Advances in Engineering Education

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From the editor: AEE Issue 16

These eleven papers comprise our 16th issue. With a solid backlog of papers we are now in a position to fulfill our objective of publishing four times per year with ideally ten papers per issue. Including abstracts, we have now had over 850 submissions to AEE. We estimate that approximately 25% of submissions eventually result in published papers. We are able to do this because of the hard work of a dedicated board of associate editors who receive too little credit for their efforts. Mary Besterfield-Sacre, John Chen, Kevin Dahm, Trevor Harding, Gul Kremer, Tom Litzinger, Dan Moore, Tamara Moore, Bill Oakes, Larry Richards, Sheryl Sorby, and BevLee Watford deserve most of the credit for making the process work. They are supported by a large list of reviewers. Even though the entire system is solely dependent on volunteers, we are able to average just over 100 days turn-around time between when the paper is submitted and when the author is notified of a decision.

As AEE matures, we continue to tweak and improve its quality and appeal to the broader engineering education community. While we will also focus on those articles that clearly document an "advance" in engineering education, we have decided to expand our pool of potential articles by expanding our definition to include under "applications" articles that apply the results of rigorous engineering education research in a learning environment. We will also consider a few exemplary articles in which the application may not have been a success, but there is much the engineering and STEM education communities might be able to learn from it. In all cases, the paper must be sufficiently grounded in prior work with a section that summarize the relevant literature. Appropriate methodology and measures should be used to evaluate the "advance" and related research findings. The paper must be well written, and fully cover the topic in an organized manner. Most important, the topic must be relevant and of interest to the broader engineering and/or the STEM education communities, including faculty, researchers, students and administrators.

This issue features eleven papers that cover a wide range of topics. A team from the University of Michigan - Julia Kramer, Shanna Daly, Seda Yilmaz, Colleen Seifert and Richard Gonzalez describe "Investigating the Impacts of Design Heuristics on Idea Initiation and Development" Their paper analyzes engineering students' use of Design Heuristics in an undergraduate engineering design course. They propose that Design Heuristics are an empirically derived set of cognitive "rules of thumb" for use in concept generation. Their results reveal widespread use of Design Heuristics among the concepts generated by individuals and selected by teams for further development; they also observed a prevalence of concept synthesis within approximately half of the design processes.

Three University of Pittsburgh investigators - Nur Ozge Ozaltin, Mary Besterfield-Sacre, and Renee M. Clark – look at another aspect of innovation and design in "An Engineering Educator's Decision Support Tool for Improving Innovation in Student Design Projects." Their Bayesian network decision support tool, modeled after Dym's design process framework, can be used by faculty to improve the innovativeness of student teams' product designs. Cross validation using outcomes data from 26 teams found the model to be both accurate and robust. As a result, it can be used to formatively assess both the process and level of innovativeness used by design teams, and, through early intervention by the instructor, lead to more innovative final design outcomes.

Another tool is proposed by a team then at Virginia Tech. Jacob Moore, Christopher Williams, Christopher North, Aditya Johri and Marie Paretti, focused on the "Effectiveness of Adaptive Concept Maps for Promoting Conceptual Understanding: Findings from a Design-Based Case Study of a Learner-Centered Tool." Their innovation - the Adaptive Map - is a novel organization and navigation tool to help students better understand large collections of information such as those found in textbooks. It promotes better conceptual understanding by leveraging expert-generated concept maps, and visualization techniques to increase usability and facilitate processing. Experimental results showed that the tool promoted conceptual understanding by facilitating advance organizer usage and students' exploration of relevant prior content.

A team of investigators at the University of Illinois - Erik C. Johnson, Brett A. Robbins, and Michael C. Loui - addressed "What Do Students Experience as Peer Leaders of Learning Teams?" Specifically, in a freshman engineering course, peer leaders facilitated optional study sessions (i.e., peer-led team learning workshops). Most leaders were undergraduate volunteers, who were asked to keep weekly reflective journals. A qualitative analysis of fourteen journals resulted in a description of the experience of leading peer-led team learning workshops over the course of the semester. The leaders were initially apprehensive about teaching and concerned with correctly answering students' questions; as the semester progressed, they were often frustrated with the difficulty of teaching, and turned to new ways of encouraging student participation. By the end of the semester, leaders reported increased self-confidence, an appreciation for intellectual diversity, and an increased interest in teaching.

A group of investigators from Rutgers University - David I. Shreiber, Prabhas V. Moghe, and Charles M. Roth developed a "Multidisciplinary 'Boot Camp; Training in Cellular Bioengineering to Accelerate Research Immersion for REU Participants." Their goal was to rapidly align student expertise with summer research goals while integrating the participants into a cohesive learning community. The Rutgers' Boot Camp provided hands-on, supervised training for techniques and procedures that were common among projects. Surveys before and after the Boot Camp, and at the end of the summer found a significant improvement in student proficiency in those techniques that were retained throughout the summer.

Irene Mena, Sven Schmitz, and Dennis McLaughlin, then at Penn State completed "An Evaluation of a Course that Introduces Undergraduate Students to Authentic Aerospace Engineering Research." In the course undergraduate students worked on research projects with graduate research mentors, providing the undergraduates with the opportunity to participate in authentic research within their field. Qualitative and quantitative data both showed that this was a positive experience for the undergraduates. It was also a positive experience for the graduate research mentors who received help on their projects and developed such professional skills as mentoring and leadership.

Fazeel Khan and Kumar Singh at Miami University addressed "Curricular improvements through Computation and Experiment Based Learning Modules." Their objective was to develop a unified approach for teaching computational analysis and model validation against experimental response. They have created a set of innovative computational-experimental studios, each of which houses at least two learning modules. The studios have contributed to the development of proficiencies in using mathematical software to create models and test their output against experimental data, expanding the scope of topics covered in courses, creating independent learning opportunities and enabling the creation of multimedia content.

Gigi Yuen-Reed and Kyle B. Reed have addressed "Engineering Student Self-Assessment through Confidence-Based Scoring." Their methodology encourages students to both think about their answers in a different way and to evaluate their confidence in the answer. Overall, students were able to accurately assess whether their answer was right or wrong 77% of the time. This also benefited instructors by identifying those topics that students tended to be less certain of, even if they were getting the correct answers, as well as picking out both over and under confident students.

A large, multi-university team - Dima Nazzal, Joseph Zabinski, Alexander Hugar, Debra Reinhart, Waldemar Karwowski and Kaveh Madani – describe the "Introduction of Sustainability Concepts into Industrial Engineering Education: a Modular Approach." They propose that industrial engineers with a focus on systems are uniquely positioned to incorporate sustainability concepts into this work. They explored how best to introduce sustainability concepts into industrial engineers' education. Curricular modifications were made which enabled sustainability concepts to be introduced into several courses through use of content-focused modules, leading to a recommendation as to how to expand sustainability education in industrial engineering programs at all levels.

Andrew C. King and Carlos H. Hidrovo discuss the "Development and Evaluation of a Mass Conservation Laboratory Module In A Microfluidics Environment." Module-based laboratory instruction allows students to investigate fundamental concepts interactively, affording new critical thinking skills and technical aptitude. Their module investigates mass conservation fundamentals in a simple microfluidic T-junction device. The experiment is highly repeatable, and can be conducted at relatively low cost. The authors quantify the module's educational impact on thirty-six mechanical engineering

undergraduates, with the results suggesting the module's efficacy for teaching mass conservation fundamentals in an undergraduate curriculum.

Two investigators at Purdue - Catherine Berdanier and Monica Cox focus on an international, graduate program in "Research and Assessment of Learning Environments through Photoelicitation: Graduate Student Perceptions of Electronics Manufacturing in India." Their project provides insight on the importance of international learning experiences in graduate-level engineering education and the value of non-traditional formats of graduate student learning. Their research has shown the value of an online, participant-generated photoelicitation survey to study graduate student learning experiences in an international setting. The photographs themselves are also artifacts for a wealth of future planned photoelicitation research on global engineering learning and international experiences. Future work using photoelicitation in engineering education could relate to cultural studies in other countries, as students experience engineering norms and practices from a global perspective.