Volume 31 Number 5 2015 ISSN 0949-149X

The International Journal of Engineering Education

Contents

Contributions in: Social Capital, Workforce, Technological Knowledge, Active Learning, Project-Based Learning, Gender, Career Goals, Global Competencies, Multinational Design Projects, Concept Maps, E-Learning, Academic Dishonesty, Outreach, Mechatronics, Mathematics, Hydraulics, Parallel Computing, Fluid Mechanics, Chemical Engineering, Robotics, Nanotechnology, Industrial Engineering

First generation college students can increase both the number and diversity of students in engineering. We use Lin's Network Theory of Social Capital, which describes relationships as being embedded with resources used to achieve a goal, as a framework for understanding undergraduate students' decisions to enroll in engineering studies. While much of the discourse on social capital in higher education focuses on inequalities and deficits experienced by first generation college students, our work helps to transition the discussion by highlighting the positive influence of education personnel as well as teachers and mentors associated with institutionalized programs. We use narrative analysis and two types of explicitly integrated complementary qualitative data to expand on Lin's theory. This paper presents an exemplar narrative describing what Lin calls the "invisible hand of social capital;" that is, when particularly resource-rich networks do not necessitate an individual knowingly mobilizing resources because information and resources are received in routine exchanges. Our findings support the need for continued proactive outreach, educational, and support systems that can serve as research-rich networks for first generation college students.

Keywords: social capital; first generation college students; narrative analysis

Liberal arts graduates, while well prepared with well-rounded education, more often than not face greater challenges finding employment or good paying jobs in their majors. That is especially true during challenging job markets usually encountered during recessionary times. This paper describes an innovative transformation model (TRANSFORM) designed for liberal arts college graduates interested in pursuing careers in advanced manufacturing. The vision of TRANSFORM model is motivated by the opportunity to leverage the creative talents of liberal arts students (a segment of the workforce that has long been underemployed) in advanced manufacturing. The model is a 12-month fast track curriculum program offering full-time coursework supported by industry-based internships in advanced manufacturing. The curriculum spans three terms: summer courses, fall courses and spring internship. Internships are designed to provide students with hands-on and project-based learning experience to facilitate their career transitions. The mission of TRANSFORM model is to provide liberal arts graduates with manufacturing education they need to step into the advanced manufacturing jobs that otherwise go unfilled due to shortage of qualified job seekers. TRANSFORM has these objectives: (1) reach out to liberal arts graduates to inform them about the career opportunities in advanced manufacturing; (2) design and deliver a creative transformation curriculum model, informed and supported by industry partners; (3) design and deliver a certificate program in manufacturing technology and manufacturing innovation; and (4) design and deliver an advising and support system tailored for TRANSFORM participants. Thus, TRANSFORM delivers a new curriculum model, a new co-op model, and a new student advising system; all tailored to effectively transition liberal arts graduates to the advanced manufacturing workforce.

Keywords: liberal arts graduates; advanced manufacturing; under-employment; unemployment; transform model; internships

This study aims to identify Technological Pedagogical Content Knowledge Model among engineering undergraduates students at the Afyon Kocatepe University. The main purpose of this research is to explain suitability of educational discipline knowledge model in terms of engineering education. This research which is in the quality of case identification is designed basing on quantitative research techniques. Likert scale is created which consist of forty nine sections which are suitable for quantitative researches by researcher. Also, there are five questions which define research group in the scale. Research group consist of Afyon Kocatepe University Engineering Faculty students. Three hundred and ninety eight students joined the research. Views of the students are registered with the help of scale and analyzed statistically. According to results found in research, activities of education and training in engineering faculty are suitable for Technological Pedagogical Content Knowledge Model. This study suggests that engineering undergraduate's education program need to focus on reinforcing the conceptual understanding, teaching strategies for specific topic and technological skill among undergraduate students of engineering education.

Keywords: technological pedagogical content knowledge (TPACK); engineering education; improving classroom teaching; teaching/learning strategies; technological knowledge

Students-centered paradigms have been proposed as beneficial to promoting enriching learning experiences. In an attempt to improve student learning experience in engineering classrooms, instructors often employ innovative strategies to foster learning engagement. One such approach is Cooperative Hands-on Active Problem-based Learning (CHAPL). CHAPL combines the characteristic benefits of some existing research-proven active learning pedagogies. This study reports responses from a survey that assessed the perspectives of chemical engineering students who were taught fluid mechanics and heat transfer concepts using both traditional classroom lecture and the new student-centered paradigm—CHAPL. Analysis of responses to closed and open-ended survey items indicates that CHAPL could differentially influence measures of significant learning and may be beneficial to enriching the learning experience. Limitations and recommendations for future implementations are discussed.

Keywords: cooperative; hands-on; active; problem-based learning; CHAPL; cognitive outcomes; affective outcomes

The purpose of this study was to assess the experiences of all students enrolled in a First-Year Engineering Course that conforms to educational best practices such as project-based learning with a clear benefit to society and a "real" customer within the community. A multi-method study that applied both closed form and free response types of survey questions to students on-line, multiple times throughout a design project was implemented. The data from over 200 students was analyzed statistically and based on the quantitative results; the free response questions were quantitized and frequencies and relevant student excerpts are presented. Results indicate that more experienced students (those that have completed 3 or more semesters of college) suggest the design project is of lower relevance and express a less optimistic attitude regarding participation in the project than less experienced students (that have completed less than 2 semesters of college). Women and men viewed the project with similar levels of optimism and interest during the first two survey administrations; but women were much more negative about the team experience at the conclusion of the project. Engineering educators should reexamine grouping more experienced, transfer, and / or non-traditional students with First-Year Engineering students in courses and / or project teams. Instructors should also consider implications of experience and gender balance on project team formation, progress, and outcomes.

Keywords: engineering education; first-year engineering; Project Based Learning; educational experience

A key component of undergraduate engineering education is preparing future engineers for the workplace. In order to help new graduates prepare for and successfully transition to the workplace, we must understand the experiences of these early career engineers. In this study, we identify and explain the career goals and actions of early career engineering graduates by answering the following questions: (1) How consistent are early career engineering graduates' career goals near the end of their undergraduate engineering studies with their future career plans? (2) What factors contribute to consistency in goals between these two points in time? Using Social Cognitive Career Theory, specifically the Social Cognitive Model of Career Self-Management, and a longitudinal, qualitative design, we analyzed interviews from 30 participants collected at two points in time: when participants were undergraduates and then later as early career engineering graduates. Participants were graduates from three different universities and were diverse with respect to sex, race, and undergraduate major. Results show that although early career engineering graduates had diverse goals, similar factors influenced career decisions. Participants generally wanted to find interesting work and focused their actions towards that goal. Family commitments geographically constrained career choices while also increasing the desire for stability. The economic downturn impacted job availability for many participants, and women were more likely than men to be in categories reflecting changes in career goals and/or pathways to original goals.

Keywords: career choice; SCCT; engineering graduates

Research in global competency for engineers often focuses on what colleges and universities can provide to their students in terms of intercultural and global experiences. There is also an impetus to study how employers view global competency, and what can be done to align employer expectations with how global competency is valued and practiced within higher education institutions. This study explores the importance that 442 employers from more than 20 multinational companies place on engineering global competencies when making hiring decisions. Furthermore, we investigate how contextual factors of an employer such as gender, job title, and company size affect the views and attitudes of these engineering global competency traits in the workplace. It is imperative that engineering programs work closely with companies that have a global footprint in order to further identify and reduce the gap between global industry demands and what skills colleges are developing among their student populations.

Keywords: engineering global competency; industry perspective; contextual factors; correlation; multinational company; hiring decisions

Exposing students to international experiences is becoming a common practice to prepare students with global capabilities. One pedagogical activity used to promote global competencies is the participation of students in multinational design projects. This is a problem-based learning approach in an international setting, where students get immersed in the solution of an engineering design task while they work in teams and collaborate with international partners. The main goal of these projects is to foster international collaboration and to offer an opportunity to the students to develop professional skills through international teamwork effort in the solution of a design problem. However, a real challenge of this practice has been to create an effective interaction among the students participating in this type of projects and to maintain the flow of information, and student engagement in the project and in their learning. The main objective of this work is to investigate the sociotechnical interaction of engineering students working in a multinational collaborative project and the role of information technology tools and the nature of the interaction in this experience. For this purpose an assessment tool was developed and used to determine the interaction among the students (frequency, quantity and quality), the value of social interaction in the flow of the interaction, and the impact of the interaction in the development of the project. The main findings of this instrument are presented in this work.

Keywords: collaborative projects; international collaboration; global teams; interaction assessment

This paper describes the procedure followed by Computer Engineering and Software Engineering programs at Atilim University, Ankara, Turkey, which led to the granting of five years of accreditation by MUDEK, the local accreditation body authorized by The European Network for Accreditation of Engineering Education (ENAEE) to award the EUR-ACE label, and a full member

signatory of Washington Accord of International Engineering Alliance (IEA). It explains the organizational structure established for preparation, determination and measurement of the educational objectives, program outcomes, course outcomes, and the continuous improvement cycle carried out during the preparation period. The aim of the paper is to share methods and experiences which may be beneficial for the other programs that are intended for accreditation.

Keywords: accreditation of engineering education, educational objectives, program outcomes, MUDEK, continuous improvement

This study designs a programmable logic controller (PLC) and wireless touch control technique for use in mechatronics learning. Its purpose is to provide a laboratory platform for students of engineering and technology to experiment with the design of wireless touch control technique. The principles of instructional systems design were implemented in the development of the learning module. This innovative two-position oscillating learning system elucidates the principles, function and application of mechatronics and wireless touch control technique. Thirty-eight students and eight domain experts answered an anonymous questionnaire. The domain experts were university professors and/or researchers with an average of more than five years of experience in mechatronics. An encouraging preliminary assessment of the proposed system demonstrated the accuracy of the embedded knowledge as well as the effectiveness.

Keywords: programmable logic controller; touch and control technique; Bluetooth, mechatronics

Concept maps have been used as an assessment tool in an array of educational domains for many years. There are a multitude of techniques to evaluate concept maps; however, many do not produce consistent results due to evaluator bias, human error, and the diversity of evaluator expertise. There is also the possibility that a student's cognitive style (problem solving structure preference) affects how that student constructs a concept map. In this paper, we explore two hypotheses related to concept map knowledge assessment. First, we consider the effects of a student's cognitive style on concept mapping performance. Second, we investigate possible correlations among prevalent concept map assessment metrics. Two sets of concept maps from 19 graduate engineering students were evaluated. The results show that the concept map assessment metrics used here are not biased by any particular cognitive style, which supports previous research among 104 undergraduate students. The results also imply that knowledge integration may be more effectively assessed using the closeness index in order to reduce evaluator bias.

Keywords: assessment; concept maps; concept map metrics

This paper presents what we call the Multiple Approach Experimental Project (MAEP), a project based on the model-building approach to learning. The MAEP complements theoretical lectures by placing students in a real situation where they design and build a physical structure. A total of 65 students divided into 24 teams voluntarily took part in the competition. Assessments from students who participated in the MAEP along with assessments from the instructors who implemented it are presented. Results show that the MAEP was welcomed and that the objective of engaging students in the subject was met.

Keywords: engineering education; multidisciplinary approach; teaching mechanical engineering

Compiling data from various recent courses through student and professor surveys in a "Theory of machines and mechanisms" course has enabled us to identify some difficulties and needs, most of which are related to the large number of students attending the course, usually above 350. This work presents the development of a helpful computer-assisted self-assessment tool to solve the problems detected. To implement this tool an environment was chosen that is very familiar to students and professors, that is, the AulaWeb e-learning platform where a questions database was developed and made available to students. As they tackle the questions set in each exercise, both they and the professors receive information in real time about how the learning process is progressing. The data obtained also enables the quality of the assessment tests used to be analysed, by calculating some indices for each question. The analyses performed in the first two years of implementation reveal a high acceptance of the computer-assisted self-assessment tool and a high degree of student and professor satisfaction. The tool has enabled the problems found in recent courses to be lessened and the teaching-learning process to be improved.

Keywords: computer-assisted self-assessment; e-learning; difficulty index; discrimination index; theory of machines and mechanisms

This study involves teaching engineering students concepts in lubrication engineering that are heavily dependent on mathematics. Excellent learning outcomes have been observed when assessment tasks are devised for a diversity of learning styles. Providing different pathways to knowledge reduces the probability that a single barrier halts progress towards the ultimate learning objective. The interdisciplinary nature of tribology can be used advantageously to tie together multiple elements of engineering to solve real physical problems—an approach that seems to benefit a majority of engineering students. To put this into practice, various assessment items were devised on the study of hydrodynamics, culminating in a project to provide a summative evaluation of the students' learning achievement. A survey was also conducted to assess other aspects of students' learning experiences under the headings: 'perception of learning' and 'overall satisfaction'. High degrees of achievement and satisfaction were observed. An attempt has been made to identify the elements contributing to success so that they may be applied to other challenging concepts in engineering education.

Keywords: tribology; teaching; learning style; assessment; mathematics; hydrodynamic

Engineering students at an American university in the Middle East were surveyed on various academic dishonesty issues in 2002 and a decade later. 135 students filled out the survey in 2002 and 588 students completed it in 2012. The study considered students' perception of plagiarism, inappropriate collaboration, cheating on exams, copyright violations, and complicity in academic dishonesty. Since 2002, the university developed a more comprehensive student academic integrity code, established an adjudication process for the code violators, introduced first-year students to the concept of academic integrity during their orientation, asked new students to sign an academic integrity pledge, encouraged faculty to clearly define academic integrity rules in their courses syllabi, and asked faculty to report violators of the code to the administration. This paper compares engineering students' perception of the frequency of academic misconduct in 2002 and a decade later. Results of the research showed that the taken measures by the institution to improve academic integrity have much greater effect on in-class exams than on out-of-class assignments.

Keywords: cheating; conduct; dishonesty; ethics; plagiarism; students

This paper presents an innovative course designed to teach parallel computing to undergraduate students with significant hands-on experience. This course represents an introduction to the main topics of parallel, distributed and high-performance computing (HPC). The course introduces main concepts and architectures used in parallel computing today, and improve students' skills to develop parallel programs using major parallel programming paradigms: MPI (Message Passing Interface), OpenMP (Open-Multiprocessing). The main objective of the course is to teach practical parallel programming tools and techniques for MIMD with shared memory, MIMD with distributed memory and SIMD. Each of these software tools can be used to give students experience with parallelization strategies, and ability to rate the quality and effectiveness of parallel programs. We evaluate the success of our approach through the use of testing and survey and provide directions for further improvements in teaching parallel programming.

Keywords: parallel computing; parallel programming; high performance computing; education; MPI; OpenMP; CUDA

This study examines the experiences of sophomore and junior level chemical engineering students and their self-reported opinions, confidence, and skill development from completing team-based design projects. These projects are an integral part of a Chemical Engineering program, which incorporates design projects across the curriculum at a large, public, research-intensive university with a high student-to-faculty ratio. The mixed-methods assessment approach blends pre- and post-project surveys featuring rated and free response questions with focus group analysis. The data analyzed in this study consists of 272 survey responses and 10 focus group participants from the Spring 2013 semester. Students in the junior level course and those with more project experience report a better opinion of chemical engineering, higher levels of design confidence, and greater professional skill development compared to students in the sophomore course and students with less project experience.

Keywords: design education; engineering design; evaluation; teamwork; perception

This paper presents a study in which learning practices of novice engineering students when programming and operating robot manipulators focus on the development of spatial skills. To provide the practices, we customized the laboratory setup: unified workspaces of available robots, designed virtual robotic cells, and developed robot manipulation tasks with oriented blocks. We examined outcomes of the proposed practice for two categories of learners: 248 first-year Technion students participated in the robotics workshop as part of the introductory Industrial Engineering and Management (IEM) course; 20 tenth graders majoring in mechanical engineering at a vocational high school, who took an outreach course in our lab. With regard to the latter, evaluation focused on the development of spatial skills and indicated significant gain in the performance of spatial perception, mental rotation, and visualization tests. For most of the Technion students the workshop was the first experience in robotics that aroused their awareness of spatial skills required to operate and program robot systems in manufacturing processes. The results argue for the educational value of the proposed learning practice and its further exploration in different settings.

Keywords: CDIO approach; industrial robotics laboratory; introductory robotics course; training spatial skills

This study aimed to introduce a new approach to identifying nanotechnology competence for college engineering students' career preparation based primarily on competence-based perspectives. While Q methodology is a powerful pattern analytic for expressing opinions of specific group and gives consideration to both qualitative and quantitative advantages, it was employed as a tool to explore and highlight the unique viewpoints and patterns of nanotechnology competencies expressed by stakeholders in the industry. Forty-seven competence statements were selected as contributing to the final Q set based on the university professors and post-doc fellows' evaluation and post interviews. Then twelve professional experts in the nanotechnology industry in Taiwan were recruited to be the Q participants. Based on the results of Q sorting and discourse analysis, two factors of the subjective viewpoint toward the expected general nanotechnology competencies of university graduates were presented, namely, personal-attributes oriented and professional-skills oriented. Although the emphases were placed on dissimilar statements by different factors, it was clear that innovation, activeness and ambition, applied chemistry, and nano-optoelectronics together constructed the core nanotechnology competencies. The results provide practical and theoretical implications for engineering education in students' training and professional development.

Keywords: discourse analysis; electro-optics; nanotechnology; professional competencies; professional development; PQMethod; Q methodology

An inquiry-based curriculum was cooperatively designed by a group of vocational high-school teachers and researchers/teacher educators under the "High Scope Project" funded by the National Science Council of Taiwan. The designated curriculum was implemented to enhance vocational high-school students' learning of advanced technology and their competence in scientific inquiry. Within the context of the targeted inquiry learning environment, possible changes of targeted students' competence in scientific inquiry were assessed both qualitatively and quantitatively to serve as cardinal evidence in supporting this innovative reform. A mixed methods approach was employed in this study for assessing targeted vocational high-school students' competence in scientific inquiry. Within the context of the High Scope Project, ten teachers of two departments ("Department of Electrical Engineering [DEE]" and "Department of Mechanical Engineering [DME]") in a vocational high-school in southern Taiwan participated in the process of designing and implementing the interdisciplinary inquiry curriculum, while their students also engaged in the learning processes. This mixed methods study was composed of two parts: a qualitative case study and a follow-up quantitative quasi-experimental study. In this article, we present the designated curriculum designed in the High Scope Project. The summary of the qualitative results showed that eleven aspects of students' change and progress in competence in scientific inquiry were generalized and categorized into six types of competence. These competencies, in turn, were classified into three dimensions: basic, advanced, and criticizing competences. The quantitative findings revealed that all participating students gained superior improvement on their competence in scientific inquiry, verifying the effectiveness of the designated curriculum. Implications derived from findings and discussions were proposed for further improvement and future study with the ultimate goal of enhancing students' competence in scientific inquiry.

Keywords: mechatronics curriculum design; engineering education; competence in scientific inquiry; vocational high-school student

Because the number of educational institutions all over the world is increasing, the competition to achieve excellence in academic quality has become a prerequisite for sustainability and continuous improvement. Certification from reputed international accreditation boards provides means for such institutions to achieve excellence through the complex accreditation processes. The Accreditation Board for Engineering and Technology (ABET) is one of the prestigious international academic accreditation bodies. Out of all the significant ABET criteria for certification, Students Outcomes (SOs) represent the heart of the accreditation process as they cover a wide range of skills and capabilities expected by the industries and labor markets. The aim of this paper is to provide a methodological approach to prioritize SOs using the Interpretive Structural Modeling (ISM) to construct a meticulous study plan. A case study on the Department of Industrial Engineering at King Abdulaziz University (KAU) is presented to illustrate the proposed approach. The results indicated that SOs can be systematically linked with the curriculum in order to build up a study plan in a systematic manner. The results also revealed that students should be trained to be able to work in teams at the beginning of the study plan. Alternatively, SOs like, 'ability to design and interpret experiments', 'understand the impact of engineering solutions', and 'engage in life-long learning' etc. were proposed to be imparted within the final year of the study plan, in the subsequent phases.

Keywords: study plan; curriculum; engineering education; industrial engineering; Interpretative Structural Modeling; ABET; students outcomes; prioritization

Professional societies and industry have called for new approaches to engineering education that will produce more science, technology, engineering and mathematics (STEM) workers, while encouraging the development of an educational climate that will foster the goal of achieving STEM literacy for all. University-based researchers designed and implemented a summer high school electrical and computer engineering camp to address a major challenge in the U.S.—the need to build awareness and excitement for engineering career paths among secondary students. Pre- and post-surveys were administered to assess students' knowledge and science self-concept. The quantitative data collection (N=38) measured baseline proficiency variables, such as knowledge of the subject matter, along with social cognitive variables such as academic self-efficacy, goal orientation, and confidence. Students demonstrated significant gains in engineering knowledge and confidence. They related engineering principles to their everyday lives, learned about engineering careers from faculty and working engineers, and became more knowledgeable about engineering theory and skills as a result of participating in authentic tasks. This study provides a replicable model for innovative engineering learning, as well as collecting and interpreting data on program effectiveness.

Keywords: engineering education; hands-on activities; K-12 education; summer camp