Advances in Engineering Education

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From the Editor

This issue contains eight articles that document "advances" in engineering education. The papers cover a wide range of topics, with focus ranging from introductory first year courses to senior capstone design. The papers present creative ways of student learning and assessment, including the use of webpages and other media to better understand complex concepts. The papers address such currently "hot" topics as the blended/flipped classroom, combining ethics with design, sustainability and entrepreneurship. Below is a short overview of each paper – happy, and productive reading!

Diana Bairaktarova (Virginia Tech) and Michele Eodice (Oklahoma) describe an innovative way for teaching thermodynamics. Rather than the traditional classroom model in which the focus is on the analysis of thermodynamic energy systems and their real world application, instructors might encourage students to creatively translate thermodynamics into languages they can clearly understand. They asked sophomore-level students to generate a creative interpretation of Thermodynamics. The resultant presentations were "a high-energy event in rhythms and rhymes, as students presented their creative work." Subsequent evaluations found that the creative interpretations helped to clarify concepts and increased students' appreciation of thermodynamics in particular and engineering in general. This was supported by performance on problems and final exam scores. The authors propose that students' engagement in creative presentations contributed to better learning of the concepts of interest. A one page overview of this paper is presented in the October issue of *PRISM*.

Robert Kirkman, Katherine Fu, and Bumsoo Lee from Georgia Tech introduce an approach to teaching ethics as design through a team-taught (i.e., philosopher and engineer/designer) Design Ethics course. Using a problem-based learning model, student teams worked through the design phases on a client's problem, considering both the design and ethical values at each decision point. Students' acquisition of ethical thinking skills and moral imagination were assessed using Latent Semantic Analysis to analyze their responses to short answer ethical design questions before and after the course. This data, combined with an ethical thinking survey and self-efficacy assessment, resulted in a number of statistically significant differences. The authors propose that "the integration of ethics and design holds promise as a way of fostering the development of professional skills among engineering students."

Nicola Brown, from Massey University, New Zealand, describes the implementation and evaluation of a website based assessment tool for project based learning. Used with first year engineering students, the author found that developing a website rather than writing a report was a less onerous task for most students. In addition, developing the website allowed students to be more creative; surprisingly, students not studying computing found the web-based reporting easier than

those with a computing background. Brown has proposed that using a website as an assessment tool is adaptable to a range of courses in which enhancing written and visual communication, while encouraging creativity, are objectives.

Cheryl Bodnar (Rowan University) led a multi-discipline, multi-university team that looked into how to make engineering student product designers more conscious of non-technical requirements in the marketplace. Rather than strictly focus on the technical aspects of product design, they note an increasing demand from industry for market-aware, customer focused graduates, attributes also associated with entrepreneurship. They have used the framework of a simulated focus group incorporated as part of a virtual internship and epistemic game Nephrotex to introduce student designers to "customer voice." They propose that increased customer exposure should lead to decreased product cost without a loss in product quality. They found that students in the focus group section produced less expensive final designs compared to the section without a focus group. They propose that this supports including exercises that lead to increased customer focus within the design process is possible without sacrificing design quality, and should further help to develop more entrepreneurial mindsets.

Jae-Eun Russell and colleagues from Iowa have investigated the effectiveness of a student-centered instructional approach on engagement and achievement in a transformed electrical circuits course compared to a traditional lecture-based format. Three surveys were administered to 243 participants over a semester; demographic information, prior learning outcomes, and course outcomes were collected after the semester was over. They found that students in the student-centered section were significantly more engaged and achieved higher learning outcomes than students in the lecture-based section, adding to the literature on blended/flipped courses. They found that the student-centered approach appeared to impact behaviors; participants valued the in-class, collaborative problem-solving activities. However, due to data limitations, they were not able to determine how the collaborative learning environment led to improved student learning. That is, although students discussed problems, asked questions of each other, and received help from teaching assistants and instructor, the students' roles (i.e., questioner and responder), the questions' nature, and the discourse that led to positive learning outcomes remained unclear.

Gail Goldberg, a STEM educational consultant examined judges using an engineering design rubric to evaluate portfolios in three different student competitions (regional, national, and global). The portfolios were posted on the Innovation Portal, a free online resource available to students, teachers, and others engaged in STEM education. Judges used the Engineering Design Process Portfolio Scoring Rubric (EDPPSR) and were surveyed by the author following each competition. Based on the results, Goldberg proposes that a complex rubric can be used by judges to evaluate competition entries both efficiently and with moderate consistency with simply cursory training. She suggests

the value of using rubrics such as EDPPSR beyond teaching and testing. Considerations when using rubrics for evaluation in the various STEM disciplines are presented.

Ryan Solnosky (Penn State) and Joshua Fairchild (Creighton) describe tools for assessing the dynamics of multidisciplinary teams in capstone courses. Two surveys have been developed based on industrial/organizational psychology theories relative to achieving high performance. The surveys were tested in conjunction with traditional qualitative verbal feedback and technical assessments in a capstone course. Their results suggest that taking an organizational behavior approach to align or shift team performance leads to better student-centered programs. In the case study described, they found that the surveys were as valuable as other tools for providing insight. However, students found the ability to formally compare their perceived behavior against others' observations to be valuable. As a result students worked with faculty on identified areas in order to improve team performance. Solnosky's and Fairchild's rapidly implementable assessment tool is available to faculty interested in having student teams improve high performance dynamics.

Claire L. A. Dancz, and colleagues, in "Utilizing Civil Engineering Senior Design Capstone Projects to Evaluate Students' Sustainability Education across Engineering Curriculum" note that engineering educators have yet to achieve consensus on how best to infuse sustainability into curricula, nor even how to assess engineering students' sustainability knowledge. To address this, they have developed a rubric to evaluate students' sustainability knowledge. Their paper describes its application to 43 capstone design projects (from 287 students) at two institutions as part of a mixed-methods assessment. Built on earlier assessment approaches, the rubric consists of nine different factors. The mixed-methods assessment included observation of student project presentations and evaluation of student reports via rubric. Using the rubric, the team found that students' performance was primarily driven by the instructor's expectations. Specifically, if sustainability was not a major deliverable of the course, then the student team was less likely to integrate sustainability concepts into its design. This suggests that if sustainability is a priority, then senior design project requirements should explicitly require a holistic sustainability application. Further, the senior design instructional team should include a knowledgeable sustainability mentor/advisor, as was demonstrated in a design project at both institutions where sustainability experts assisted the teams.