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Chemical Engineering (ChE) is one of the engineering disciplines with the highest participation of women. This article describes the experiences of Black and White women in chemical engineering programs that stand out because they attract and retain women at higher rates than peer institutions. We use a mixed-methods approach, quantitatively describing the trajectories of Black and White students at three Selected and seven Other institutions using data from a large, multi-institution dataset and qualitatively describing the experiences of seven Black and nine White women through focus groups at those Selected institutions that were identified as "pockets of success" for women through the quantitative findings. We find that Black and White students have better outcomes at Selected institutions than at Other institutions; they are more likely to graduate within six years and more likely to remain in ChE. We find through focus groups that women are attracted to their institutions and departments due to institutional reputation and identify six reasons that these women stay in ChE at these institutions: Sisterhood, Real-World Experience, Real-World Examples, Faculty Caring, Sense of Accomplishment, and "I Got This Far." We conclude that institutional reputation is a factor in students choosing the institution but that the elements of reputation are different at the Selected institutions. Persistence in ChE appears to be most highly associated with relatedness. This can manifest through relatedness with other students, faculty who care, and the larger professional community through real-world experiences and examples.

Keywords: chemical engineering; graduation rates; persistence; student retention; stickiness; women

This study presents a unique synthesized set of data for community college students entering the university with the intention of earning a degree in engineering. Several cohorts of longitudinal data were combined with transcript-level data from both the community college and the university to measure graduation rates in engineering. The emphasis of the study is to determine academic variables that had significant correlations with graduation in engineering, and levels of these academic variables. The article also examines the utility of data mining methods for understanding the academic variables related to achievement in science, technology, engineering, and mathematics. The practical purpose of each model is to develop a useful strategy for policy, based on success variables, that relates to the preparation and achievement of this important group of students as they move through the community college pathway.

Keywords: community college transfer; engineering; STEM policy; data mining; academic variables

This paper presents a study of the relations between workload as measured by the lecturer, student grades on a final test and student satisfaction as measured in a course survey in a first year engineering course. The study covers 10 years, from 2004 to 2014, and grades/scores from 827 students. During this time the lectures were given by the same lecturer using the same textbook and the study only reports on the exam part of the course. The purpose of this study was to evaluate whether the general assumption of 'more is better' is valid for the relation between workload and the final results, i.e., grades and satisfaction. The workload was estimated by measuring the time it took the lecturer to solve the homework assignments and the student satisfaction was estimated by using results from annual student ratings made each year. The grades used were from the final exams only, not the final course grade. The results reveal that there are no relations between the workload, final exam grade and satisfaction, when compared two by two (workload vs. grade, workload vs. satisfaction and grade vs. satisfaction).

Keywords: workload; grades; student ratings; longitudinal study

The need for science and engineering workers has raised concerns regarding the persistence of undergraduate students in engineering. Since academic institutions ordinarily provide students with feedback on course performance through grades, understanding the role of course grades in influencing student major choice and major switching behavior is critical. This research

identifies factors associated with switching majors within engineering, as well as examines how students' expectations regarding future grades may influence major choice. The data include individual-level demographic characteristics and detailed transcript records from 27,065 students in the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). Logit regression analysis on the likelihood of switching majors indicate that students who initially declare industrial or mechanical engineering are less likely than those who declare electrical to switch majors. Scores on the Scholastic Aptitude Tests (SATs), as well as introductory course grades in Calculus and Physics are associated with the likelihood of changing majors. Findings from the propensity score analysis show that students with higher grade point averages in introductory courses are more likely to stay in their intended engineering major if they expect to receive relatively higher grades in their intended major's upper-division courses. Research findings have broad implications for academic institutions and how grading distributions and practices may be associated with students' switching behavior and major choice in engineering.

Keywords: course grades; major choice; switching; persistence

Focusing on the mechanical engineering undergraduate program at the University of Alberta, this study attempts to quantify biases in student evaluation of teaching (SET) results that could be attributed to SET protocol, course content, and course delivery mode. SET results were compiled for five academic years of paper based SET evaluation and one semester of online SET evaluation. 20 core undergraduate courses were included; class size from 70–130; 35 professors. Statistical analysis included compilation of frequency histograms, determination of means and standard deviations, and rank-sum tests for significant differences based on aggregated data for several stratifications. Results showed significantly reduced response rate for online SET when compared to paper; ratings of professor evaluation were not different. No significant differences were found when results were compared on the basis of course content or delivery mode. Our aggregated data showed SET protocol lead to lower response rate, but not significant differences in instructor evaluation. Course content and delivery mode did not manifest in significant changes in SET results. Typical variability in instructor rating was 0.4/5.0 considering all data. Administrators and senior faculty should be aware of these results when ascertaining instructor performance. Although focused on one department, the study is a first step in a larger evaluation of SET in engineering. The study identified key variables that must be further evaluated.

Keywords: universal student rating of instruction; student evaluation of teaching; engineering; education; measurement

This study investigated whether the inclusion of a student-centered research component in an introductory materials science course resulted in a larger knowledge gain relative to traditional pedagogies. The redesigned course was taught in five different sections, over three academic years, at one of the largest public university, namely Texas A&M. Gains in conceptual understanding were quantified by comparing pre- and post-course completion Materials Concept Inventory (MCI) scores. Pre- and post- Pittsburgh Engineering Attitudes Scale—Revised (PEAS-R) was used to measure the impact of redesign course on student attitudes towards engineering. Additionally, a post hoc survey was conducted to collect students' opinions on research experiences at the end of semester. Students in the redesigned class demonstrated higher knowledge gain on the MCI relative to traditional lectures, consistent with previous studies that examined the effect of in-class active learning pedagogies. The post hoc survey showed a positive response of the students' with regards to improvements in their critical thinking, quality of learning, oral, written, and communication skills.

Keywords: course-wide research project; Student active learning; Engineering education; Materials science and engineering

Once student learning approaches have been identified, the instructor can remove or mitigate factors that encourage surface learning and develop their course to encourage deep learning. When instructors organize appropriate learning activities to ensure that students engage in active learning, civil engineering students are more likely to develop a deep approach toward learning. Therefore, identifying civil engineering students' learning approaches is an important factor in their academic success. The present study examined the learning approaches of civil engineering students in three universities in Turkey and the extent to which their learning approaches were related to gender, age, type of university, year of study, and construction management course success. Data were collected from civil engineering students in undergraduate programs at three different universities using the Revised Two-Factor Study Process Questionnaire (R-SPQ-2F). The questionnaire was directly administered to students, and 174 participants responded to the survey. The study findings revealed week correlations of learning approaches with age and year of education, and moderate correlations between learning approaches and construction management success.

Keywords: civil engineering education; learning approaches; construction management; deep approach; surface approach

Engineering science courses, such as Thermodynamics, are often seen as difficult, and students have difficulty understanding the concepts and solving the problems. In an effort to improve the situation, we developed a well-structured, cooperative teaching-learning strategy, Cooperative Pair Problem Solving (CPPS), suitable for large groups (more than one hundred students) for implementation during tutorial sessions. CPPS will be of interest to educators already making use of tutorial sessions where students solve problems under the guidance of the lecturer and/or assistants. For educators expecting students to solve problems on their own, as homework, CPPS presents a viable alternative strategy to harness the proven advantages of Cooperative Learning. This article describes the procedure we followed with the implementation of CPPS during the tutorials. It further reports on the extent to which we were able to structure the five elements of CL and the effect this had on the tutorials. The study was performed at two universities in South Africa. The population comprised the second-year engineering students taking their first course in Thermodynamics—in total, approximately 400 students in three groups. The students and assistants completed questionnaires and two observers were asked to attend tutorials and report on their observations. There was almost universal agreement that CPPS led to effective cooperation between the students. From the questionnaires, it was clear that positive interdependence was sufficiently structured into the procedure. The majority of students engaged in promotive interaction and took responsibility to complete the task. The students possessed sufficient social skills to work effectively together, and group processing was effected by letting the groups grade their own work. It was found that an effective group formation procedure is vital for the successful implementation of CPPS otherwise students tend to sit with friends, and positive interdependence and promotive interaction suffer. Although CPPS was developed in a Thermodynamics environment, we are convinced that it can also be implemented successfully in other engineering science and even pure science courses where instructors want to implement CL during problem solving tutorials.

Keywords: cooperative learning; large groups; pair problem solving; Thermodynamics

The main objective of this paper is to introduce a new transdisciplinary collaborative research process model to develop collective intelligence through input from research teams as well as academic and non-academic experts. The paper discusses the need for new types of collaboration to solve complex problems and reviews the development of transdisciplinary approaches and collective intelligence. The paper proposes a transdisciplinary collaborative research process composed of three parts: (1) team building and collaborative problem understanding; (2) development of collective intelligence through interpretive structural modeling to classify the problem factors according to driving power and dependence, and (3) use of design structure matrices for transdisciplinary assessment and knowledge integration to form project teams. The proposed process model is illustrated through an example of a rural eco-village system of systems (SoS) drawn from the context of a senior capstone design course.

Keywords: transdisciplinary collaboration; information sharing; collective intelligence; interactive management; interpretive structural modeling; design structure matrix; eco-village

It is critical to focus on the foundations of innovative design in preparing today's engineers. An understanding of the relationship of design team processes to product innovativeness can be used to mentor teams in producing innovative designs. Our objective was to measure process-level differences between engineering teams that produced innovative versus non-innovative designs by examining the behaviors and characteristics of team members from problem definition to working prototype. To do this, a mixed methods analysis was conducted on reflections made by design students. Reflective journal entries were coded using a framework tool developed in a grounded fashion from the student data. Hypotheses about the prominent themes that emerged from the content analysis were then evaluated using statistical testing to determine if process-level differences existed between teams with innovative versus non-innovative artifacts. We found that innovative teams solved problems significantly more than non-innovative teams and were proactive, reworking items early and believing in working hard initially. Innovative teams also critically assessed their skillsets and sought expertise when necessary significantly more. Many of the characteristics that innovative teams exhibited significantly more are characteristics of high performing teams as well as the entrepreneurial mindset currently advocated within engineering education. This type of design process data can be used by engineering educators to mentor teams in developing innovative outcomes. Having demonstrated that process-level behavioral characteristics of design teams can be measured, our framework tool can be used by other educators to further assess process-level data and continue to establish additional connections to innovative designs.

Keywords: innovation; engineering team design; reflection; qualitative framework

Case-based instruction has been found to increase student engagement and motivation in engineering classrooms. However, there is a lack of qualitative in-depth examination of student perceptions of the use of cases in engineering. The current study examined undergraduate engineering students' perceptions of implementing case studies in a mechanical engineering course, what aspects of case studies were beneficial and what aspects were challenging. Twenty-seven students enrolled in an undergraduate mechanical engineering course were interviewed using a semi-structured protocol. The interview protocol asked students about their experiences when learning from cases in the course. The interviews were transcribed and coded to develop categories and themes related to student views about cases. The interviews produced a rich set of qualitative data, which suggested that students found cases to be beneficial with regards to allowing them to see real world application of course concepts. Students also reported some challenging aspects of learning from cases, such as frustrations with the ill-structured nature of cases and the inefficient use of class time when using cases. Cases offer a potential mechanism to engage students in the classroom, but face resistance and challenges. Hence, it becomes important for instructors to carefully engage students in the case study approach.

Keywords: case-based instruction; qualitative interview

With the continuous development of information and telecommunication technologies, intelligent control has been penetrating into every aspect of human's life. Automobile manufacturing is no exception. In particular, teaching laboratories that combine intelligent control with automobile manufacturing have recently attracted teachers' attention from various universities and colleges. The intelligent car lab presented in this paper is developed on top of a competition developed by Freescale, a semiconductor company, together with the Chinese Higher Education Automation Professional Education Committee in China. This competition is held in several Asian countries for the sake of cultivating students' practical abilities. The paper introduces the whole learning environment process, preparation made by teachers and students from Shanghai Maritime University, and the setup of a concept of adaptive intelligent car lab. We introduce the project components, technical developments achieved by the students and discuss the benefits of the whole experience. We show that throughout this proactive learning environment, students learnt a large amount of technological and design knowledge and enhanced their hands-on technical abilities, as well as learning new group-project capabilities, thus providing a solid foundation for their professional future.

Keywords: proactive engineering learning; adaptive car lab; engineering student competition

The paper discusses the educational concept of lifelong learning (LLL) and also presents the results of a survey to assess the understanding of LLL by engineering instructors. The study is undertaken in the background of the general stance of engineering instructors towards students' professional skills development required by the accreditation agencies. It covers also the assessment methods to determine whether LLL skills have been acquired and some strategies employed to promote it.

The paper opines that as technology advances in modern knowledge-based economies, industry and other employers will more and more require engineers who are multi-skilled, adaptable and who can operate flexible systems. Therefore professional engineers who are committed to LLL will be in greater demand. Qualified engineers who are less skilled or have no capacity to upgrade their skills or adapt to rapid changes will less likely find attractive employment. The role of instructors in understanding and applying LLL competency cannot be overemphasised. However, in general instructors are not usually sure about their knowledge of LLL and are to some extent reluctant to include lifelong learning skills development in their teaching.

The conclusions are that the attitude of students, knowledge of instructors and the learning environment are critical in promoting lifelong learning ability of engineering students.

Keywords: lifelong learning; self-directed; distance/non-formal learning; adult education; accreditation; graduate attributes

Much of the existing research on engineering students' conceptual understanding focuses on identifying difficult concepts in specific courses and curricula. Although there are a great number of findings from which engineering educators may be able to draw, few are directly transferable from their original context and few inform instructors about how to improve learning. This paper seeks to fill the gap by investigating conceptual understanding across four engineering disciplines. Specifically, the present study seeks to answer the following overarching research question: What are the patterns in engineering students' conceptual understanding across four engineering content areas? We used an amplified secondary qualitative data analysis to examine over 250 interviews with engineering students that were initially conducted to understand students' conceptual understanding in different disciplines of engineering. The engineering topics represented in the data set included mechanics of materials, transportation engineering, fluid mechanics, and digital logic. Two themes emerged from our analysis that apply to students' understanding across four diverse content areas within engineering: (1) students inappropriately group dissimilar phenomena, processes, or features, and (2) students reason using simplified causal relationships. These themes lend themselves to suggestions for instructional practice across disciplines and for future research areas.

Keywords: conceptual change; conceptual understanding

The present study investigates how technology assisted and designed teaching influences engineering students' understanding of the connection between the graph of a function and its derivatives. An engineering student group (n = 27) was taught with the assistance of GeoGebra while a control group (n = 20) was taught in a traditional way. The data of the study consist of the documents and photos of the observation of two lectures and the students' answers to the pre and post tests. In our theoretical framework we discuss the distinction between conceptual and procedural knowledge. When creating the teaching sequences we applied variation theory. In the analysis of the students' pre and post tests results we applied statistical methods. Our experiment revealed that the GeoGebra-assisted teaching design created more opportunities for students to grasp the connection between a function and its derivatives.

Keywords: conceptual knowledge; derivative graphs; technology; variation theory

Mechanical engineering (ME) departments in research universities face the challenge of educating mechanical engineers who will graduate with a balanced knowledge in engineering science and mechanical design. The source of this challenge is the inherent difference between teaching analytical thinking, which is required for most engineering-science courses, and design thinking, which is required for project-based design courses. The purpose of this paper is first to propose a new approach that can potentially bridge the educational gap between analytical and design thinking, which we refer to as integrated thinking. Second, we show how it can be applied to various ME undergraduate courses, which we refer to as integrated courses. Our approach reforms science engineering courses by (a) stressing the physical interpretation of mathematical derivations; (b) requiring students to analyze, design, and sketch simple mechanical devices based on the learned theoretical material; and (c) modifying project-based design courses to emphasize the importance of analysis as part of the creative design process. A pilot course focusing on dynamics and vibration which we called Integrated Design and Analysis, was offered in the ME department at the Technion, where it was well-attended by senior ME students. The positive feedback of the students who took the course suggests that integrated thinking might be successfully applied in many areas of ME education, such as fluid mechanics and heat transfer, control, and mechatronics, and that our approach may contribute to changing the current divided pattern in ME education.

Keywords: design education; design thinking; integrated thinking

In spite of the advances in technology in the e-learning field during the last decades, there is still a gap of software and tools that actually improve the assessment of this kind of education by preventing students from cheating when they perform their activities online. Currently, most learning management systems do not offer enough tools or characteristics to check that students are who they assure when they carry out their exercises or online tests.

Facial verification software can be considered an interesting tool to answer this need. This facial software helps to verify the identity of the students when they perform their activities, with the intention of confirming whether they are who they claim to be. However, its use could modify the academic results of the students due to psychological factors (e.g., they could feel spied, ashamed or too controlled).

The aim of this article is to investigate whether the utilization of facial verification software can modify the academic performance of students in their online activities. In this work, the grades of 70 master students were analyzed and the conclusions pointed out that the academic performance obtained by the students is similar for both groups: those who have used facial authentication and those who did not use it.

Keywords: e-learning; glossary; test; Moodle; facial authentication; online learning; academic performance

This study investigated the affordances and constraints of dynamic physical and virtual models integrated into a dynamics course. Students in a dynamics course were assigned to one of three groups: traditional instruction, traditional plus physical manipulatives, and traditional plus virtual manipulatives. Using observations of problem solving sessions, student questionnaires, and pretest/posttest written assessments we triangulated affordances of physical and virtual manipulatives for learning dynamics. Key affordances of the manipulatives included direct experience of motion of the mechanism, the ability for students to test or verify their ideas about the mechanism's operation and facilitating communication for collaborative learning. Pretest to posttest changes in mechanical reasoning favored the use of physical or virtual manipulatives over traditional instruction alone. Results suggest that adding physical and virtual manipulatives to traditional instruction in dynamics may help students better reason about mechanical systems than with lecture and problem solving using static diagrams alone. By exploring how different manipulatives can help students understand dynamic systems, this study contributes to the larger body of research on helping students develop mechanical reasoning in engineering.

Keywords: dynamics; manipulatives; affordances

Nowadays, university students have grown up surrounded by Web 2.0 technologies, which they are able to use with ease. These technologies provide an opportunity to improve the learning/teaching process through collaboration, the exchange of knowledge and above all, the motivation created by the use of these technologies that are generally utilised by students in their day-to-day social life.

The integration of Web 2.0 technologies into the learning/teaching process must be addressed in a critical way, taking into account the objectives to be achieved and the type of teaching to be undertaken. Teachers can find a wide range of available Web 2.0 technologies and it is often difficult for them to decide which type is the best one for their needs. This paper proposes a methodology based on software engineering methods and designed for software selection that provides recommendations to evaluate the function and options of Web 2.0 technologies according to the specific needs and characteristics of the subject to be taught and the types of students involved in higher education.

The methodology consists of a formal guide to aid teachers when they need to select and put Web 2.0 technologies into practice in a learning/teaching process. In order to offer a practical demonstration of the application of this methodology, the experiences of various teachers in engineering degrees are described.

Keywords: engineering education; Web 2.0; selection methodology; case study; learning and teaching process

In recent years, in response to higher construction industry standards for project design and delivery under budget, time and safety constraints, technological advances have dramatically changed how design and construction information is represented and managed. To prepare students to respond to these new industry demands approaches to teaching dynamic construction planning and management practices are changing. As a result, simulation games are gaining interest as an approach to providing students with learning experiences better aligned with complex problems in the areas of construction bidding, planning and management. However, while the use of simulation games in teaching construction shows some promising results, it remains sporadic due to high development costs, implementation challenges, and uncertainty of their effectiveness as learning tools. To address this gap, we developed and evaluated a free and open-source construction management game—the Virtual Construction Simulator (VCS)—that involves teaching a more holistic decision making process to planning and managing construction projects. This paper discusses the learning objectives that guided VCS3 development, implementation and assessment, and concludes with findings and recommendations for its broader implementation and future research.

Keywords: engineering education; simulation game; learning assessment; construction management

To ensure the success of mobile learning, the use of an appropriate methodology to design and implement mobile device based on educational tools is a key issue. Industrial Computing (IC) subject is a third year compulsory subject of Industrial Electronic and Automation Engineering degree, which instructs students in the design and validation of Industrial Computing Systems (ICS) to control medium size industrial processes. IC is organized through a Problem Based Learning (PBL) methodology to carry out the implementation of ICS. In a traditional IC class, students had overheads to follow teacher's demonstrations. Students did not complete project implementation because they were unable to follow part of the explanations, and hence they get unmotivated. To solve this problem, an IC mobile device based multimedia teaching methodology, namely m-IC is developed. m-IC allows integration of lecture videos, problems, laboratories and development demonstrations of ICS projects. In this way, m-IC allows students autonomously plan their formation process and receive teacher guidance using a mobile phone. Moreover, smartphones availability makes these devices good candidates to learn IC. To show how students interact with m-IC, a smartphone application is detailed. The successful evaluation of m-IC by around 800 students during four years is presented.

Keywords: smartphones; mobile devices; distance learning; problem based learning; industrial computing; multimedia systems; automation and electronic engineering

We investigate two approaches incorporating two types of intragroup interaction (cooperative and competitive) using simulation based training (SBT) with teams—a pure and a mixed approach—within the supply chain management domain. SBT commonly refers to the use of simulation in the context of education. We examine how a combination of these two interaction types would work in situations wherein both are used in succession. Our purpose is to improve teaching and establish better ways to educate industrial engineering students using SBT. The first hypothesis is that from a pedagogical perspective, it is more effective to use a mixed approach for intragroup interaction when using SBT techniques for engineering education than a pure approach. The second hypothesis is that when using a mixed approach, the order of the two interaction types affects the learning outcomes. The study examined the effects of a new advanced SBT computerized simulation environment on two classes of freshman undergraduates in an Industrial Engineering program in a premier technical university. Each student completed four exercises, of which the first and last were individual tasks and the middle two were done by teams of two students. The students' performance was statistically analyzed. The results, rendered as guidelines on how to use SBT for team training, indicate that when teaching using SBT, a mixed approach for intragroup interaction is better than a pure approach. Moreover, if a mixed approach is used, the order is significant. In particular, we found that it is preferable to start with competitive interaction and then move to cooperative interaction. Our findings suggest that at the training stage, it is better to train teams using both types of intragroup interaction, starting with a competitive interaction followed by a cooperative one.

Keywords: engineering education; simulation based training; teaching approaches; competitive and cooperative

The main purpose of this paper is to present a literature review of Entrepreneurship Education in engineering courses. From an initial search in Scopus, 16,835 documents were collected. This search was enhanced by applying filters to the documents. Conducting a new research with the keywords Entrepreneurship and Education, and restricting to articles in journals and the engineering field, 74 articles were selected and mapped by a Webibliomining model. A few research studies have examined the practices and beliefs in entrepreneurship education. Thus, this paper consolidates concepts from literature to help understand, develop and drive models of the entrepreneurship education in engineering. Based on the literature review, this paper provides a useful core of references that includes the oldest, the newest and the highest citations of Entrepreneurship Education in engineering.

Keywords: entrepreneurship education; technology transfer; entrepreneurship business

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the Bachelor's Degree in Building in Spain

After five years since the introduction of the European Higher Education Area (EHEA) in Spain, it is time to examine its achievements. This study focuses on technical architectural studies and its transformation into a Bachelor's degree in Building. The analysis takes into account key issues such as the reduction in the number of new students due to the crisis in the Spanish construction sector that started in 2008. This paper presents a study of the impact of the Bologna Process on the abovementioned bachelor's degree programme from the point of view of the first-year subject of Descriptive Geometry. The methodology is based on time series analysis and correlation parameters of data collected between 2005 and 2014. The results, on one hand, show high correlations (0.94–0.98) between the decrease in the number of students enrolled and some construction sector economic variables, such as construction employment. However, according to surveys, the vocations are still the main reason of career choice. On the other hand, they also show that the four-month period division of the subject established in the new bachelor programme has improved students' academic performance. This is clearly shown in the range of students with marks over 7 out of 10. In conclusion, the Bologna Process has led to an improvement in the academic performance of first-year students and the development of highly motivated and engaged learners in the new Bachelor's degree in Building programme. In contrast, it is shown that the implementation of the EHEA will not reduce the number of years spent by students in their studies nor decrease the rate of students who drop out.

Keywords: construction sector; higher education; career choice; descriptive geometry; academic performance