

# The International Journal of Engineering Education

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Present study is focused on assessing the success, implementation time and cost of the most common teaching-learning activities carried out in collaboration between academia and industry, as well as of those aimed at a greater connection between studies and “real” industrial world, considering both the opinions of teachers and students. Final aim is to analyze such opinions, together with the “success vs. implementation cost” and “success vs. implementation time” ratios for the different activities, so as to improve our understanding on the most efficient ones and reinforce our subjects trying to prioritize these collaborative actuations.

Main results show the beneficial effects of project-based learning activities and of students’ taking part in real projects for developing their final degree theses. In addition several actuations easy to implement, such as visits to enterprises or invited talks, in fact provide more remarkable teaching-learning outcomes, than other expensive and more complicated activities, including longer educational trips.

**Keywords:** university extension; academia and industry; teaching-learning process; learning strategies; real-life learning

<b>Hyungseok Yoon and Joosung J. Lee</b>	1068–1079	Entrepreneurship Education and Research Commercialization of Engineering-Oriented Universities: An Assessment and Monitoring of Recent Development in Korea
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This research aims to assess and compare the entrepreneurial competitiveness of KAIST (Korea Advanced Institute of Science and Technology) and MIT (Massachusetts Institute of Technology) from entrepreneurship education and research commercialization standpoints. The assessment results have provided KAIST with strategic directions for implementation of new measures to enhance its entrepreneurial competitiveness. The new measures which brought a positive impact on the entrepreneurial performance of KAIST have been used to develop catch-up strategies for engineering-oriented universities in late-comer countries. The key findings of this research provide policy makers in late-comer countries with strategies for the successful university entrepreneurship.

**Keywords:** entrepreneurship education; research commercialization; catch-up strategy

<b>Martine Buser</b>	1080–1087	Engineering Students as Innovation Facilitators for Enterprises
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This paper addresses the role that Engineering Master Students may play in contributing to the development of innovation for enterprises. Based on a formalized tripartite cooperation between a student, an enterprise and a Danish university, the programme combines traditional academic curricula with a mentor company. Drawing on the concepts of Mode 2 knowledge production and knowledge governance the circumstances under which these innovations can take place are described and analysed. The empirical material is taken from a longitudinal study (2009-2011) of the master programme; the study combines qualitative and quantitative approaches. Both students and enterprises assess the master programme very positively and more than half of the companies confirmed that the students have contributed to innovation processes. The analysis shows how formal and informal governance mechanisms need to complement each other in order to enable a successful progression for all the parties involved. However the study also underlines that the master programme faces challenges which are usually not part of engineering curricula, for example, improving students’ social and communication competences and autonomy.

**Keywords:** engineering education; innovation; knowledge governance; mentorship; Mode 2

<b>Anne Hess, Dieter Rombach, Ralf Carbon, Daniel F. Murphy, Michael Hoeh and Christian Bartolein</b>	1088–1099	The Role of Collaborative Capstone Projects—Experiences from Education, Research and Industry
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An integral part of software engineering curricula at universities are practical classes or projects that enable students to apply theoretical knowledge gained in lectures on concrete practical examples. Practical projects, in particular, defined as university-industry collaborations provide the potential of being very beneficial especially in graduate education: in such realistic project settings, students can experience real-life software engineering challenges and achieve learning objectives that go beyond typical

learning objectives of practical assignments during classes or even practical projects defined by faculty members. However, such collaborative projects have to be planned carefully and also come with various challenges. In this article, authors from academia and industry share their experiences gained during a history of successfully conducted collaborative projects. These experiences comprise objectives, benefits, challenges and lessons learned both from an educational viewpoint (i.e., students, supervisors), research viewpoint (supervisors), and industry viewpoint (customer). The experiences summarized in this article could serve as motivation and valuable information for other universities and industry companies intending to plan and organize collaborative projects of this kind.

**Keywords:** collaborative project; software engineering education; capstone project; industry-university collaboration; experiences; lessons learned; challenges

**Rasha Stino** 1100–1108 People I Wish I Had Met Before Graduating™ Speaker Series for Construction Contracting Course

Presented in this paper is a description of the guest speaker series model established in a long-standing civil engineering course at the University of Michigan in Ann Arbor. In the Winter 2010 semester, the author launched an industry based guest speaker series called People I Wish I had Met Before Graduating™ to further enrich the educational experience of students in CEE 431, Construction Contracting. Success of the series based on student testimonials and surveys led to its recognition by the Civil and Environmental Engineering Department as a valuable resource and its utilization by fellow faculty in CEE 431 and other departmental initiatives. Among the contributions of the speaker series are the creation of a faculty resource containing a description of the series and its correlation with the curriculum and course objectives, a library of speaker topics relevant to professionals and academicians in the industry, a roster of speakers and established key talking points, a template for a student resource packet, and a survey. Typically, speaker series are offered in seminar-type courses. The model presented in this paper differs in that the speaker series had to be selectively assembled and incorporated into a traditional course with a specific, pre-defined curriculum such that it became an integral and meaningful part of the overall educational experience. This was the first time a guest speaker series had been established for CEE 431 at the University of Michigan, representing a significant change to the standards of practice. There is no documentation available to verify how widespread this practice is for comparable courses at other institutions, suggesting that it is uncommon. The following sections discuss the rationale behind the speaker series; provide a course description, including, curriculum and objectives; describe the speaker series model, including topics, structure and, the series application by others; present students' assessment of the series through testimonials and surveys; and offer conclusions.

**Keywords:** industry guest speakers; engineering education; construction engineering and management; construction contracting

**S. Chandrasekaran, A. Stojcevski, G. Littlefair and M. Joordens** 1109–1118 Project-Oriented Design-Based Learning: Aligning Students' Views With Industry Needs

This paper focuses on the alignment of students' views on project-oriented design-based learning (PODBL) with today's industrial needs. A Collaborative relationship between academic institutions and industrial expectations is a significant process towards analytical thinking (linking the theory and practice). Improving students' knowledge as well as the students' transition into industry, requires efficient joint ventures by both learning institutions and industry partners. Project-based learning (PBL) is well developed and implemented in most engineering schools and departments around the world. What requires closer attention is the focus on design within this project-based learning framework. Today design projects have been used to motivate and teach science in elementary, middle, and high school classrooms. They are also used to assist students with possible science and engineering careers. For these reasons, design-based learning (DBL) is intended to be an effective approach to learning that is centered on a design problem-solving structure adopted for a problem-oriented project-based education. Based on an industry design forum, which the authors conducted in Melbourne, Australia in 2012, a research study was performed to investigate the industry and academic requirements for students focusing on achieving design skills. To transform the present situation in the academic teaching and learning environment and to fulfill industry needs, this research study also investigated the students' views on design skills.

**Keywords:** design-based learning; project-based learning; problem-oriented and project-based learning; industry needs

**Jesús Manuel García, Enrique Soriano, Imanol García and Higinio Rubio** 1119–1125 Implementation of Service-Learning Projects in Engineering Colleges

In recent years, engineering colleges have started to integrate service-learning projects into many of their required courses. In the literature, there are many important definitions for service-learning pedagogy, including reciprocity, reflection, coaching and community projects. This paper presents a service-learning pedagogy implementation program for educating engineering undergraduates to solve real-world problems. Three project models for mechanical engineering, ranging from a single semester to a full calendar year, form the basis for the analyses presented. Finding appropriate community partners and projects are critical for a successful experience for all involved parties. From the results of this analysis, it is possible to conclude that, through these projects; students acquired and applied the competencies in the defined curriculum.

**Keywords:** service-learning; assistive technology; community engagement; design

**Narcis Ursache and Cristinel Mares** 1126–1135 On Student Skill Development through Integration of Industrial Expertise in Module Delivery

This case study sought to develop an engineering module which would bring in experts from industry to educate future engineering specialists in aircraft product development in order to address the industry standards and codes of practice. The industry staff lectured on key aspects of aircraft design integration and collaborated with the academic involved in teaching this module. The proposed development was mapped against the current accredited MSc/MEng curriculum. The industry partners participated in the aircraft design project development and its technical quality assessment during the academic year. The student learning experience and employability was enhanced through the application of the theory in a practical module assessed according to industry requirements.

**Keywords:** higher education; employability; assessment; aerospace engineering; aircraft design

**Teboho Pitso** 1136–1143 The Creativity Model for Fostering Greater Synergy between Engineering Classroom and Industrial Activities for Advancement of Students' Creativity and Innovation

This article describes the TRIZ-based Creativity model whose prototype was iteratively tested for efficacy in closing the transactional space between undergraduate classroom activities and industrial processes with the purpose of advancing undergraduates' creativity and innovation. The testing of this creativity model included presentations in two conferences of the International Multi-Conference on Engineering and Technological Innovation (IMETI) organised under the auspices of the International Institute of Informatics and Systematics (IIIS) and received excellent reviews (an average of 85%). The effectiveness of this creativity model in developing students' creative abilities was also tested on twenty-four, final-year Process Instrumentation undergraduates after two iterative pilot studies. The pre- and post-test results derived from evaluating students' creative abilities through the standardised Torrance's Tests of Creative Thinking (TTCT) show significance as measured through the t-test. Given the establishment of statistical significance in this study, it can reasonably be inferred that the TRIZ-based Creativity model with its leveraging of the university-industry nexus had a positive effect on increasing undergraduates' creative abilities and sets conducive conditions for students' innovativeness. The design and testing of this creativity model needs to be understood within the

framework of the emerging synergistic connection among universities, industry and government which seeks to drive greater innovation and technological advancements for which the university-industry nexus was accentuated in this study.

**Keywords:** TRIZ; creativity, innovation, TTCT; Engineering Education

**Alan J. Levy and Weilin Li** 1144–1154 Adaption of the Clinical Correlation Instructional Model for 2nd Year Engineering Science Courses

A study is described in which the clinical correlation/integration instructional model, currently employed by Medical Schools, is adapted for the 2nd year engineering science course Mechanics of Solids. The model consists of integrating into basic applied science courses (typically taught by researchers) a number of clinical correlation lectures (taught by guest clinicians/practitioners) which illuminate the scientific principles. The idea is that this will: (i) increase student interest (which is largely in the “clinical” application and not in the theory), (ii) increase student motivation, (iii) enable students to differentiate between professional career paths, (iv) provide relevance by showing how course material can be used in practice, (v) increase student self-efficacy by providing a diversity of role models who are practitioners and not researchers. Five clinical correlation lectures were taught by dynamic, experienced, practicing engineering “clinicians” who formed a diverse mix across gender, age, and race/ethnicity. These individuals, all employed in industry, were selected from the ranks of Department Advisory Board members and alumni. The program also contained a modest mentorship component although this is not discussed here. An evaluation program, which provides gender specific results, assessed aspects of student attitudes towards the program and their perceptions of engineering. The results overwhelmingly demonstrated (i) intense interest in the program and (ii) increased motivation in the desire to become engineers. An increased understanding of career paths (differentiation) was also clearly demonstrated. Student understanding of their profession (relevance) increased and student comments on role model clearly indicated the positive effects of the program. Overall course performance improved as well, as indicated by a near halving of the drop and failing rates. The 1 year study clearly demonstrates the enormous potential of the model to positively impact engineering students in the critical 2nd year.

**Keywords:** university-industry collaboration; engineering science curriculum enrichment; industrial case studies; guest lecturers

**Victoria Townsend and Jill Urbanic** 1155–1165 Industrial Field Trips: An Integrated Pedagogical Framework of Theory and Practice

The purpose of this paper is to propose a learning-centered, scholarly, and pragmatic pedagogical framework for facilitating field trips for engineering students in cooperation with industry. Salient features of the field trip pedagogical literature from K-12 and science education are aligned as research goals. They emphasize that field trips need to involve curriculum links, follow-up, clear purpose, and active learning. They also affirm that field trips have the ability to yield social and affective learning, holistic learning in a dynamic system, long-term memory, and learning anchors. These goals are mobilized here by implementing Dewey’s experiential continuum with Deming’s plan-do-check-act cycle and constructive alignment. This teaching-learning methodology is tested with a case study: a Manufacturing Processes Design class of 17 undergraduate, industrial engineering students in an accredited engineering program. The research results, which span a semester, are aligned to evidence the literature goals along with additional academia-industry collaboration benefits from a student learning perspective. These added benefits include student engagement, deep learning (including affective learning), joy in learning, and community synergy. Thus, learning value for students is yielded from the proposed, rigorous framework for industrial field trips in engineering education; the framework accomplishes scholarly alignment with pedagogical literature in parallel with empirical results that ensure successful application in a pragmatic manner.

**Keywords:** industrial field trips; experiential learning; community learning space; plan-do-check-act cycle; constructive alignment

**Thomas J. Siller and John Durkin** 1166–1171 University-Industry Partnership to Develop Engineering Students’ Professional Skills

Colorado State University has formed a unique partnership with its engineering industry colleagues to develop and deliver a program on engineering professional skills for undergraduate students. The Professional Learning Institute (PLI) has been a required component of our degree programs since 2009. It has been designed to address the professional skills components of our accreditation criteria, as specified by the ABET. The program includes regularly scheduled workshops presented by practicing engineers in five tracks: leadership, ethics, cultural adaptation, civic and public engagement, and innovation. Our graduates are now gaining a deeper awareness of these important skills through interaction with practicing engineers. This has resulted in them being more attractive employees to our engineering employers.

**Keywords:** professional skills; leadership; ethics; innovation; cultural adaptation; civic and public engagement; innovation

**Mateus Cecilio Gerolamo and Lillian do Nascimento Gambi** 1172–1183 How Can Engineering Students Learn Leadership Skills? The Leadership Development Program in Engineering (PROLIDER) at EESC-USP, Brazil

This article aims to describe the Leadership Development Program in Engineering (PROLIDER)—a partnership between the Sao Carlos School of Engineering (EESC), University of Sao Paulo (USP) and Brazilian Companies. The PROLIDER has gained importance with its partners because it assists engineering students to develop leadership and management skills still during their undergraduate course. Since 1999, approximately 150 engineering students from two public universities located in Sao Carlos, Brazil (250km far from Sao Paulo City) have taken part in this Program. The undergraduate students are usually involved in the program during the last year of their course and are employed as trainees by the partner companies, which provide financial support for the program. At the end of each year of the program and after finishing their engineering degree, the students are ready to be employed by these companies as engineers (junior analysts, consultants, etc.). The retention rate is extremely high during the transition of the students from the program to the companies that participate in each yearly program. After some years, it is normal that some engineers change their jobs, but the retention rate still remains satisfactory. The industry partners of the program have also observed a faster development of these newcomer engineers in order to assume management and leadership roles. In general, the program benefits engineering students in terms of intensive development in leadership and managerial skills. The program also has a positive impact on students because it encourages discussion to improve the curricula of the engineering courses of the Sao Carlos School of Engineering at the University of Sao Paulo including more leadership skills content. Companies are also benefited by the program as there are more prepared newcomer engineers for their strategic job positions. Researchers can also obtain results from this program by doing multidisciplinary research in areas such as engineering education in leadership, leadership development for engineers, and so on. Therefore, universities and engineering courses should encourage professors and researchers to pay more attention to this kind of initiative that demands time and effort.

**Keywords:** engineering education; leadership; leadership development program in engineering

**Ana Moreno, Julio Lumbreras, Carlos Mataix and Ignacio J. Pérez-Arriaga** 1184–1191 Engineering Education for Sustainability: A Multistakeholder Case Study on ICT and Transportation

Under the auspices of the Spanish Royal Academy of Engineering, a large group of academics, civil servants and industry professionals have thoroughly examined the sustainability of the current transportation model and the implications that Information and Communication Technologies (ICT) could have on increasing transportation sustainability. Based on this work, the authors have developed a model to integrate this subject in engineering education.

The research found out the need for additional layers of complexity in the education of engineers. Specifically, engineers need to

acquire the corresponding technical competences, the ability to apply them in transportation systems, the transversal integrated competences, and how all this relates to sustainability values.

Truthful to their role in society, engineering schools should be centres of debate for the elaboration of technical solutions to current sustainability problems. In this paper the interplay between ICT, transportation and sustainability, has been analysed showing the role that engineering schools should play as scouts of the future and facilitators of social debate.

**Keywords:** information and communication technologies (ICT); transport sustainability; transversal competences

**Sungjong Park and Guesoo Cha** 1192–1198 A Study on the Assessment of Key Competencies for Automotive Engineering Technology Education in Korea

In order to find out the gaps in key competencies, those of employees in industry and students in college should be analyzed. Key competencies of students and technicians in automotive fields are scaled and compared to each other. Furthermore, the differences between two groups are analyzed to check on the gaps. Initial test sheets are reconstructed as an improved one after the prior assessment reflecting the opinion of industry to execute reliable level assessment. The area and level of key competencies are set up by literature analysis and consultation. The average scale of key competencies is assessed by students and technicians respectively. Numeracy, understanding organization, technology skill, problem-solving, inter-personal relation, communication skill, self-management and development, resource management and information application are selected as key competencies in Korea. Three levels of key competencies are set up. Key competencies of automotive college and industry are compared. Regardless of areas, the gaps between the two are significant shows a kind of discrepancy between industry and college requiring a scheme to fill the gaps.

**Keywords:** key competencies; gap; automotive fields; assessment; engineering technology education

**John W. Davies** 1199–1204 Using Students with Current Industry Experience to Evaluate Course Delivery

This paper considers the opportunity for academic-industry collaboration that arises when a proportion of engineering students in a cohort are part-time students with current industry experience. It describes a study that took the opportunity of probing the response of these students to aspects of course design, using their perspective to answer the questions: ‘How successful are we in our attempts to create realistic project work for students, and what improvements should be made?’ The consensus from semi-structured group interviews with 52 students is that the project work they have experienced is generally realistic from a technical point of view, enhanced by basing projects on a real site, using real data, and working with a realistic brief. Some students considered the briefs to be too open-ended to be realistic, but others relished the opportunity this presented. Team-working aspects of university group projects were not considered realistic by the students; they pointed out that the environment in engineering practice is very different because it is moderated by the management structure and professional expectations of staff. The role of a client figure was identified as important in creating realism. The paper considers the potential conflict between some aspects of realism in project work and educational benefit.

**Keywords:** part-time students; course evaluation; realistic project work; team-work

**Monica F. Cox, Tasha Zephirin, Nikitha Sambamurthy, Benjamin Ahn, Jeremi London, Osman Cekic, Ana Torres and Jiabin Zhu** 1205–1221 Curriculum Vitae Analyses of Engineering Ph.D.s Working in Academia and Industry

In recent years there have been discussions surrounding the under-preparedness of Ph.D. graduates of highly specialized doctoral programs, lacking interdisciplinary focus and professional skill development, to succeed in future complex work environments. To address these concerns, Golde and Walker suggest re-conceptualizing doctoral education such that Ph.D. holders are developed as “stewards” of their disciplines. To provide initial insights into how engineering can be viewed through a stewardship lens, the authors conducted a content analysis of thirty-six curricula vitae of engineering Ph.D. holders who have been employed in one of four occupational sectors- (1) academia only, (2) industry only, (3) academia and then industry, or (4) industry and then academia. This effort seeks to operationalize their experiences into the three tenants of the stewardship framework—generation, conservation and transformation—and provide a new perspective for future discussions around the preparation and expectations of engineering Ph.D. holders. Industry participants reported higher generation and conservation than academia only participants; academia to industry participants reported higher instances of generation followed by conservation; industry to academia participants, on average, reported higher generation; and a new category, “other,” was the lowest instance across all groups.

**Keywords:** curricula vitae; stewardship; doctoral education; engineering professionals

## Section II

### Contributions in: Blended Learning, Cooperative Learning, Innovation, Academic writing, Safety, Wind Energy

**Hamidreza Kashefi, Zaleha Ismail, Yudariah Mohammad Yusof and Fariba Mirzaei** 1222–1237 Generic Skills in Engineering Mathematics through Blended Learning: A Mathematical Thinking Approach

Generic skills are such an important requirement for successful engineers that their development in undergraduate courses is deemed essential. This paper summarizes the design of a blended learning environment based on mathematical thinking and creative problem solving aimed at improving generic mathematics skills in a group of undergraduate engineering students. The main goal of this study is to identify the effectiveness of the designed blended learning mathematics course on engineering students’ generic skills. Results indicated that the blended learning engineering mathematics course has a positive effect on students’ communication, problem solving and technological skills. However, the scores for both pre- and post-test for students’ teamwork skills remained virtually the same. Some students’ responses to the mathematics problems and journal writing describing their struggle, progress and growth encountered in the research implementation are also presented.

**Keywords:** blended learning; communication; creative problem solving; engineering mathematics; generic skills; mathematical thinking; teamwork; technology

**Nadjib Brahimi, Fikri Dweiri, Imad Alsyouf and Sharfuddin A. Khan** 1238–1247 Implementing Co-operative Education in an Industrial Engineering Program in the United Arab Emirates: Experience and Lessons Learned

This research presents the co-operative (co-op) education experience in an Industrial Engineering and Management program in the University of Sharjah, United Arab Emirates (UAE) and its role in achieving the students’ learning outcomes. Previous researchers found that students who choose a co-operative education achieve higher Grade Point Average (GPA) and emphasized the role of a student’s professional experience in meeting the non-technical engineering skills criteria of the Accreditation Board for Engineering and Technology (ABET). In this research, an effort is made to show the degree of achievement of both technical and non-technical skills expected from the program’s graduates. The graduates’ data are analyzed using descriptive statistics. We show the differences

between the genders' choice of co-op or Senior Design Project (SDP) option as well as their Cumulative Grade Point Average (CGPA) and the achievement of ABET criteria. The results show that more than 50% of the students choose the co-op over the SDP option and this number has been increasing over the last few years. Knowing that UAE society is composed mostly of expatriates of many different nationalities, we have analyzed the choice of students based on their nationalities and found that the co-op is the favorite choice for Emirati students with an overwhelming female majority (92%), while Expatriate students favored the SDP option. Our results confirm other findings in the literature in terms of CGPA and achievement of learning outcomes. For example, the CGPA was higher for students who choose the co-op (2.95 out of 4) than for the SDP students (2.70 out of 4). The students' achievement of the ABET criteria was almost 9% higher for co-op students compared with that for SDP students. Based on these results, we are recommending the implementation of co-operative education in other engineering programs in the University of Sharjah.

**Keywords:** co-operative education; industrial engineering; student learning outcomes

**Hsiou-Huai Wang, Shih-Chung Kang** 1248–1259 Cultivating Imagination in Entry-Level Civil Engineering Students:  
and **Tsung-Kai Lee** Exploring the Effects of an Innovative Instructional Model

Imagination, the limitless ability to form mental images and concepts through thinking, is inherent in human cognition as the basis for the creative activities and inventions that have driven human technological and engineering innovations. Imagination should be cultivated in the process of preparing future engineers. This study develops an imagination instructional model for entry-level engineering college students. Three features of imagination: possibility, connectivity and boundary-crossing, are established as the theoretical basis for an instructional model called IDEAL. This model was implemented in an introductory engineering course and its effect was evaluated. The results showed that: (i) The IDEAL model significantly increased students' overall imagination, and more especially, (ii) it significantly enhanced students' boundary-crossing capacity. This study makes contributions to current engineering education by first exploring the inherent features of imagination, constructing a workable instructional model for the cultivation of imagination, implementing the model to an introductory engineering course and showing its effect.

**Keywords:** engineering education; imagination; possibility; connectivity; boundary-crossing

**Marcia Laugerman, Mack Shelley,** 1260–1269 The Engineering Admissions Partnership Program: A Navigation Strategy  
**Steve K. Mickelson and Diane T. Rover** for Community College Students Seeking a Pathway into Engineering

This paper presents the evaluation of a program designed to improve transfer outcomes for community college students pursuing an engineering degree. The program, the Engineering Admissions Partnership Program (E-APP), was designed to improve the navigational success of community college transfer students through connections to the university. These connections include coordinated academic advising, peer-mentoring, campus visits, and online social and professional networks. The objective of the study is to determine the efficacy of the E-APP and its interventions, which will be measured by increased participation rates and increased university retention rates for E-APP participants. Outcome data for the students are analyzed statistically for significant differences between the quasi-experimental groups (E-APP or not E-APP), matched based on Math ACT scores. The results show significant improvement in first-year retention rates for E-APP participants. The results of this study are both transferrable and scalable. This research may help increase the success of community college transfers to engineering through developing and implementing similar navigational programs across the country.

**Keywords:** community college; retention; STEM; enrollment partnership programs

**Sarah L. Gassman, Michelle A. Maher** 1270–1280 Supporting Students' Disciplinary Writing in Engineering Education  
and **Briana E. Timmerman**

As demands for research productivity increase, engineering faculty, particularly untenured junior faculty, must efficiently expedite the development of their graduate students' disciplinary writing skills. This paper reports on the outcomes of a semester-long graduate course offered to facilitate engineering students' production of a manuscript ready, or near ready, for submission to a peer-reviewed engineering journal at the end of the semester. Course content addressed the purpose of and information included in each of four sections of a standard engineering research paper. Data generated from course participants and their faculty advisers were used to assess the extent to which course participation resulted in publication submission, textual production in each of four standard article sections, and perceived changes in student writing that was attributable to course participation. Findings suggest implications for policies and practices supporting the development of engineering students as disciplinary writers.

**Keywords:** academic writing; civil engineering; disciplinary writing instruction; graduate students

**David C. Shallcross** 1281–1293 Using Concept Maps to Assess Learning of Safety Case Studies: The  
Eschede Train Disaster

The Eschede train disaster remains one of the worst railway accidents in Europe in recent years. The loss of 101 lives was caused by a range of factors but was most caused by poor engineering design decisions. The derailment of the high speed ICE train at the town of Eschede in Germany and the subsequent collapse of a bridge on to the train provides an excellent context in which to introduce first year engineering students to the importance of safety in an introductory course. The poor design decisions that led to the derailment and the subsequent collapse of the bridge have been used as a case study in a general first year engineering subject at the University of Melbourne for several years. This paper begins by describing the sequence of events that started with the fracture of a steel tyre on one of the bogies on a passenger coach and that culminated in the collapse of a concrete overpass collapsing onto the train. The key lessons that may be learned from the disaster are then described. The learning around this safety case study is assessed in the classroom using concept maps. An analysis of 84 concept maps prepared by the class 15 weeks after the material had been presented to them provides an insight into how well the students integrated and retained the material from the case study. A method is proposed to analyse the concept maps to assess student and cohort learning of the case study.

**Keywords:** safety; case studies; concept mapping; Eschede train disaster; assessment

**Everett Sheble, Steffen Bickle and** 1294–1308 Wind Energy Lab Module for Mechanical Engineering Undergraduate  
**Carlos H. Hidrovo** Curricula

This paper describes the development and implementation of a project-oriented undergraduate-level fluid mechanics laboratory experiment centered on evaluating the performance of a scale-model wind turbine. It seeks to provide a road map for educators who wish to use the material within their engineering curricula, and to demonstrate that material's effectiveness. Technical concepts explored include power and energy, wind turbine theory and practice, dimensional analysis, scientific uncertainty and engineering measurement. Instructions for assembling the laboratory set-up are included, along with examples of results obtained by undergraduate students performing the experiment at the Mechanical Engineering Department of The University of Texas at Austin in the Spring 2013 semester. Students' proficiency was measured via pre- and post-project examination. Students were also invited to complete a survey to provide feedback on their experience of completing the lab. Results of the examinations and surveys were mostly positive, with excellent improvement in a broad range of tested competencies and high levels of student satisfaction. Methods for addressing the areas that need improvement are discussed, in particular the content on dimensional analysis and scientific uncertainty.

**Keywords:** wind energy; fluid mechanics; efficiency; power coefficient; wind turbine