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Contents

Contributions in: Social Capital, Female Belongingness, Gender-Based Teams, Innovation, Leadership, International Teams, Engineering Design, Design-Based Learning, Active Learning, Knowledge Assessment, IT Service Management, Mobile Learning, Personalized Learning, Software Engineering, Simulation, Electric Circuits, Digital Circuits, Hydrology, Impact of Mathematics and Physical Science

The primary goal of this paper is to explore the relationships between engineering undergraduate student demographic characteristics and the social capital these students utilize when making academic and career decisions. This multi-institution study is carefully aligned with the Network Theory of Social Capital. Employing cluster analysis to characterize several key aspects of 1,410 undergraduate engineering students' social capital–namely, the composition and characterization of their social networks and indicators of their resource access–the authors explore latent patterns in the data, and uncover social capital profiles. These profiles are then related to demographic characteristics through additional statistical analyses. In particular, the paper investigates and challenges the theoretical notion regarding the significance of gender and race/ethnicity in students' social network characteristics and social capital indicators. Unlike other social capital work in education, this paper presents findings that gender and race/ethnicity are not significant or adequate for characterizing the social capital of engineering undergraduates.

Keywords: social capital; cluster analysis; underrepresented groups; name generator; resource generator

The support structure in a prototypical foreign credentials recognition program for internationally-educated engineers (immigrant engineers) was assessed via survey research with four cohorts of program participants (N = 100; n = 61). The study investigated program participants' experiences with and perceived value of a range of informational, academic, social, personal, and financial supports that the program had developed. The data also allowed for an exploratory interpretation of the dynamics when one cultural group (in this case, Filipino) greatly outnumbers all other cultural groups represented within the overall cohort. The framework of collectivism is used to explain the underlying motives and intentions of group behaviours, and the framework of social capital sheds light on intra- and inter-group dynamics that may not be readily apparent to group members themselves. The findings can serve as a guide to other qualifications recognition programs and to initiatives, regardless of jurisdiction, where culturally diverse cohorts are co-mingling in educational or professional practice settings.

Keywords: immigrant professionals; internationally-educated engineers; qualifications recognition; foreign credentials recognition; social capital; collectivism

The need to increase the number of underrepresented groups in engineering is a moral as well as socioeconomic imperative. Women have been traditionally underrepresented in engineering in the U.S.; understanding how women identify with engineering and see a career in engineering as a means to positively impact the world may begin to address this persistent gap. This work reports on a qualitative study which gathered open-ended survey responses from 46 women enrolled in college engineering. Using the previously-developed Critical Engineering Agency (CEA) framework to understand how women identify with physics, math, and engineering, we provide insight into the ways in which women can feel they belong in engineering. Fostering this belongingness may begin to create lasting ties between women and their engineering majors and may help to retain more women in the first few years of college, when they are more prone to leave.

Keywords: Critical Engineering Agency; identity; women in engineering

The development of teamwork skills is an important aspect of engineering education as the interdisciplinary nature of the industry requires graduates to be able to work professionally with others in a team-based environment. Any miscommunication or obstruction from team members can result in lower team performance, thereby affecting the overall goal of the team. With this in mind, many engineering programs have designed their courses to address the teamwork component in engineering. Engineering design courses in particular often focus on teamwork as an integral part of the course in an effort to prepare the students for their careers. The current study addresses the perceptions of team effectiveness and team satisfaction among students working in same-gender teams on two separate campuses of an engineering university in the United Arab Emirates (UAE). Many universities in the Middle East have gender-segregated campuses to promote education while respecting traditional Islamic norms. While the specific execution may differ, the authors anticipate that the results could be translatable to any team-based engineering course in the region. Based on the current study, female students rated themselves as more effective in their teamwork than male students, while male students were more as satisfied with their teams as a whole than female students. Female students also gave higher scores on peer evaluations than male students. In both cases, however, student assessment of individual team members in the peer evaluation

was higher in the intermediate course than in the introductory course. Student interviews provided additional insights regarding team processes in UAE university classrooms. The present study provides an exploratory analysis of team effectiveness and satisfaction in this unique sociocultural environment.

David M. Bourrie, Chetan S. Sankar and **L. Allison Jones-Farmer**   967–985   Conceptualizing Interactions between Innovation Characteristics and Organizational Members' Readiness to Adopt Educational Innovations

Although substantial funding has been expended to develop new educational innovations, especially in engineering, few have found widespread acceptance in the classroom. Little is known regarding the interactions among the variables that influence successful dissemination and adoption. This research proposes a framework to show the interactions between innovation characteristics and the readiness of an educational organizations' faculty members, administration, and students to become aware, intend to adopt, adopt, and use educational innovations. One hundred eighty seven engineering education papers published during 2007–2012 were analyzed to identify the characteristics of educational innovations that influence their eventual dissemination. The researchers analyzed a sample of these articles (37) and synthesized the results to develop a framework. Interrater reliability among the researchers was 0.86. The proposed framework describes the interaction between characteristics of an educational innovation and an organizations' readiness to disseminate and adopt an innovation. The framework is then illustrated with examples. This framework provides a mechanism to link the outcomes, interventions, and context where the outcomes are the successful dissemination and adoption of educational innovations, the interventions are the characteristics of the innovation, and the context is the organizational readiness (readiness of faculty members, administrators, and students to adopt the innovation). For widespread dissemination and adoption to occur, educational innovators must incorporate positive characteristics in the innovations and implement them in organizations that are ready for such change.

Clinton M. Stephens and **David M. Rosch**   986–997   Building Leaders: A National Examination of the Leadership Capacities within Engineering Undergraduate Students

The demand for leadership capacity in engineering graduates is growing. However, little research has been done to examine the current state of leadership education of engineering students. Using a college experience framework, we tested how engineering students' leadership-oriented experiences and outcomes differ from non-engineering students. This study examined a national representative sample of students (N = 90,444) encompassing 101 higher education institutions. The results suggest that engineering students are less involved in group experiences in high school, but do not differ from comparable peers in self-reported leadership capacity coming to college. The involvement gap continues throughout their higher education. While their self-reported leadership capacity remains similar to comparable non-engineering students, the results suggest their ability to interact on diverse teams remains depressed. This study has significant implications for the processes engineering educators utilize to support their students in building working relationships and successful teams.

Pere Ponsa, José Antonio Román, Elisabet Arnó and **Jaume Pérez**   998–1006   Professional Skills in International Multidisciplinary Teams

The international engineering education programs must guarantee that a graduate possesses the attributes to work effectively within a global environment. It is therefore necessary to establish the competencies required for this effective working within an international context. The International Design Project Semester (IDPS) program integrates technical knowledge and professional engineering skills from a point of view of multidisciplinary and international teams. The preliminary results shows that it is possible to integrate international students in the classroom using the model role playing (each team has his own role and it is necessary share and collaborate with other teams) and next, observe the acquisition of skills of the engineering students (creative thinking, interact with others, dealing with conflicts, positive attitude).

Sung-Hee Jin, Ki-Il Song, Do Hyoung Shin and **Soobong Shin**   1007–1020   A Performance-Based Evaluation Rubric for Assessing and Enhancing Engineering Design Skills in Introductory Engineering Design Courses

Using the developmental research methodology, this study develops a performance-based evaluation rubric that can assess and enhance students' engineering design skills in introductory engineering design courses. The effectiveness of the proposed performance-based evaluation rubric was validated in the context of engineering design activities for students and practical directions for instructors to evaluate student performance. The proposed rubric included four phases, namely the problem, the solution, implementation, and process management, based on seven performance criteria and 21 measureable scales.

Maria Clavert and **Tuomas Paloposki**   1021–1032   Implementing Design-Based Learning in Teaching of Combustion and Gasification Technology

Design-based learning (DBL) is a pedagogical model that promotes deep learning of technical fundamentals and of practical skills in the context of real-world design experiences. Solving design problems in project-based setting provides a natural and meaningful venue for integrated learning of both science and design thinking skills. In this study, we explore the practical implications of the design-based learning model within two Master's level courses on energy technology. We describe the implementation of DBL model at Aalto University Design Factory platform, present the resulting course grades and drop out rates of 244 students registered in the courses between 2010–2012. Anonymous feedback was received from 106 students and we analyze it utilizing thematic analysis. We conclude that design-based learning results in a good balance between theoretical knowledge and design thinking skills. DBL motivates the students by providing them with a real-life engineering problem. The project of building a physical deliverable provides a natural setting for intensive teamwork and communication. The study presents theoretical framework and practical example for implementing DBL model in engineering education.

Robert M. Leicht, Sarah E. Zappe, Kirsten S. Hochstedt and **Michael Whelton**   1033–1047   Employing an Energy Audit Field Context for Scenario-Based Learning Activities

This paper provides an overview of how scenario-based learning was implemented in an architectural engineering course focusing on building construction principles, energy auditing, and building retrofits. In completing the scenario, students were able to visit two on-campus buildings, one of which was in the process of being renovated, interact with workers and managers on-site, and experience real-world applications of the principles used in-class. After completing the site visit, students were then asked to complete an assignment, which required them to develop a feasibility report regarding the assessment of a future renovation

project. This paper will discuss the assignment in detail and then provide an overview of the evaluation of the student experience. Guiding research questions for the evaluation focused on direct measures of student learning, students' self-efficacy from 37 students, for tasks relating to energy auditing, and students' perceptions of the activity. Overall, students had a positive perception of the activity. Responses on exam questions included statements that students would have only learned from the activity, rather from other classroom experiences. Students' interest in energy auditing significantly increased following their participation in the activity. Other instructors who would like to include more relevant and real-world activities for students may wish to consider creating scenarios that allow students to better understand what engineers in industry actually do and to see course principles being enacted in practice.

Keywords: scenario based learning; case based learning; experiential learning; architectural engineering; energy audits; retrofits

Jose M. Such, Natalia Criado and   1048–1057   An Active Learning Technique Enhanced with Electronic Polls
Ana García-Fornes

Only very few students answer questions like: "Did you understand this?", "Do you have any questions?" etc. In this paper, we present an active learning technique that is based on the think-pair-share technique improved with the introduction of electronic polls to obtain anonymous instant feedback from the students. Electronic polls have been usually performed using Classroom Response Systems, but these systems introduce several problems related to the excessive cost of the systems and the technical problems that they may cause to the instructors. Thus, we have implemented our active learning technique using an Interaction System that provides the benefits of supporting electronic polls but avoids the problems of Classroom Response Systems. We also present an example of how we applied our proposal to a set of Operating System lectures. Finally, we evaluate our proposal and demonstrate that the results we obtain are very similar to the ones obtained in the existing CRS literature without the problems that they introduce.

Keywords: active learning; electronic polls; feedback; participation; think-pair-share

Andrija Bošnjaković, Jelica Protić,   1058–1070   Automating the Knowledge Assessment Workflow for Large Student
Dragan Bojić and **Igor Tartalja**   Groups: A Development Experience

The paper presents our long-term experience at the University of Belgrade—School of Electrical Engineering in the development and use of the software system called *Test*, designed to automate the knowledge assessment workflow for large student groups in situations that usually require the use of pencil-and-paper testing. The test assembly is done interactively and/or automatically from a database of problems (questions, coding assignments, etc.) and previous tests. In order to enable objective and uniform knowledge tests, a rich set of parameterized problem selection criteria is made available to teachers. Preparation, scanning, and analysis of bubble sheets are highly automated and designed to work with plain paper and regular scanners. The *Test* system integrates with relevant learning management systems and the school's information system. Quantitative measurements have indicated improvements in both test quality of individual tests and uniformity of test quality across multiple tests, compared to the tests assembled manually according to intuitively applied criteria. The system is used for the introductory programming courses at the School. It has been developed through a number of diploma theses. Overall experience showed that the designed system provides an appropriate automation tool, a useful educational platform, and a valuable base for further research.

Keywords: automatic optical inspection; automated test assembly; educational technology; heuristic algorithms; knowledge assessment tool; test authoring tool

Ali Yazici, Alok Mishra and   1071–1080   IT Service Management (ITSM) Education and Research: Global View
Paul Kontogiorgis

This article provides an overview of Information Technology Service Management (ITSM) and investigates the education and research activities in this discipline from a global perspective. The objectives of the study are to inform the training organizations (e.g., universities, training institutes) on the current status of the educational activities in ITSM at undergraduate and graduate levels; and to guide the researchers by providing quantitative data on the research activities conducted in the field. In the educational arena, the statistical data showed that, stand-alone undergraduate/graduate programs are becoming popular among the high school graduates with elevated expectations of the market place, in addition to the appreciation of the IT service management area by the IT sector and the public. The results of the research findings provide guidelines for curriculum developers in the design and implementation of courses for the de facto interdisciplinary ITSM degree/certificate training programs and motivate and guide the researchers by providing the most recent quantitative data on the ITSM field. It is one of the first studies to provide education and research trends in ITSM area. The present study adds to this important stream of emerging research area and contributes by advancing the understanding of ITSM education and research issues. This paper advances the current state of knowledge on ITSM education and explores recent research trends in this area which is becoming standard towards providing quality IT services in enterprises.

Keywords: IT Service Management (ITSM), Service Management, ITIL, Organization, Quality, COBit, Web of Science

Yu Huan, Xueping Li, Mehmet Aydeniz   1081–1091   Mobile Learning Adoption: An Empirical Investigation for Engineering
and Tami Wyatt   Education

The emergence of mobile learning or m-Learning indicates a new opportunity for the education industry. Yet, there is a lack of a comprehensive understanding about the factors that influence its effective adoption. Further, it is unclear how to implement m-Learning that incorporate all stakeholders' perspectives. Built on Unified Theory of Acceptance and Use of Technology (UTAUT), this paper presents an extended adoption model and an empirical evaluation using data collected from a survey of engineering students ($N = 377$). The structural equation modeling technique is used to evaluate the causal model and confirmatory factor analysis is performed to examine the reliability and validity of the measurement model. Our findings indicate that performance expectancy, attainment value, self-management of learning, ubiquity, service quality, and perceived enjoyment significantly affected m-Learning adoption intention. The implication of this study to educators, system designers, and university administrators is discussed.

Keywords: engineering education; mobile Learning (m-Learning); technology adoption; Unified Theory of Acceptance and Use of Technology (UTAUT)

Luis de-Marcos, Antonio Garcia-Cabot,   1092–1105   Parliamentary Optimization to Build Personalized Learning Paths: Case
Eva Garcia-Lopez and   Study in Web Engineering Curriculum
Jose-Amelio Medina

In this paper we present a practical application of POA (Parliamentary Optimization Algorithm) for creating personalized learning paths in online learning. The objective of building a personalized learning path is to produce a suitable sequence of learning units for a student to work with. We present and tune the parliamentary metaheuristic for a practical instance of the sequencing problem in a web engineering master programme and compare it with standard versions of other well established metaheuristics (PSO and genetic algorithms). Results suggest that permut-POA deals satisfactorily with sequencing problems and it is easy to fine tune, and also that it outperforms the other optimizers.

Keywords: courseware sequencing; personalized learning; e-learning; parliamentary optimization algorithm; particle swarm optimization; genetic algorithm; web engineering education

In this paper, a capstone course in software engineering is described that exposes students to lean principles advocated by Kanban. While retaining the main characteristics of its predecessor course, which concentrated on teaching agile software development using Scrum, the new course also introduces the most important Kanban concepts, i.e., visualization of the workflow and limitation of the work in progress. Kanban concepts are introduced in two ways: in combination with Scrum (as Scrumban) or as a "pure" Kanban (omitting some of the Scrum activities considered waste). Students are required to work in teams responsible for the implementation of a set of user stories defined by a project domain expert playing the role of the Product Owner. During the course, they must maintain a Kanban board and measure lead time. The paper discusses the use of different Kanban boards and work in progress limits, and analyzes the students' progress in reducing lead time. A summary of the lessons learned and recommendations is given reflecting the issues to be considered when teaching similar courses. A survey among students has shown that they liked both approaches and were overwhelmingly positive about the course.

Keywords: lean software development; Kanban; Scrumban; capstone course; software engineering education

Offering safe, relatively inexpensive and reproducible teaching environment for exploring phenomena, interactive course modules are applications of special interest in education. Engineering and physics students usually have difficulty understating the topic of electrical circuits. There is limited evidence in the literature supporting the premise that utilizing interactive course modules improves student learning for the topic of electric circuits. Understanding the topic of electric circuits is important for high school students who plan to enter engineering programs at universities in Turkey since it is a topic covered at the university entrance exam conducted nationwide. Moreover the topic of electric circuits is taught in many engineering programs. This study explored the question that whether the achievement of students using interactive course module is different from the achievement of students taught with didactic teaching along with traditional teaching tools with fifty high school students. The pre-test/post-test with control group research design is used to investigate the research question. Findings revealed that utilizing interactive course modules to teach the topic of electric circuits is found to improve students learning better than teaching the same content with didactic teaching along with traditional teaching tools. Further research should be undertaken to compare the use of the simulations and real laboratory equipment.

Keywords: educational technology; interactive exercises; simulations; electric circuits

Given the recent call for engineering faculty to employ more student-centered learning strategies with course objectives that align with real-world, application of content, the current study discusses the implementation and benefits of the flipped classroom in a lower-level engineering course. Using the same course content, student end of course opinion surveys were compared for a traditional lecture ($n = 23$) and flipped digital circuits engineering class ($n = 29$). In particular, three items from the student opinion survey were of interest: instructor's teaching helped me learn, accessible to students, and organized course well. It was predicted that student ratings would be more positive on each of the three identified end of course opinion survey items for the flipped class compared to its traditional lecture counterpart. Results supported the study's prediction in addition to providing supplemental findings for the future use of the flipped classroom in engineering and other STEM courses. The multiple benefits of the flipped class pedagogical strategy are discussed with respect to future implementations for faculty teaching STEM courses.

Keywords: flipped classroom; inverted classroom; active learning; electrical engineering; digital circuits; freshmen level engineering courses

The Learning Enhanced Watershed Assessment System (LEWAS) is a high-frequency, real-time environmental monitoring lab on the Virginia Tech campus that supports watershed research and education. Student-centered modules that incorporate hands-on activities and LEWAS data have been implemented into a senior level hydrology course at VT (30 students) and several freshman level introductory engineering courses at Virginia Western Community College (73 students). A multi-loop assessment plan demonstrates how researchers at a large public university can collaborate with community college faculty to improve assessment methods and classroom module development. Assessment results show student learning gains through active and collaborative LEWAS-based learning modules. A pilot test of a LEWAS-based interactive online educational tool called the Online Watershed Learning System (OWLS), which allows students to access real-time data, virtually explore the LEWAS watershed, and examine case studies, has also produced results that indicate that student learning improves through virtual access to real-time and historical watershed data.

Keywords: hydrology education; environmental monitoring; enhanced student learning; virtual learning

The general conclusion arrived at in the literature is that the South African National Senior Certificate (NSC) is not a reliable predictor of academic success at traditional universities. By sharing research undertaken at a South African University of Technology (UoT) on the impact of individual cognitive factors and NSC results on study success, this paper shows that this conclusion is not necessarily true for South African UoT Engineering students. To assess this impact and determine the readiness of students for UoT Engineering curricula, the relationship between pre-university academic factors and the success of engineering students was investigated. An ex post facto study was carried out on a sample of 416 students drawn from first-time-entering National Diploma engineering student cohorts of 2009 and 2010 to determine a possible correlation between their NSC results, additional pre-admission test results and the number of subjects passed after one year and four years of study, respectively. The findings indicated that NSC Mathematics and Physical Science are statistically the most significant predictors of success in the first year. Despite the pre-admission tests used in this study not revealing significantly more about a student's potential than only the final NSC results, the conclusion reached by the researchers was that such tests might be useful when student application data is unreliable, i.e. when students apply with Grade 11 or interim Grade 12 results.

Keywords: National Senior Certificate; engineering curricula; cognitive factors; first-year success; admission testing; student dropout