

# The International Journal of Engineering Education

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- Ahmad Ibrahim** 1835 Editorial
- Ning Fang, Oenardi Lawanto, Wade Goodridge, Idalis Villanueva and Kurt Becker** 1836–1846 A Research Experiences for Undergraduates (REU) Site Program on Engineering Education Research
- This paper describes a U.S. National Science Foundation-funded Research Experiences for Undergraduates (REU) Site program that aims to provide undergraduate students with experiences in engineering education research (i.e., education research in the context of engineering). This paper provides an overview of the program and briefly describes the common intellectual focus of this REU Site program. Over the past two years, a total of 16 undergraduate students, seven graduate mentors, and five faculty mentors have actively participated in the program. Four important components of the program are described in this paper, including student recruitment and selection, REU seminars, weekly reflections, and REU research projects. The results of the project evaluation show that the program has made a positive impact on increasing education research skills and communication skills of the participating REU students. Eighty percent of the participating REU students reported that the research projects they worked increased their motivation and confidence for continuing to engage in engineering education research.
- Keywords:** Research Experiences for Undergraduates (REU); REU Site program; engineering education research; self-regulated learning
- Anastassis Kozanitis and Jean-François Desbiens** 1847–1858 Canadian Engineering Students' Motivation in the Context of a Shift Toward Student-Centered Teaching Methods in an Outcome-Based Education
- A recent transition to an outcome-based engineering education in Canada has prompted changes to instructional and pedagogical methods. Given that students can express a different degree of motivation depending on the course and on the learning activities within a course, there is a need to examine the motivational dynamics that drive the students in the learning process. Moreover, most studies on engineering students' motivation have examined motivational components independently. The purpose of this study is to analyze the joint contributions of student characteristics, their perception of instructors' attitudes and behavior when interacting with students, as well as their perception of the nature of the learning activities and their impact on student motivation within a course. The sample was composed of 215 students attending a francophone engineering school in Canada. Participants completed a questionnaire composed of 42 items from various existing instruments. Multiple linear regression analysis was used to predict the set of motivational components for this study. Instructors' attitudes and behavior, as well as higher-order cognitive tasks are significantly related to student motivational components, resulting in a positive impact on mastery goal, performance goal, task value, control beliefs, and self-efficacy.
- Keywords:** motivation; teaching methods; student-centered
- J. C. Cuevas-Martínez, A. Triviño-Cabrera, M. D. Molina-González and A. J. Yuste-Delgado** 1859–1866 Two-Tier Assessment Based on Collaboration and Competition to Enhance Engineering Students
- This paper reports the results of a two-year experiment in which competitiveness and collaboration were employed to support university students in their learning process, with the intention of simultaneously improving their motivation, teamwork, initiative and resolution. The main novelty of the designed framework is that it is composed of two tiers: Global competition in all subject activities is complemented by short-term competition associated with the lab sessions. The short-term competition favors students' ongoing work and engagement, whereas the global competition can help them balance their workload. A total of 167 students of engineering participated in this study. The results show that the approach was beneficial to the students.
- Keywords:** student motivation; higher education; competitive learning; collaborative learning
- Nichole Ramirez, Sally Smith, Colin Smith, Tessa Berg, Beata Strubel, Matthew Ohland and Joyce Main** 1867–1878 From Interest to Decision: A Comparative Exploration of Student Attitudes and Pathways to Co-op Programs in the United States and the United Kingdom
- Cooperative education programs (co-op) play a vital role in developing engineering and computing students' applied technological skills and professional self-confidence. Nevertheless, not all students choose to participate in co-ops. Through empirical data collection undertaken at two universities, this article explores students' perceptions about co-op programs and why some students do not participate in optional co-op programs. The 408 participants were in one of three groups: (a) co-op participants, (b) interested applicants and non-applicants, or (c) those not interested and/or did not apply. Using Rational Choice Theory as an interpretive framework, quantitative and qualitative analyses of surveys and interviews were used to compare and contrast experiences, approaches, motivations and attitudes across student groups in the United States and the United Kingdom. Results show that US and UK students who identified as not being interested in co-op shared similar perceptions, including the perceived cost of additional time to graduation. Students also expressed concern that taking time away from campus to complete a co-op would affect social interactions with their peers. The results of this work can be used to inform co-op program processes and policies, highlighting ways in which programs can increase participation. The study also shows how key stakeholders can learn cross-cultural 'best practices' to make co-op education accessible and effective.
- Keywords:** cooperative education; perceptions; student pathways; computing; engineering

Persistence of undergraduate engineering students has long been a challenging issue in many engineering programs at higher education institutions in the United States (U.S.). Although much research has been performed to study factors affecting student persistence, research findings vary from institution to institution due to cultural and other unique differences at each institution. The present research adds to the knowledge base by employing readily available institutional data to determine factors affecting persistence of engineering undergraduates at a public research university in the U.S. Institutional data collected on declared engineering majors were sorted into equal-sized groups of 383 persisting students and 383 non-persisting students, totaling 766 students. Statistical t-tests were performed to analyze numerical (continuous) data that correspond to four factors: high school GPA (graduate point average), ACT (American College Testing) math score, composite ACT score, and projected age at graduation. Statistical Pearson's chi-squared tests were conducted to analyze categorical data that correspond to six other factors: gender, marital status, residency status, campus residence, scholarship, and financial aid. The results of statistical analysis show that students with higher high school GPAs, ACT math scores, or composite ACT scores were more likely to persist in engineering. Older or married students were also more likely to persist than younger or single students. When compared with in-state resident students, out-of-state resident students were less likely to persist, and international students were more likely to persist. Students who had received financial aid were more likely to persist than those who did not. These research findings have practical implications. Higher education institutions can adjust entrance criteria to increase the chances of success for students admitted into engineering programs.

**Keywords:** persistence; undergraduate engineering students; institutional data; quantitative research

**Linda Stern, Colin Burvill,  
John Weir and Bruce Field**

1888–1902 Metrics to Facilitate Automated Categorization of Student Learning  
Patterns while using Educational Engineering Software

In this paper we describe the use of metrics for analysing student interactions with educational software. We applied this metric-based approach to a class of 200 second-year undergraduate students using an educationally-oriented software simulator to solve specific problems in mechanical engineering design. Our results show that a metric can facilitate categorization of student learning patterns. We suggest how similar metrics could allow automated feedback on learning to both students and educators. Since it is based on numerical analysis and modelling, our approach is particularly well-suited to software used to support teaching and learning in engineering and other mathematically-based disciplines.

**Keywords:** learning analytics; technology for learning; mechanical engineering education; audit trails

**Nissim Sabag and Elena Trotskovsky**

1903–1910 An Examination of the Relationship between Instructional Strategies to  
Learning Styles Distance and Students' Achievements

Some researchers claim that a close match between a student's learning style (LS) and the teacher's instructional strategies (IS) supports students' achievements. Accordingly, in order to maximize student achievements, teachers should adjust their teaching strategies to fit their students' learning styles. The current paper deals with a true field experiment aimed at examining the relationships between the distance of teachers' IS to students' LS and students' learning achievements. An IS-LS distance for each student and his or her teacher was measured, and its correlation to this student's achievements was calculated. The Felder-Soloman Index of Learning Styles (ILS) was used to measure students' preferred LS as well as teachers' preferred IS and a method for measuring the IS-LS distance was developed. The research population, comprising 165 students and 8 teachers from one high school and two colleges, completed the ILS questionnaire. The absolute value of the difference between the student's LS to teacher's IS defined the IS-LS distance; the distances were calculated for each student and the relevant teacher. If the argument that a good IS-LS match contributes to a student's achievement is valid, then a significant negative correlation between the IS-LS distance and the student's achievements must appear. The correlations between the IS and LS distances and students' achievements in 17 courses were calculated in order to answer the above question. The research findings do not support the assumption that matching IS to LS improves student achievements.

**Keywords:** engineering education; instructional strategies; learning styles

**A. Cervone, J. A. Melkert,  
L. F. M. Mebus and  
G. N. Saunders-Smits**

1911–1921 Push or Pull Students into Blended Education: a Case Study at Delft  
University of Technology

Blended education, or "flipping the classroom" is rapidly becoming a mainstream form of teaching within universities. Within Engineering Education, it is popular as it allows more time in-class to focus on hands on activities such as demonstrations and solving complex problems. This paper discusses the effort conducted to re-structure, according to the blended learning principles, the "Propulsion and Power" course of the Aerospace Engineering Bachelor degree programme at Delft University of Technology (TU Delft). The redesigned course was supported by a dedicated online & blended education unit within the university, and is characterized by a very peculiar structure due to the different approach chosen by the two involved lecturers. The first lecturer decided to "pull" the students, by proposing a number of additional videos available in the World Wide Web as a support and complement to the material taught in class. Conversely, the second lecturer opted for a "push" approach, self-recording theory videos to be watched by the students at home and devoting the in-class hours to exercises and applications of the theory. This format resulted in a clear improvement of the average exam grades and pass rates. The student feedback showed enthusiasm about the new blended course, with only a very small minority still preferring the previous, more traditional approach. Although there seems to be a slight preference of students towards the "push" strategy, the "pull" approach has also been widely appreciated. However, the objective to re-attract students to the contact hours in class was only partially achieved, since just a slight improvement in the number of attending students was observed. This paper clearly shows that the efforts to implement a blended teaching strategy has great benefits for both students and staff alike.

**Keywords:** blended learning; online education; student engagement; electronic assessment; aerospace engineering

**Fabricio Kurman Merlin, Vera Lúcia  
Duarte do Valle Pereira and Waldemar  
Pacheco Júnior**

1922–1934 Applying Piaget's Equilibration Theory to Understand Conceptual  
Learning in Engineering Education

Conceptual learning bridges the novice-expert gap, enabling transfer of structured knowledge to develop skills for new situations in engineering for both technical and humanistic domains. Though substantial information about expertise development is already available to support teaching in engineering, it is directed largely ascertaining characteristics or status of novices and experts and lacks emphasis on cognitive mechanisms responsible for bridging or transposing from one behavior status to another. Thus, this article explores the cognitive mechanisms stimulating engineering students' conceptual learning under Piaget's equilibration theory, which addresses the main problem of knowledge construction. In order to discuss Piaget's equilibration theory usefulness for the conceptual learning process, we present a case study where we tracked the progress of 18 Brazilian engineering students enrolled in 'Introduction to Engineering', over two semesters. In this humanistically-oriented course, freshmen are challenged to theoretically connect Science, Art, Technology, and Engineering concepts in order to stimulate critical thinking skills. We gathered data through semi-structured interviews, applying Bardin's content analysis techniques. The discussion of the results provides an interesting view of the utility of Piaget's theory in engineering education in humanistically-oriented courses as an alternative to focusing on transformations in conceptual learning.

**Keywords:** genetic epistemology; equilibration theory; conceptual learning; engineering education; higher education

This study investigates electrical engineering students' engineering epistemological beliefs by using the Chinese version of the Epistemological Beliefs Assessment for Engineering (CEBAE). We recruited 468 electrical engineering students from two research-based universities in Taiwan. Prior to the study, confirmatory factor analysis and reliability testing involving 188 engineering students were performed to evaluate the validity and reliability of the CEBAE. The results revealed that Taiwanese engineering students in research-based universities had only slightly sophisticated engineering epistemological beliefs. Students' educational backgrounds influenced their engineering epistemological beliefs. As the grade level progressed, students' engineering epistemological beliefs became more sophisticated (with the exception of the third year). Female engineering students exhibited significantly more sophisticated engineering epistemological beliefs compared with their male counterparts.

**Keywords:** engineering epistemology; electrical engineering education; engineering philosophy

**Sarah E. Zappe, Kirsten S. Hochstedt, Dan Merson, Lindsey Schrott and Thomas A. Litzinger** 1942–1959 Development and Implementation of Quantitative Methods to Study Instructional Practices in Engineering Programs

Government agencies and professional organizations are calling for changes in engineering, science and math education. In response to these calls for change, engineering education scholars are undertaking a variety of investigations of change within engineering education, including studies of instructional practices and the factors that influence choice of instructional practices. This paper provides a detailed description of the development and implementation of three quantitative methods to characterize instructional practices within engineering undergraduate programs. The three methods are: analysis of course syllabi, a student survey, and a faculty survey. For each method, the development and implementation processes are described including major challenges that were encountered and how they were addressed. Data are presented for one program in order to illustrate the types of results that are derived from each method and the types of conclusions that can be drawn from the combined data set. The overall goal of the paper is to provide sufficient detail to allow other engineering programs to adapt, or adopt, the methods to undertake studies of instructional practices. The coding scheme for the syllabi analysis and copies of the items used in the student and faculty surveys are included in appendices of the paper.

**Keywords:** research-based instructional practices; assessment; teaching practices; educational improvement

**Kerrie A. Douglas, Anastasia Rynearson, Şenay Purzer and Johannes Strobel** 1960–1971 Reliability, Validity, and Fairness: A Content Analysis of Assessment Development Publications in Major Engineering Education Journals

After more than a decade of efforts to enhance the quality of engineering education research, including assessment development, it is timely to explore what types of validity evidence are frequently reported in assessment research articles. According to the *Standards for Educational and Psychological Testing*, the foundation of quality assessment rests on evidence of reliability, validity, and fairness. The purpose of this study was to explore what aspects of reliability, validity, and fairness evidence are provided in assessment instrument development publications in major engineering education journals since 2005. Using quantitative content analysis, the authors reviewed twenty-nine articles published in four major engineering education journals between 2005 and 2015. A coding scheme, based on Messick's Unified Theory of Validity and the *Standards for Educational and Psychological Testing* was developed to code the aspects of reliability, validity, and fairness provided in each article. Frequencies for each code are reported. Engineering education articles on instrument development most frequently reported evidence related to aspects of internal reliability, content-related validity, and substantive aspects of validity. However, studies of generalizability, consequences, and fairness were largely void. In addition, reliability was most frequently studied through internal reliability coefficients, while other forms, such as test-retest were less frequently reported.

**Keywords:** validity; instrument development; assessment; measurement; reliability; fairness

**Camilo Vieira, Roberto Aguas, Molly Hathaway Goldstein, Şenay Purzer and Alejandra J. Magana** 1972–1983 Assessing the Impact of an Engineering Design Workshop on Colombian Engineering Undergraduate Students

Engineers iteratively apply their disciplinary knowledge to develop solutions to ill-defined problems considering varying and often competing criteria and constraints. Design is a process engineers use to solve ill-defined problems necessary to fulfill human needs. While worldwide institutions are increasingly introducing engineering design in undergraduate engineering education, the extent of integration of design into the curriculum occurs at varying degrees. In this study we focus on a higher education institution in Colombia through a single case design. We specifically evaluated the effect of a workshop designed to introduce engineering design to engineering students in a context where there have been limited initiatives and resources to introduce engineering design. Two groups of students from different engineering programs in a public university in the Colombian Caribbean region participated in an eight-hour workshop. The workshop involved a design challenge of creating a net-zero energy house using a CAD tool. The two groups were comprised of 20 systems engineering students and 25 industrial engineering students. Pre- and post- instruments were collected and analyzed to assess the effect of the workshop on students' understanding about engineering, disciplinary knowledge, and effective practices of engineering design. The results suggest that the design workshops employing CAD simulations can support engineering education in three ways by: (1) broadening student knowledge about the engineering practice; (2) fostering the acquisition disciplinary content knowledge; and (3) increasing student proficiency regarding engineering design.

**Keywords:** engineering design; Colombia; CAD; Energy3D

**Shawn S. Jordan, Nielsen Pereira and Odesma Dalrymple** 1984–1998 The Impact of Design Swapping on Student Design Sketch Quality

This study seeks to explore the implementation of design swapping to encourage students to document their designs. Design swapping involves having teams swap design sketches shortly after a design review such that they construct another team's design. Teams are incentivized to document their designs through sketches because other teams build their designs. This study seeks to investigate the effects of the timing of notification of students on the overall quality of design sketches in the setting of an engineering summer camp for middle and high school students and student perceptions of the design swapping activity. Data sources included design sketches, design sketch quality scores, and individual reflective survey question responses. A total of 136 middle and high school students participated in the study, split across 39 teams at 8 different sites. Data were analyzed using descriptive statistics, repeated measures ANOVAs, and thematic analyses. Results showed that students who were notified prior to a design review of an imminent design swap generated higher-quality design sketches than those who were not notified or notified after a design review. Some participants saw design swapping as a positive opportunity for growth and real-world engineering experience, while others found it challenging. Design swapping is a viable pedagogical strategy to encourage students to generate higher-quality design sketches, and provides students with a surrogate client in the absence of a real client.

**Keywords:** pre-college design; design sketches; design quality; swapping sketches; STEM

**Dragan Vasiljević, Biljana Stošić and Branislav Popkonstantinović** 1999–2015 Invention Reasoning Scheme Based on Workshop Design Konstruktion (WDK) Artefact Models and its Application in the Patent Search

Patent system has an important role in engineering design process as it provides a source of ideas through patent information. On the other hand, the patent system poses potential constraints on the engineering design process, because a granted patent in force may prevent the exploitation of a technical solution. The aforementioned issues are the main reasons why the patent search should not only be performed as a search for ideas and a search for potential constraints on the innovation process, but also be taught in engineering design courses. Namely, in order to be able to carry out their future tasks in industry, engineering students need to be capable of handling patent information since it strongly influences any industrial innovation process. The existence of information, however, does not guarantee its proper usage, since patent search requires considerable knowledge and effort by the searcher to access and benefit from the information contained in patent databases. For this reason, we developed an invention representation and reasoning scheme based on engineering design artefact models in order to improve the quality of patent search process, primarily among non-experienced searchers, such as engineering students who typically use patent information as a source of ideas in engineering design and product development projects. The invention reasoning scheme contains categories adopted from the theory of technical systems, primarily the model of transformation process and the model of technical system, as well as categories from other Workshop Design Konstruktion (WDK) theories, and is aimed at supporting reasoning during the patent search process. In order to investigate the applicability of such a scheme in patent search, a case study on a small group mainly consisting of mechanical engineering students was conducted, which demonstrated that this patent search reasoning tool based on the WDK artefact models may be successfully applied in patent searches conducted by non-professional patent searchers.

**Keywords:** patent search; engineering design; artefact models

**Wesley Carpenter** 2016–2024 Engineering Creativity: Toward an Understanding of the Relationship between Perceptions of Creativity in Engineering Design and Creative Performance

Few studies have focused on perceptions of engineering students with respect to the importance of creativity in engineering design. Previous researchers have tended to focus on perceptions concerning the degree to which creative thinking is emphasized in the classroom, rather than on whether students value creativity as an important part of the engineering design process. Moreover, the relationship between students' perceptions of the importance of creative thinking in engineering design and their creative performance has not been investigated. The purpose of this study was to identify engineering students' perceptions of creativity during the engineering design process and compare perceptions of students who scored at the extreme ends on a creativity test called the Creative Engineering Design Assessment (CEDA). Of the 42 students that took the CEDA, eight students scored at the extreme ends and were subsequently interviewed. The perceptions that were investigated reflected the two primary influences on a students' motivation to be creative as posited by the expectancy-value theory, namely engineering students' perceptions of the importance of creativity during engineering design and their perceptions of their own ability to be creative in engineering design. The findings of this study support predictions made by applying the expectancy-value theory, which holds that students who value creativity in engineering design and confidently believe they have the ability to be creative are more likely to be creative in various engineering design scenarios.

**Keywords:** creativity; engineering design; perceptions; expectancy-value theory; mechanical engineering

**Haifeng Liu, Xili Ding, Gang Zhou, Xiaoming Li, Ping Li, Xianghui Gong, Xuenan Gu, Fang Pu, Haijun Niu, Deyu Li and Yubo Fan** 2025–2032 Developing Practical Abilities through a Teaching Reform of Tissue Engineering Course for Undergraduates

This work describes a teaching reform of Tissue Engineering course that designs a laboratory course for senior undergraduate students, where students are challenged with a real-life tissue engineering application and provided with a hands-on experience applying oriented biomaterial technology and cytotechnology by conducting an experiment. Forty senior undergraduate students coming from School of Biological Science and Medical Engineering in Beihang University attended the course. The laboratory course was designed to guide students in raising research questions, generating strong hypotheses, identifying appropriate methodologies, and collaborating with each other to solve problems. Feedback from students attended this course has indicated that, while students find the expectations challenging in the early stages of the course, finally they are able to increase awareness and deepened their understanding of this field. We hope that this kind of educational modality could spread out to other interdisciplinary fields and contribute to the fast development of modern interdisciplinary science and technology.

**Keywords:** interdisciplinary field; Tissue engineering; laboratory course; practical abilities; undergraduate students

**Andrés Iborra, Bárbara Álvarez, Pedro Sánchez, Juan A. Pastor and Tanya Suárez** 2033–2047 ICT Entrepreneurial Ecosystem for Engineering Education

Entrepreneurship is a powerful route to integrating skilled people into the working market. However, its teaching is particularly weak in engineering degree programmes. The objective of this innovative action has been to develop an entrepreneurial ecosystem to improve ICT entrepreneurial skills at engineering universities of countries with weaker entrepreneurial tradition in new technologies. An acceleration programme has been designed for engineering students with the objective of creating start-ups, going beyond the concept and becoming a start-up in early stage. Innovative methods have been applied to create and accelerate start-ups within an entrepreneurial ecosystem adapted to the university context. Four years of experience (2012–15) have allowed us to collect indicators and improving the proposed methods to scale up the model to the wider EU. Two hundred sixty-one students have participated in this experience and fifty-six start-ups have been created. Of those, thirty-eight have successfully finalized the programme.

**Keywords:** interdisciplinary projects; cooperative learning; engineering education; IoT

**Shannon K. Gilmartin, Angela Shartrand, Helen L. Chen, Carolyn Estrada and Sheri Sheppard** 2048–2065 Investigating Entrepreneurship Program Models in Undergraduate Engineering Education

Major private and government organizations in the U.S. are promoting entrepreneurship education for undergraduate students, including engineers. Different configurations of entrepreneurship learning opportunities have emerged, not all within or in partnership with schools of business. There is some uncertainty about how entrepreneurship programs targeted to engineers are structured, with what purpose and pedagogical approaches. This study is designed to address uncertainty about entrepreneurship learning opportunities for undergraduate engineers and examine facets of formal engineering entrepreneurship programs. Our study considers the histories, missions, and pedagogies of these programs. We conducted in-depth interviews with program directors at 12 entrepreneurship programs across the U.S., and then coded the interview transcripts in a two-stage, collaborative process. Our findings show that entrepreneurship programs for engineers often are designed to provide business education in light of otherwise limited opportunities for formal, classroom-based business and entrepreneurship learning. Student demand is key to program growth; available faculty resources can pose a challenge. Programs vary in terms of goals around venture creation, types of interactions with students from other disciplines, and even how "entrepreneurship" itself is defined. Pedagogical features include experiential learning and hands-on activities, and self-directed learning environments that promote tolerance for ambiguity and failure. Implications for assessment of student outcomes, new program development, educational research, and engineering education as a whole are discussed.

**Keywords:** engineering entrepreneurship programs; entrepreneurship education; program design; entrepreneurship learning outcomes

The internationalisation of the curricula is considered one of the principal factors for the improvement of teaching in engineering. Nonetheless, lack of a contextualized conceptual and methodological framework hinders the incorporation of an international dimension into the university education for future engineers. This article presents the steps of an investigation that seeks to address this problem. The principal objective of this study is the elaboration of a methodological guide for the internationalisation of the engineering curricula at the Instituto Tecnológico de Costa Rica [Costa Rica Institute of Technology—IICR]. As a result of this study, a guide and scale for the implementation and assessment of curriculum internationalisation are developed. Additionally, the results of a diagnostic pilot study on the internationalisation of the undergraduate programs in agricultural and biotechnology engineering at IICR are obtained. This article can be useful for faculty, school directors, program coordinators, advisors and members of curriculum committees, among others involved in the teaching, development and management of the curriculum and graduate program quality.

**Keywords:** internationalisation of the curriculum; undergraduate engineering programs; curriculum development; plan of study; IICR

**Haosheng Shen, Jundong Zhang and Hui Cao** 2083–2097 Marine Engineering Virtual Training and Evaluation System: A Learning Tool for Marine Engineers

To improve the application value and range of the traditional marine engine room simulator, a marine engineering virtual training and evaluation system is developed in this paper. Through comparing with the similar applications in the market, advantages of the one developed in this paper are showed. In addition, automatic evaluation function based on fuzzy evaluation method is developed and integrated in the training system, which is able to realize the fixed evaluation items regulated in the seafarers examination outline and the user-defined situation evaluation items by using XML to establish the evaluation question base. To improve the automatic evaluation accuracy, “Least Square Method” is used to fit the fuzzy membership function. At last, to verify the practicability and application value of the learning tool developed in this paper, 60 juniors majored in marine engineering, 10 experienced chief engineers are selected to carry out an experiment. By analyzing the experiment result, it is found that the virtual training system is accepted as a learning tool by the participants and the evaluation score generated by the automatic evaluation module is reasonable and real.

**Keywords:** engineering education; marine engineers; visual simulation; virtual training; automatic evaluation

**Nenad Jovanovic, Zoran Jovanovic and Aleksandar Jevremovic** 2098–2106 Evaluation of Simulators for Teaching Computer Networks

This paper provides a short description of thirteen computer network simulators that are mainly used for educational purposes. Criteria for the evaluation and comparison of the simulators were presented. The criteria are applied in order to compare the simulators being described. This comparative analysis is useful when selecting a suitable simulator for teaching a specific computer networks course.

**Keywords:** network architecture and design, simulation and modeling, computers and education

**David M. Bourrie, L. Allison Jones-Farmer and Chetan S. Sankar** 2107–2120 Learning Technologies: Bridging the Gap between Intention, Adoption and Routine Use

Substantial funds are invested in developing educational technologies with the goal that faculty members adopt and routinely use these technologies. This research establishes that there is a gap between the development and widespread adoption/use of these technologies. This paper investigates (1) which critical success factors (CSF) influence faculty members to adopt and routinely use technologies, and (2) whether the CSFs moderate the adoption process. Based on surveys of 335 computer science and electrical engineering faculty members, the research findings pinpoint the factors that influence the adoption and routine use of educational technologies. These results can be used by developers of educational technologies to create and establish plans to increase faculty awareness of and create positive attitudes towards the technologies.

**Keywords:** adoption; critical success factors; faculty members; learning technologies; readiness

**Viljan Mahnič and Tomaž Hovelja** 2121–2133 The Influence of Diffusion of Innovation Theory Factors on Undergraduate Students’ Adoption of Scrum

Since Scrum is the most widespread agile software development method, teaching it is an important issue to prepare students for their professional careers. Scrum is often taught within the scope of a software engineering capstone course, which makes it possible for students to learn Scrum practices through practical project work. In this study, we use the Diffusion of Innovation theory (DOI) to analyze to what stage such a course enables students to assimilate the core Scrum practices and the factors that have the most impact on Scrum adoption. The study is based on the results of a survey that was conducted after each Sprint of the capstone course at the University of Ljubljana, Slovenia; the course has four Sprints and was attended by 88 undergraduates. It is shown that at the end of the course, all core Scrum practices reach either the acceptance or the routinization stage, and 11 most influential DOI factors are identified.

**Keywords:** Scrum; capstone course; diffusion of innovation; software engineering education; agile software development

**John R Haughey and D. Raj Raman** 2134–2150 Influences of Mechatronics on Student Engagement in Fundamental Engineering Courses: A Systematic Review

In our review we examined the primary and secondary influences of mechatronic experiences on student engagement in fundamental engineering courses. Using a systematic review methodology, we collected 402 articles with publication dates ranging from 1990–2014. Screening on title and abstract information reduced our included sources to 137, from which we mapped six parent and 22 child codes. Appraising 17 of these articles we identified eight high quality studies as the focus of our synthesis, which identified five primary influences (Student Motivation, Self-Efficacy, Course Rigor, Learning Retention, and Gender) and two secondary influences (Accreditation and Ease-of-Implementation). In these influences we found evidence that mechatronic experiences can increase student motivation, self-efficacy, and course rigor. Also, positive effects on learning retention, gender diversity, accreditation efforts, and ease of course content implementation were identified. Future research is needed to clarify: (1) if mechatronic experiences truly increase student motivation and self-efficacy more than lecture-based strategies, (2) how the positive short-term impacts of these experiences translate to subjective academic success (i.e., future course and career goals), (3) how implementation logistics are influenced by experience type (i.e., open-ended projects verse contests), class size, institution and industry support, etc., and (4) to what degree the factors of gender, underrepresented student groups, course curricular placement, and activity type influence student engagement.

**Keywords:** student engagement; mechatronics; problem-based learning; project-based learning