

Design Engineering Education

The Design Education Committee (DEC) of the Design Engineering Division is pleased to have the opportunity to provide papers for this special issue of the *Journal of Mechanical Design*. With this edition the significance of recent research in design engineering education and the importance of design education to the success of the design research community are recognized.

A Call for Papers for this special issue proposed several topics which were believed to have considerable potential interest. Emphasis was placed on “evidence-based” work as opposed to anecdotal experiences. Papers were encouraged that included some form of the evaluation of creative ideas and which applied the scientific method to assess effectiveness. Over 25 papers and/or abstracts were received in response to the Call for Papers, and a standard JMD review process ultimately resulted in 16 papers being accepted and completed for this special issue. Several topics came to the forefront. One group of papers embraced experiential learning under the topic of the integration of design throughout the curriculum and designing across the curriculum. Another group concentrated on research, creativity and the cognitive factors associated with design. The papers have been placed approximately in that order.

The opening paper is a Commentary authored by Warren Seering entitled, “Articulating a Learning Objective.” He examines the distinction between science and engineering and compares the processes whereby science yields understanding while engineering yields artifacts. At the heart of the Commentary is the question: “Are we preparing our students to be engineers, scientists, or both?” Seering proposes that since a great majority of undergraduates go on to be practicing engineers these students would be better served if we “placed greater emphasis on the engineering process as part of the engineering experience.”

This is followed by a paper by Reid Bailey who studied the “Effects of Industrial Experiences and Coursework During Sophomore and Junior Years on Student Learning of Engineering Design.” He examines the fact that although seniors know more about design than first-year students it is not clear where this knowledge is gained. Bailey assessed the design process knowledge of seniors and found that “industrial experience greatly increases students’ recognition that documentation needs to occur throughout the design process.” He goes on to further examine this in light of idea generation, development of requirements, decision making, building and testing prototypes, and final designs.

Hey, Van Pelt, Agogino, and Beckman have provided “Self-Reflection: Lessons Learned in a New Product Development Class.” In this paper they examine experiences in new product development classes that provide an effective vehicle for authentic learning and realistic design experiences in an academic setting. In attempting to determine what students learn in these courses, Hey et al. surveyed students in a multidisciplinary class and conducted interviews with industry partners. The study showed the importance of working in multidisciplinary design teams using the new product development process. Another conclusion was the importance of emphasizing “softer” skills.

“Teaching High School and College First-Year Students Prod-

uct Development by Deterministic Design With PREP” is the subject of the paper by Graham, Slocum, and Moreno Sanchez. Some ten years ago, these authors postulated that students can learn a deterministic design process not only to learn about design but also to better study science and math with peers. The work of individuals is followed by a Peer Review Evaluation Process (PREP) prior to the brainstorming by the students. In addition to several significant outcomes, it was found that this process is especially useful for diverse teams of designers.

The infusion of design into the curriculum through an eight-semester course sequence called the engineering clinics is articulated in the paper “Integrating Design Throughout the Mechanical Engineering Curriculum” by Kadlowec, Bhatia, Chandrupatla, Chen, Constans, Hartman, Marchese, von Lockette, and Zhang. Through this sequence students learn the art and science of the design process in a multidisciplinary team environment. The paper presents the results of assessment of the engineering clinics based on survey data and accreditation objectives and outcomes. These clinics were found to be a positive and integrated design experience in the curriculum which assists students in achieving the program objectives.

Next, in “Assessing Student Team Performance in Industry Sponsored Design Projects,” Keefe, Glancey, and Cloud, describe the experiences and lessons learned in assessing student performance in team-based project courses. A set of rubrics linked to the instructional objectives was developed that defines and communicates expectations during the three phases of the project process. These phases include synthesis of a valid concept, management of resources, and interaction and communication.

Leary and Burvill have focused on Quality Function Deployment (QFD) in the paper titled: “Enhancing the Quality Function Deployment (QFD) Conceptual Design Tool.” Research has shown that customer satisfaction can be improved while design time and cost can be reduced through the use of QFD. The authors have observed that this method produces impediments for novice designers. They report on a series of enhancements that have been developed to overcome these impediments and to assist the robust transfer of QFD capabilities to novice designers. A novel method has been developed to overcome the limitation by enabling the inclusion of design constraints.

Another “experiential” paper describes the findings from an empirical study that was carried out with engineers in senior roles. The objective was to determine the knowledge set that is important for design engineers. The paper by Ahmed, “An Industrial Case Study—Identification of Competencies of Design Engineers,” found that knowledge related to the process was perceived as more important to those related to the product itself. It was also found that it took less time to gain experience in the “process” than in the “product.”

McKenna identifies that the transfer of knowledge is a “topic of central importance to the education community because it enables educators to understand how knowledge learned in one context can apply or transfer to new contexts.” Focusing on the transfer of knowledge brings a learner-centered approach to education such

that learning experiences are designed to reinforce and build on students' prior knowledge. This is examined in detail in the paper "An Investigation of Adaptive Experience and Transfer of Design Process Knowledge."

Field's paper, "Visualization, Intuition and Mathematics Metrics as Predictors of Undergraduate Engineering Performance," addresses the difficulties experienced by many engineering students who are academically strong but struggle in design courses. On the other hand, some "average" students perform exceptionally well in design classes. One of the findings of this research indicated that "while general academic competence was of prime importance, a student's spatial skill and their comfort in making assumptions were important factors in predicting their design success."

Sahin, Boe, Terpenney, and Bohn investigated whether illusions play a role in understanding discrepancies among the media in different product development stages in the paper, "A Study to Understand Student Perception and Model Discrepancies Using Visual Illusions and Data Evaluation Analysis." Since product developers in many cases rely on different display media for design realizations, discrepancies in how a product is perceived in different display media could be costly and time consuming. In order to better understand these discrepancies, a two-step Data Envelopment Analysis approach was used to identify the trends of how two illusions affected the shape perception. Specific insights were extracted for both educating student designers and training professionals.

An exploratory study that transfers lessons on creativity and the use of CAD tools from an industry case study to engineering design education is presented in the paper, "Creativity and the Use of CAD Tools: Lessons for Engineering Design Education From Industry," by Robertson, Walther, and Radcliffe. They found four influences on the use of CAD on creativity of designers and "the one positive and three negative effects were confirmed by a theoretical investigation of creative problem solving in engineering design."

What factors impede a creative environment in engineering design? This is a question asked and answered by Floey and Kazerounian in their paper, "Barriers to Creativity in Engineering Education." Research was conducted in the fields of psychology and educational psychology to identify the factors that create an edu-

cational environment conducive to creativity. "Ten Maxims of Creativity in Education" provides a set of criteria that form the basis of the authors' work in judging current engineering design education. Surveys were conducted that did not show positive results when evaluated in light of engineering students' academic experience.

A major trend in the implementation of the product realization process has been the extrapolation of the design of prototypes to innovation and the development of business plans. McAloone describes how this has been addressed at one institution since the year 2000 in the paper, "A Competence-Based Approach to Sustainable Innovation Teaching: Experiences Within a New Engineering Program." He addresses the emphasis that Scandinavian countries place on innovation and sustainability. In 2002, a five-year Bachelor-Masters program was formulated and launched that runs in parallel with the existing mechanical engineering program. The lessons learned from the first three years of this application are presented and discussed.

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