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Section I

Special Issue

Selected Papers from the 2012 Capstone Design Conference

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Opportunities for industry involvement in capstone design courses go beyond industry sponsorship of capstone design projects. Representatives from industry can serve as guest lecturers, curriculum advisors, and design project sponsors and team mentors. Since 2000, industry participation has been a core part of the capstone design course at Marquette University. Practicing engineers provide a relevant, practical real-world perspective of their topic, reinforcing its importance to professional engineering practice. Students and faculty benefit from the up-to-date treatment of the topic provided by guest speakers from industry who have expertise in the topic and are willing to share their experiences with students. Students benefit from industry sponsorship of senior design projects through the opportunity to work on real-world problems of importance to industry, exposure to industry and company-specific project management and product development processes, and familiarity with economic, legal, and regulatory design constraints. This paper provides a brief description of the Multidisciplinary Capstone Design course at Marquette University, examples of industry involvement in the course, and the observed benefits of industry involvement to students, the university, and industry participants. It presents examples of current practices used at other schools as well as helpful recommendations for managing industry participation in capstone design courses.

Keywords: capstone design; industry involvement; career preparation; design education

The desired overall outcome for any university Capstone design project is for the students to have completed a successful project and to have had a relevant learning experience. Within this expectation, however, a Capstone design project completed in conjunction with an industry sponsor will inevitably generate certain additional expectations from both the industry sponsor and academia. At Brigham Young University there have been a number of teaching and coaching aids used to prepare both the students and the project sponsors so that the eventual outcome is satisfactory to all. These learning tools create opportunities for success by bridging Capstone design requirements and educational objectives with industry's willingness to partner with academia, creating a better understanding of the learning process and requiring the completion of a professional, finished project. This paper describes how to create a culture of communication between industry sponsors and student teams, explores the need for training for both liaison engineers and Capstone faculty coaches, and discusses lessons learned regarding the need for involvement from both industry and academia.

Keywords: capstone; industry sponsor; liaison engineer; faculty coach

The capstone process is meant to provide students with real-world design experiences, thereby developing skills that are transferrable to the corporate environment. To address the growing concerns of providing students with adequate preparation for the workplace, the Electrical & Computer Engineering and Computer Science Department at Ohio Northern University adopted both an industry-based project management standard and a corresponding project management documentation practice as an operational framework for their capstone design course sequence. Additionally, in order to provide capstone teams with appropriate technical expertise across the multidisciplinary topics that make up a typical design experience, a Project Review Board consisting of faculty selected specifically for their expertise relative to each project is assigned to each capstone team to both provide guidance and to conduct performance reviews. Both formative and summative assessments of the design process include the use of multiple communication formats to both internal and external audiences at specified decision points in the process. These two forms of assessment are evaluated using a standardized set of rubrics, providing benefits to students by explicitly stating performance expectations and to faculty by establishing a common definition of skill competencies. The quantitative and qualitative post-activity assessments indicated an improved student capstone experience. Recommendations are provided to assist other institutions in adopting the processes and protocols discussed in this paper.

Keywords: senior capstone projects; industry project management standards; rubrics

Project teams, a mainstay in industry practice, are being employed in many capstone design courses. This paper examines industry models for teams and their application to a specific capstone design course. Following Katzenbach and Smith's basics of high performing teams, teams are formed based on individuals' skills. The team is made accountable and committed both as a group and as individuals through the structure and format of the course. The course structure is then planned so that teams progress through Tuckman's development stages of forming, storming, norming and performing, during their two semester capstone design project.

Keywords: teams; capstone; development stages; design process

Students are a primary stakeholder in engineering Capstone Design courses, but the student voice risks being overlooked in discussions of Capstone Design pedagogy and development. While many engineering programs collect student feedback and performance data for accreditation purposes, the engineering education and engineering design literature provide few resources that capture student perspectives on Capstone Design, especially across multiple institutions. The 2012 Capstone Design Conference hosted two well-attended panel sessions called "Student Reflections on Capstone Design" specifically to highlight student experiences in Capstone Design courses with industry-sponsored projects. Each panel featured four different panelists who had recently completed their Capstone Design courses, had worked with different industrial sponsors, and represented different institutions and engineering disciplines. The facilitator of each panel asked the same initial questions of the respective panelists and then opened the conversation to questions from the audience. Although the trajectory of the two panels varied, content analysis of the transcribed discussions revealed similar themes from both groups. This paper addresses the analysis methodology, emerging themes, and sample reflections/suggestions from the student panelists. Discussion of the themes and student comments provides a foundation of student perspectives to aid faculty and industry liaisons in strengthening the Capstone Design experience.

Keywords: Capstone Design; industry sponsored projects; capstone pedagogy; student reflection; workplace communication

Engineering professional skills are critical components of an engineer's performance in industry. Engineering professional skills include the ability to work in a team environment, awareness of and ability to contextualize engineering ethics, and an ability to establish and realize professional development goals. Engineering capstone design courses present the opportunity for an authentic learning experience with respect to complex, professional skills in situations similar to those in which they will be used in practice. The Transferable Integrated Design Engineering Education (TIDEE) consortium of engineering educators and researchers have developed and tested the Integrated Design Engineering Assessment and Learning System (IDEALS). IDEALS consist of nine modules with formative and summative assessments to guide and measure student learning of professional skills integrated with complementary instructional materials to facilitate use in project courses. Results from prior testing were positive from both student and faculty perspectives, but a key stakeholder—recent alumni users now working in industry—required further representation to determine IDEALS impact. A total of forty-two alumni that were recent users of the system completed the survey. 85%, 86% and 70% of survey respondents attributed enhancement in professional skills to the IDEALS teamwork, professional development, and professional responsibility modules respectively. Additionally, 82% of respondents reported some enhancement in terms of their reflective writing skills.

Keywords: professional skills; assessment; learning; IDEALS; teamwork; professional development; responsibility

Undergraduate students are increasingly engaged in developing products and technologies that are commercially viable outside of the university through their involvement in courses and experiential programs focused on product design and entrepreneurship. The involvement of undergraduates in intellectual property protection leads to interesting questions related to how best to align student interests with institutional policies and practices since most are not employed by their universities in the way that faculty and many graduate students are. This paper summarizes the results of a survey designed to examine trends in the level and nature of undergraduate involvement in creating intellectual property. It was administered to intellectual property professionals in technology transfer offices at 30 U.S. universities with strong emphases in engineering, science, and technology. Findings indicate that involvement in intellectual property protection among undergraduates is growing at over half of the institutions surveyed; there is a lack of consensus among institutions of how to manage IP generated by undergraduates; and that the resources technology transfer offices have to devote to communicating policy is critical to the manner in which policy is applied.

Keywords: Intellectual property; technology commercialization; undergraduate; entrepreneurship; engineering education; product design; innovation

A review of capstone related literature indicates similar-not identical-approaches to design that include various concepts of what is a problem statement, and problem statement development, evaluation and assessment. There appears to be a variety of approaches for developing the capstone student's ability to craft a quality statement of the project problem. There are few specifics as to what should or should not be included in the problem statement and what is found reflects the preferred design process or programmatic requirements. This paper describes findings from an exploratory study of methods and expectations associated with crafting capstone problem statements. This work is directed at determining what characteristics are valued in a problem statement. The research finds that problem statement characteristics vary with programmatic requirements and preferences in academia and industry. Statistics point to alignment of academia and industry on all but two pre-selected problem statement characteristics, Identified Design Methods ($p = 0.040$) and Evidence of Current Art Research ($p = 0.043$). Industry is found to have the more rigorous point of view for the two characteristics.

Keywords: capstone; problem statement; design

This paper studies the differences between student experiences in domestic and international capstone design offerings for mechanical engineering students at Clemson University. For this, we conducted surveys and interviews of students participating in both the traditional domestic version of a capstone course at Clemson University and a group of students that participated in an international, study abroad version of a capstone course jointly administered by Clemson University and West Virginia University. The surveys were given to students before and after the program to assess whether the international component had an impact on their global awareness when compared to their peers in the traditional domestic program. The surveys, due to the low sample size

available from only a dozen participating students, are augmented with interviews conducted at the end of the international program. The findings suggest that there is not a significant change in recognized attributes of global awareness for the population, but there was some movement within individuals. It is also seen that the reasons for participation in the international version of the course varied widely from a desire for international experience to the desire to graduate during the summer sessions when the only capstone option was the international version. The findings begin to provide justification for the international option based on some improvements with global awareness, but additional investigation is warranted as existing programs are continued and new programs introduced.

Keywords: senior design; engineering globalization; international capstone; capstone design

In this paper, a review of a workshop directed by the author, as part of the 2012 Capstone Design Conference held at the University of Illinois, Urbana-Champaign, May 30–June 1, is presented. In the workshop, a theoretical approach that interprets how students form relationships, and how relational environments form student thinking, was presented that gives insight toward how to create high-performance teams in a very short time. The theory and reflection that were shared with workshop participants are based on the author's own experience with his clinic program, and the methods are based on the value-memetic theory known as Spiral Dynamics, originated by Clare Graves in the 1950s, and further developed by his student, Don Beck. During the workshop, the format of a capstone design clinic, measurably successful from an industrial recruitment and a project completion perspective, was presented, and the differences between the fundamental relational structure of this type of clinic, where independent, trust-based relationships are emphasized, vs. one with more traditional grading and policies, and instructor-assigned groups were contrasted. Following this, theory of relational development that all students were subjected to was discussed, and case studies from the workshop director's own program were distributed, highlighted and discussed.

Keywords: capstone design; project based learning; relational development; psychology of learning; theory of mind; Spiral Dynamics; empathy in learning; structure of knowledge; global engineering; student development

Capstone design is an opportunity for students to apply their newly obtained knowledge in a real-world setting. Oregon State University's School of Mechanical, Industrial and Manufacturing Engineering provides students with choices of internally (originating from within the department offering the capstone course) and externally sponsored projects and uses an assessment system based on written reports and the quality of the deliverable (e.g. prototype). Providing different projects for each group of students has made tracking and managing the progress of each project difficult. The large amount of work required to provide the necessary support for students has historically fallen to faculty. However, recently, much of this work has been shifted to graduate student assistants. The graduate students serve as technical advisers, project managers, centralized communication hubs, and report graders. When compared to faculty, graduate students tend to be more accessible to students, project sponsors, and instructors; they seem more motivated to provide high quality results, they provide comparable levels of student assessments, and they are easier to hold accountable. For many graduate students, the capstone projects are extensions of their research. Concerns over graduate student inexperience are resolved by having a faculty member available for support as necessary. Several tiers of graduate advisers are used and are illustrated through case studies. The first tier uses graduate students simply as report graders. The second tier adds project advising. The third tier adds responsibility for creating a device, such as testing equipment, for the capstone students' use in validating that their design meets requirements. The fourth tier includes grading, advising and responsibility to extend, as necessary, the output of the capstone students' work to create a fully functioning deliverable for the sponsor. The fifth tier is similar to the fourth, but the project topic is a key component of the graduate students' degree research. Through case studies, faculty and graduate adviser grade comparisons, and content analysis from student reports, Graduate Assistants have been observed to be valuable contributors to an enhanced capstone course at all levels of involvement.

Keywords: senior design; capstone; graduate advisers; graduate mentors; mentor; protégé

Section II
Contributions in: Systems Design, Creativity, Imagination, First Generation Students, Diversity, Retention, Leadership Styles, Learning Styles, Cross-Cultural Comparisons, Improving Students' Performance, Engineering Mathematics, Examinations, Distance Learning, Computer-Based Assessment, Project-Based Learning, Laboratory Activities, Nanotechnology, Chemical Engineering, LabVIEW

Educating Engineers in systems thinking and systems design require an approach to teaching and learning in which the purpose is to achieve competence rather than to acquire specialised subject knowledge, abstracted from its socio-technical context. Such an approach is structured by context-driven enquiry, supported by learning power, positioned at the interface of knowledge generation and use, and grounded in a commitment to sustainable development. Rather than beginning with pre-defined abstract subject knowledge, the students begin with an engineering problem in a particular territory or a place, and develop a systems architecture, a holistic way of defining that territory, which facilitates synergy as well as analysing performance. In order to do this, students need to be able to uncover the different knowledge systems through which their territory can be perceived and known, and explore the different parameters and measurements which can be applied to them. Such 'systems architecting' cannot be achieved through rote learning or the cognitive application of pre-defined knowledge, since by definition the solution to the problem to be solved cannot be known in advance. Rather it depends on the ability to learn, and to progress through an open-ended, formative, dynamic learning process. It is framed by a selected purpose, fuelled by learning power (including creativity, meaning making, curiosity and resilience) and co- generated through knowledge structuring processes. It begins with experience and observation and concludes with a product which is a unique application of knowledge for a particular engineering purpose. One of the challenges of technology enhanced learning is how to integrate learning design in an architectural framework which leverages mobile, social and 'big' data to enhance the processes and social relationships of learning, rather than simply providing information or evaluating

outcomes. The approach presented in this paper outlines what can be understood as 'learning design principles' which support the development of semantic web applications, through the application of learning power and knowledge structuring processes. A pilot study demonstrates that students who successfully undertook an assignment requiring the development of a systems architecture increased in the strategic awareness—a key dimension of learning power. This small pilot study makes a contribution to the debate about the education of Chartered Engineers characterised ''by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change'' (UK Engineering Council)

Keywords: systems designing; creativity; engineering education; knowledge structuring processes; learning power; identity; learning architecture; systems thinking; systems engineering

This study analyzes how *human aggregate* moderates the effect of *inspiration through action* on student imagination. A survey was administered at five universities across various regions of Taiwan. The participants in this study consisted of 543 engineering majors. Structural equation modeling was used to test all the proposed hypotheses. The results showed that *inspiration through action* had the strongest effect on student imagination, followed by *human aggregate* and *social climate*. Our data also indicated that student imagination levels were highest when students were also high in inspiration through action and human aggregate.

Keywords: engineering education; human aggregate; imagination; inspiration through action

The purpose of this paper is to examine in detail the roles that families, particularly parents, play in the academic and career choices of students majoring in engineering at the undergraduate level, with a particular emphasis on how roles may differ when considering the parental level of education. Previous studies have reported the various influences on students' decisions to enter and persist in engineering at the undergraduate level. Though the role of the family has been identified as an important influence, there remains a limited understanding of specific family roles. In this large qualitative study design, the authors use constructivist epistemology, an emergent design, and a basic interpretive approach. Semi-structured interviews were conducted with a sample of 118 engineering undergraduates enrolled at two universities and representing diversity in parental educational attainment. Based upon interview transcripts, six distinct family roles were identified in participants' academic and career choices. Variations in certain family roles were found with parental educational attainment. This study is innovative in that it significantly contributes to the knowledge base of family, especially parental, influences on engineering students by including the previously under-explored factor of parental educational attainment. Findings are synthesized into recommendations for developing recruitment and retention interventions for engineering undergraduates, particularly students with little or no familial experience with higher education.

Keywords: parental education; family roles; first generation college students

Despite efforts made by the engineering community, the struggle to increase racial and ethnic diversity continues. As women and ethnic minorities make up a larger percentage of the United States labor force, academic departments need to support the development of students from these talent pools. To improve the retention of these students, engineering departments need to be inclusive, allowing students to feel welcomed, valued, respected, and supported. The overall purpose of this study was to develop and pilot a survey instrument, grounded in Tinto's Model of Institutional Departure, to provide engineering educators and administrators with a tool that can be used to investigate how underrepresented engineering students rate the level of inclusion within engineering departments, paying close attention to gender and race/ethnicity. Herein we specifically report on the instrument development and the initial findings through data collected from two public, predominately White research institutions with high undergraduate engineering student enrollment. Our results demonstrate that the Engineering Department Inclusion Level (EDIL) survey can yield valid and reliable scores with the population of interest. Before embarking on further data collection to continue developing the survey, we wanted to determine what value the survey might have. Results indicate no differences between men and women from underrepresented populations but that African-Americans rated the same environments less inclusive than other racial/ethnic groups across all of the scales. Finally, PhD students scored University Pride lower than participants at other academic levels. Moreover, based on initial data results, we suggest further research on feelings of inclusion as an important aspect to creating a diverse environment.

Keywords: retention; diversity; engineering departments; inclusion level

The objective of this work is two-fold. It concerns: (1) to design scales related to a transformational leadership style and the performance of the professor in the classroom as well as (2) to evaluate the relationship between these constructs. As a result, this paper offers a tool to evaluate the implementation of a transformational teaching style and performance of the professor in the classroom, developing a joint activity between professors and students. The total number of students in this research was 203 and it involved institutions from three countries.

Keywords: leadership style; performance of professor; classroom; higher education

Student learning styles are an important factor to consider when designing pedagogy and course curriculum to optimize or maximize student learning outcomes. As online and distance education expands rapidly across national borders to reach a global audience, a cross-cultural, comparative study of learning style preferences among different nations helps provide insights into whether diverse cultural backgrounds and experiences affect student learning styles, and if so, how. The present study focuses on a cross-cultural comparison of learning style preferences between American and Chinese undergraduate engineering students. A total of 132 sophomore (second-year) engineering students from two comparable universities in the United States and China participated in the present study. The 44-item Felder–Silverman Index of Learning Styles questionnaire survey was employed to measure the students' learning style preferences. Students' exam scores in two foundational core engineering courses (statics and dynamics) were also collected. The results of statistical t-tests show that there existed statistically significant differences between American and Chinese students in four learning style dimensions: reflective ($p < 0.01$), sensing ($p < 0.01$), visual ($p < 0.01$), and verbal ($p < 0.05$). These differences represented a medium-sized effect. On average, American students had a higher preference than Chinese students in all these four learning style dimensions. The results of correlation analysis show that a statistically significant correlation ($r = 0.286$, $p < 0.05$) existed between American students' active/reflective learning style preferences and the average statics exam scores. It is suggested that instructors use diversified teaching styles to accommodate the diverse learning style preferences of students, and that students develop a balanced (or well-rounded) learning style preference in each learning style scale (active/reflective, sensing/intuitive, visual/verbal, and sequential/global) to accommodate the teaching styles of instructors, as well as the needs of particular engineering courses.

Keywords: learning styles; cross-cultural comparison; American undergraduate engineering students; Chinese undergraduate engineering students

The policy of economic liberalization pursued by India over the last two decades has attracted global players and intensified competition in the Indian market. To compete effectively in this scenario, Indian companies need to address competency gaps quickly. The rapid growth of Information Technology and IT enabled service sectors has spurred growth in engineering education, without the requisite improvements in governance, infrastructure and quality of faculty. Most students gravitate to studying engineering under parental or peer pressure rather than genuine aptitude, consequently their academic and subsequent careers suffer. Research shows that if aspirations are aligned to innate ability with greater engagement in learning new knowledge and skills, the student's potential and performance improves. This paper presents a study in which students were assessed for their innate ability and assigned appropriate roles and counselled to articulate their aspiration in terms of life and career goals. They were then subjected to competency based education in collaboration with engineering institutions. Interim assessments indicate that students who took part in the collaborative program performed significantly better and demonstrated greater industry and role readiness than the rest of the students.

Keywords: innate ability; aspiration; competency; engagement; potential

One of the uses of Engineering Mathematics is to provide underpinning knowledge which is useful and often essential for Engineering modules later in an undergraduate engineering degree course. It can be the case, however, that students perceive distinct boundaries between an Engineering Mathematics module and Engineering modules and fail to link what is being taught in both. The purpose here is to help alleviate this problem by incorporating a computer algebra system into an Engineering Mathematics module, so making the teaching and learning process more accessible and meaningful, providing students with a more realistic way of how professional engineers tackle problems today, increasing student skills, hopefully increasing their interest and finally breaking down the boundary alluded to above. The inclusion of the computer algebra system gave students a better appreciation of how essential Engineering Mathematics is within Engineering modules in general. However, its inclusion had a detrimental effect on interest. It was noted from the survey that the students liked the hands-on and self-discovery approach.

Keywords: engineering mathematics; computer algebra system; integration

The purpose of this article is to present student perspectives of open book examinations, contrasting them to those for closed book examinations. Reasons and advantages of using open book examinations are offered and may be aligned with important accreditation criteria stipulated by official accreditation bodies, such as the Engineering Council of South Africa. The perspectives of senior electrical engineering students, enrolled in a telecommunications module, regarding open book examinations from two higher educational institutes in South Africa were obtained using a questionnaire survey. More than 80% of students from a residential contact university and less than 60% of students from an open distance learning institute passed their open book examination. The questionnaire survey highlighted that more than 50% of the polled students would prefer open book examinations.

Keywords: open book; closed book; examinations; accreditation; perspectives; open distance learning

This paper proposes a novel computational approach based on time series analysis to assess engineering design processes using a CAD tool. To collect research data without disrupting a design learning process, design actions and artifacts are continuously logged as time series by the CAD tool behind the scenes, while students are working on a design challenge. These fine-grained data can be used to reconstruct and analyze the entire design process of a student with extremely high resolution. Results of a pilot study in a high school engineering class, in which students solved a solar urban design challenge, suggest that these data can be used to measure the level of student engagement, reveal the gender differences in design behaviors, and distinguish the iterative and non-iterative cycles in a design process. From the perspective of engineering education, this paper contributes to the emerging fields of educational data mining and learning analytics that aim to expand evidence approaches for learning in a digital world.

Keywords: computer-based assessment; computer-aided design; time series analysis; engineering design; engineering education; educational data mining; learning analytics

To address the difficulties in teaching interdisciplinary subjects in engineering, this paper presents the process of developing a project-based mechatronics curriculum with the final artifact of an electronic pet robot. The curriculum was designed and implemented in a real mechatronics class for a semester in a university, and an evaluation study collected students' opinions on the effectiveness of this electronic pet robotic project-based mechatronics curriculum. The results of the study showed that the project increased student motivation, improved student performance, and gave students hands-on experience to develop skills in mechatronics system design. Students' responses to the evaluation study also demonstrated their positive attitudes towards the electronic-pet project-based learning, and the students also considered their teamwork to be successful.

Keywords: project-based learning; artifact; Mechatronics; engineering education; electronic pet robot; interdisciplinary learning

This paper proposes a sputtered deposition-based technology to develop a nanotechnology project into a laboratory activity. This technology can make nanotechnology more appealing to students by enhancing the attractiveness of engineering curricula. In laboratory activity, nanotechnology courses using a laboratory platform and physical vapor deposition implemented nanotechnology exploration projects enhance interest and offer sufficient knowledge to students. Such courses can help students to understand nanotechnology concepts and the applications of sputtered deposition-based systems. This nanotechnology exploration project in the form of a laboratory activity has been evaluated successfully based on the evaluation results and responses to questionnaires: students and experts rated the nanotechnology laboratory activity highly, with mean values of 4.093 and 4.263, respectively. As for the Cronbach's alpha coefficient of the nanotechnology laboratory activity, questionnaire results showed that the satisfaction levels of experts and students in this study were 0.953 and 0.947, respectively. These results demonstrate the excellent reliability of the survey's internal consistency. Furthermore, more than 78.34% of the students, those with scores over 80, found the laboratory activity learning in the nanotechnology exploration project to be very good or excellent. Moreover, the students obtained very good academic results.

Keywords: nanotechnology; laboratory activity; physical vapor deposition; statistical questionnaire

An ultrafiltration membrane module was assembled and used for treating an oil-in-water (O/W) emulsion. This lab set-up was implemented to teach membrane separation processes within Chemical or Environmental Engineering programmes. The experimental set-up and procedure are described, as well as typical results obtained by students, underlining the main objectives and reasoning expected to be accomplished in each stage of the work. Particular emphasis is given to the discussion of the impact of some variables, such as pressure driving force, surface velocity and emulsion concentration, on concentration polarization, recovery and rejection. The use of this technology at an industrial scale is also discussed. The implemented lab experiment has a relevant pedagogic impact and facilitates students to grasp the inherent theoretical concepts, as perceived from their reports and oral discussions. Moreover, the work has been well accepted and appreciated by students, as can be inferred from the questionnaire; their assessment also showed the fulfilment of the established technical and pedagogic objectives. Particularly relevant is the importance that students attribute to the execution of the experimental work to comprehend the concepts (i.e. importance of a hands-on approach).

Keywords: ultrafiltration; chemical and environmental engineering; membrane module; oil and water

This paper introduces an efficient blended learning approach to teaching LabVIEW-based graphical programming and examines the impact of the proposed approach on LabVIEW certification test scores. A traditional course was blended with e-learning technology to boost the programming skills of students and to better teach advanced topics. The need to complete student-designed projects and a certification exam encouraged the students to use the e-learning system outside of class, in addition to their work in regular classroom time. Individual data analysis and student survey results showed that e-learning was mainly used as a tool to help prepare for the certification test. In our case study, students who used the e-learning system achieved certification test results almost 40% higher than those who only had face-to-face learning experiences.

Keywords: engineering education; blended learning; e-learning; graphical programming; LabVIEW; certification test