



## From the Editor

This issue consists of eight papers on topics ranging from flipping the classroom to augmented reality. In between are papers on designing devices for the less developed world and a freshman-senior linked capstone design course structure. Papers address biomedical applications, device design, safety, measuring group/team development, problem based learning, and real-world applications. These eight “advances” deal with freshmen through graduate students, and cover a number of the engineering disciplines. The papers come primarily from the U.S. with one from Europe. Together, they should provide a number of ideas that can be used to improve classroom learning.

Stephanie Butler Velegol, Sarah E. Zappe, and Emily Mahoney from Penn State were involved with some of the early experiments in flipping the classroom. Their paper “The Evolution of a Flipped Classroom: Evidence-Based Recommendations” describes experiences in flipping or inverting the course; i.e., lecture material online and viewed outside of class; class time used for problem solving. It also contains a comprehensive review of the literature. They did find that students come to class better prepared to apply the knowledge gained from the short lectures to solve problems or do other activities. In their own experiments in flipping they found that students liked having the flexibility to learn the new concepts on their own time and in their own way, preferring this new pedagogy over the traditional classroom. Students appreciated interacting with the faculty and their classmates during class time. The authors believe that flipping a course allows students the opportunity to become active learners through such activities as problem solving, guest speakers, idea generation, and field trips. They proposed that the flip model can be adapted to fit a variety of course settings.

Garey A. Fox, Paul Weckler, and Dan Thomas at Oklahoma State University describe a provocative way of bringing together freshmen and seniors to address real-world problems in “Linking First-Year and Senior Engineering Design Teams: Engaging Early Academic Career Students in Engineering Design.” Biosystems Engineering senior design at Oklahoma State University is a two semester course with client provided projects. The paper describes how first-year and transfer students enrolled in an introductory engineering course are linked to the senior design teams through capstone projects as a more effective way to introduce design. First-year students design a small portion of the capstone project, identified and supervised by the seniors. More than 90% of introductory students agreed that the project was worthwhile, while seniors viewed the mentoring as beneficial. More specifically, by linking, first year engineering students were able to effectively decide on whether engineering, particularly Biosystems Engineering, was an appropriate choice. The authors proposed that similar



linkages may be beneficial at other institutions where first-year engineering students must take an introductory engineering course, and senior design is a two-course sequence.

Rachel Dzombak (at UC Berkley) and Khanjan Mehta and Peter Butler at Penn State describe “An Example-Centric Tool for Context-Driven Design of Biomedical Devices.” The authors propose that if engineers are to function in an increasingly interconnected and borderless world, then in order to create viable solutions to challenges posed by diverse populations, students must receive an experiential education in engineering design including identifying the needs of customers living in communities radically different from their own. Here, the authors are concerned with acquainting students with the unique context and constraints of developing countries, something quite difficult due to the breadth of pertinent considerations and the time constraints of academic semesters. Their solution is Global Biomedical Device Design, or GloBDD, a tool that facilitates simultaneous instruction in design methodology and global context considerations. The focus is on an example-centric approach to user-centered and context-driven design of biomedical devices. GloBDD employs real-world case studies to help students understand the importance of identifying external considerations early in the design process; e.g., anthropometric, contextual, social, economic, and manufacturing considerations. The tool is integrated into a junior-level biomedical device design class.

Results indicate that GloBDD engages students in design space exploration, leads to sound design decisions, and teaches students how to defend these decisions with a well-informed rationale. Use of the tool ultimately enabled students to create better designs, faster. Fieldwork in Kenya validated that the student-made devices were culturally appropriate as well as physiologically sufficient. Though originally used for biomedical design, GloBDD is purposefully saved as a website template, to facilitate the development of similar tools for other kinds of technologies. It has inspired the design of an analogous tool for exploring failure modes of agricultural technologies in the developing world and documenting design decisions made by student teams on such technologies.

Arezoo Shirazi and Amir H. Behzadan at Central Florida discuss “Content Delivery Using Augmented Reality to Enhance Students’ Performance in a Building Design and Assembly Project.” Under the supposition that instructional technology can enhance student engagement and the quality of learning, the authors implement and assess the effectiveness of an augmented reality (AR)-based pedagogical tool. They describe a model building design and assembly experiment with two separate (control and test) treatments that was imbedded in an undergraduate construction and civil engineering course. They found that students who used the AR tool performed better than those who did not with respect to certain (but not all) measures. In addition, the AR students spent more time on collaboration, communication, and exchanging ideas. Students ranked the effectiveness of the AR tool very high and felt it had the potential to transform traditional teaching methods.



The authors note that although the tool did not eliminate the need for a real classroom environment and teamwork participation, it helped students become more autonomous in their learning experience by assisting them during class without the constant presence or intervention of an instructor.

Carolyn Clevenger (Colorado - Denver), Carla Lopez Del Puerto (Puerto Rico - Mayaguez) and Scott Glick (Colorado State) describe an "Interactive BIM-enabled Safety Training Piloted in Construction Education." Their paper describes the development of a construction safety training module featuring interactive, BIM-enabled (building information modeling), 3D visualizations, and tests to see if it can enhance safety training related to scaffolds. The module is part of an undergraduate construction safety course at Colorado State University. Student feedback was strongly positive. Results suggest that the module is effective and correlates to a higher level of knowledge compared to only using standard, more traditional, training techniques.

Francisco Ferrero with five colleagues from Spain and England describe "An ECG Lab Project for Teaching Signal Conditioning Systems in a Master's Degree in Mechatronic Engineering." Their paper describes a lab project linking theoretical principles with practical issues of signal conditioning systems, as part of a Master's Degree in Mechatronic Engineering. Students designed and tested a signal conditioning circuit that monitors the heart's electrical activity. The paper is the result of five years of lab project work, in which student feedback has led to improvements. Student satisfaction with the module has consistently been positive; the instructors involved with the project believe results are transferable to other settings.

Kerri S. Kearney, Rebecca Damron, and Sohum Sohoni at Arizona State discuss "Observing Engineering Student Teams from the Organization Behavior Perspective using Linguistic Analysis of Student Reflections and Focus Group Interviews." As stated, group/team development in computer engineering courses are evaluated from an organization behavior framework, specifically Tuckman's model of the stages of group development. Their investigation is conducted through linguistic analysis of student reflection essays, and focus group interviews. As such, they present STEM education researchers with a method to obtain nuanced information about how groups and teams function. One take away is that instructors with similar engineering classroom environments should expect group development to move quickly through early stages, suggesting that instructors should deliberately move groups and teams quickly to performing. Further, the way that the groups progressed through the developmental stages was likely affected by prior knowledge of other team members, prior group work, and the technical nature of the task. They propose that "with a clear understanding of the differences between groups and teams on the instructor's part, careful planning of the course project accordingly, and a dialogue about this with the students, we expect students to function even better in collaboratives in the classroom that may better transfer to authentic workplace skills."



Michael E. Hanyak, Jr. proposes a “Conceptual Framework to Help Promote Retention and Transfer in the Introductory Chemical Engineering Course,” that was developed at Bucknell. The framework of a holistic problem-solving methodology with a problem-based learning approach has led to an environment that nurtures deep rather than just surface learning when compared to the traditional lecture-based format. Learning gains were determined using an in-house concept inventory; in addition, after nine months, students retained their conceptual knowledge. The author suggests that by successfully integrating major cooperative learning elements, long-term retention of fundamental principles will be retained by students.