information. Astursat has been designed in order to provide solutions for the shortages detected in similar commercial software packages. As an example, Astursat allows the possibility of defining a geographical region of interest where the images and animations can be focused on. Additionally, Astursat allows the generation of personalised combinations of different datasets from several instruments. Different processed images and video frames will be shown and discussed to illustrate the results achieved with the tool. An analysis of the impact of this project in Academia will be included.

Keywords: environmental; final degree project; image processing; meteorological; remote sensing; software; telecommunication engineering

Incorporation of employability skills in the industrial engineering curriculum to bridge the gap between industry and institutions of higher education has become a major issue. This study appraises the employability skills of industrial engineering graduates based on the skills that required additional training, skills that are needed for job performance and skills that are received/emphasized in the curriculum. Two batches of questionnaires are administered to the participants of the study. The first batch is administered online to students, employed alumni and faculty members. The second batch is distributed to instructors of core courses. Thirty-six items of skills are arranged under seven basic employability skills that were previously reported are employed in the evaluation. Of the seven employability skills, following management, leadership and information technology skills are identified as skills that require additional training. The responses toward skills required for job performance and skills that are received/emphasized in the curriculum are ranked higher by participants based on the percentage of agreement. This study advocated that the perception of participants provides greater insight into the skills items that should be emphasized in the industrial engineering curriculum to enhance the employability of graduates.

Keywords: attitudes; curriculum; employability skills; performance skills; training

This paper investigates the effectiveness of the flipped classroom methodology to build conceptual knowledge mental models. In particular, it examines the learning process and outcomes of 40 students of a course on Physical Electronics in the last year of a bachelor's degree program in Physics, for which specific educational resources have been developed to implement the flipped classroom. Among them, non-interactive resources are better to present topics and ideas, whereas interactive resources are more useful to establish links between them to build and check the models. The examined data entail grades, laboratory reports and rubrics, outcomes of learning activities, and direct observation, showing that the flipped classroom improves the construction of mental models, providing teaching resources where the topics and main ideas are presented, developed and exercised, and allowing students to establish links to build and check the models. Furthermore, this strategy increases the personal commitment of the students, fostering autonomy and cooperation with peers, all of which makes it an effective pedagogical tool to build knowledge mental models.

Keywords: flipped classroom; model construction; active learning; collaborative work; e-learning

The learning process has proved to be highly effective when students learn about real world problems, because these cases stimulate and motivate the students to a greater extent. In this regard, it is intended to introduce the undergraduate engineering students to the computational fluid dynamics (CFD) using a topic of current importance, i.e. simulation of the human lung air flow. It is thought that this new approach will encourage and improve their perception towards the Fluid Mechanics subject as well as it should stimulate the learning process. Based on results from research activities, a new teaching material was developed for simulation of pulmonary biological flows. The learning process is a combination of master class and e-learning through the material available at the "virtual campus" platform. Three different indicators had been chosen to measure the project success after the lectures. These are results of a knowledge test, the number of entries to the working material at the virtual campus (visit counter), and a satisfaction survey. Obtained results indicate a great benefit from the activity, with 97.8% of students passing the knowledge test. As a result, the fact of moving away from a theoretical CFD lecture to an introduction of practical concepts through a real-world problem, engage the students to a higher level allowing an improved learning process and subject perception.

Keywords: computational fluid mechanics; e-learning; engagement; integrated STEM education; motivation; undergraduate engineering

Building Information Modeling (BIM) provides many theoretical benefits to construction teams, but practical challenges and issues during implementation hinder companies' ability to realize its full value. Educational research suggests that problem-based learning may support students learning the necessary skills required to resolve the common issues in BIM-based construction projects. While the literature indicates value to problem-based learning for BIM education, the process for creating problem-based learning modules for BIM is less clear, which forces educators to make their best guess at how to create effective learning modules. In order to provide a consistent methodology that will enable educators to create effective BIM-related problem-based learning modules, this study proposes a structured process for developing learning modules. The proposed learning module development process involves several tasks aimed at strategically developing and validating problem statements to ensure that they represent the types of problems students are likely to face in their careers. Additionally, the process of developing an implementation strategy involves tasks intended to ensure that students are motivated to complete the learning module and instructors are prepared to assess the success of their students. To test the feasibility of this process, the authors created an example BIM learning modules related to common people- and process-related BIM problems. To validate the applicability of these modules and implementation strategy, the developed modules were presented to industry experts who confirmed that they were representative of the types of problems they faced and skills they believe are necessary to resolve the defined problems. This paper contributes to the engineering education body of knowledge by presenting a re-useable methodology for developing problem-based learning modules and creating a lesson plan for implementing the developed modules for BIM education.

Keywords: Building Information Modeling (BIM); problem-based learning; industry practitioners

Despite decades of effort, and billions of dollars invested to improve engineering education, there is still a lack of knowledge on how to transform faculty into users of effective instructional strategies. This study concludes that instructional development programs have a good potential for promoting lasting change in faculty when the design is based on a one-month summer immersion period with a stipend, and when it is aligned with all the stakeholder's interests and concerns. After the faculty complete one week of workshops, the change process is compelled by the preparation of 60 standardized lesson plans for two courses (30 per course), per participant, plus the requirement that they experiment with the new techniques in the classroom. The study is based on N = 27 faculty members of civil, mechanical, electrical, computer, and industrial engineering, and physics. Faculty and student survey results identify several successful impacts of the program, including faculty adoption of research-based instructional strategies and increased faculty and student satisfaction. The success of the program is attributed to its incorporation of several best practices suggested by the faculty development literature. This article may be very practically relevant either to individual instructors who aspire to change their own teaching practices, or to Heads of School and Departments who want to improve the teaching and learning activities throughout their school as a whole, and who could use the description of the program as a suitable model to be followed.

Keywords: faculty development; change strategies; diffusion; immersion; active learning