

Guest Editorial: The 2016 Capstone Design Conference

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The goal of the 2016 Capstone Design Conference held in Columbus, OH was to build upon the success of previous conferences (2007 and 2010 in Boulder, CO, 2012 in Champaign, IL, and 2014 in Columbus, OH) and expand the community of educators, students, and industry members engaged in discussing, analyzing, and improving capstone design education. Sessions at the 2016 Capstone Design Conference were designed for vibrant sharing of ideas and experiences across the capstone community via interactive panel sessions, poster session socials, hands-on workshops, and other formal and informal networking activities. This editorial discusses conference planning, structure, and feedback. Technical papers that follow in this issue document scholarship surrounding noteworthy capstone course innovations. Most of these began as four page peer-reviewed papers included in the conference proceedings.

Keywords: capstone design courses; design pedagogy; capstone conferences; capstone community

1. Introduction

The goals of the 2016 Capstone Design Conference were to continue to attract capstone design community members (capstone design educators and administrators, industry sponsors, students, and other stakeholders), share best practices, and identify methods to improve capstone design education. The conference was held June 6 to 8, 2016, in Columbus, OH, USA. Specific conference information, including the complete conference program and early versions of many papers appearing in this special issue, is available at the Capstone Conference website (www.capstoneconf.org). The papers in this special issue represent a cross-section of best practices and topics of interest to capstone design course stakeholders as well as design researchers.

2. Conference design/planning

Planning for the 2016 Capstone Design Conference began formally at the end of the capstone conference in 2014, with the establishment of an organizing committee representing different institutions and a range of engineering and related disciplines. Following good design practice, the Organizing Committee solicited input from capstone design instructors and representatives from industry at a special planning session at ASEE 2015. Attendees of this session were surveyed about their experiences in capstone courses and asked to suggest topics of interest to the capstone design community. The Organizing Committee specifically solicited feedback to indicate how the Capstone Design Conference could help improve capstone design courses. Feedback from attendees indicated a preference for

maintaining the format of previous conferences to allow for interactive discussion and networking opportunities with other capstone design community members at the 2016 conference.

3. Conference structure

The 2016 Capstone Design Conference contained many of the standard conference components, including papers, posters, panel discussions, and workshops. All of the submitted papers underwent a peer review process. The conference was intentionally structured to enable and facilitate discussion and interaction beyond what occurs at many academic conferences. The bulk of the conference consisted of highly interactive, facilitated panel sessions on topics of interest to the capstone design community. Most panel sessions focused on topics addressed by authors of accepted papers. Some panels were targeted toward faculty, administrators, and industry representatives whereas others were targeted to the student attendees, although all panels included a mix of attendees in the audience. Panel facilitators engaged the panelists and the audience in discussions guided by prepared questions and issues raised by the audience. Panel sessions were clustered around several themes, as noted below:

PERFORMANCE ASSESSMENT

- *What I Wish I Had Known . . . (A Student's Perspective)*
- *ABET & Capstone*
- *EPICS Panel*
- *Capstone Expos*

PROJECT SELECTION & ADMINISTRATION

- *International Capstone Projects*
- *Design Challenges and Competitions*
- *Corporate Sponsored Projects*
- *Project Management*
- *Difficult Conversations*
- *Roles and Responsibilities in Capstone*

CAPSTONE COURSE DESIGN

- *Systems Engineering in Capstone*
- *Prototyping in Capstone*
- *Entrepreneurship in Capstone*
- *Nifty Ideas and Surprising Flops*

CAPSTONE INSTRUCTIONAL PRACTICES

- *Encouraging Creativity in Capstone Design*
- *Multidisciplinary Model for Capstone Success*
- *Enhancing Capstone Success*
- *Tips for Teaching Capstone*

Rather than many short presentations, authors of accepted papers displayed posters in two conference-wide poster sessions. Thirty five posters showcased conference papers by capstone design faculty, and twenty five posters highlighted recent capstone design projects by students. Poster topics included design reviews, project sourcing and scoping, writing and communication, supporting capstone design teams, assessment and project scoring, sponsorship agreements and external relations, peer review and cooperative learning, intellectual property, virtual teams, competition teams, and entrepreneurship in capstone design. These posters addressed both key components of cutting edge capstone design programs and current challenges faced by capstone design educators, students, and sponsors. The combination of interactive panel and all-conference poster sessions provided attendees with multiple opportunities for interaction, networking, and sharing of best practices.

The conference featured eight workshops spread across the conference, some over boxed dinners and others in the morning run concurrently with optional tours. Workshops ranged from the broad (*User-Oriented Assessment Tools for Industry Sought Learning Outcomes*), to the specific (*Using the Constraint Source Model to Manage ABET Design Expectations*). Two workshops focused on training and support for capstone faculty: *Capstone Project Scoping and Negotiation with Prospective Clients*, and *IEEE Workshop on Technical Standards*. Two workshops addressed resources for capstone design teams: *Idea Generation with Design Heuristics* and *Reflection in Engineering Courses: Focus on Capstone*. Two workshops provided hands-on exposure to specific technical or pedagogical tools: *Rapid Design of Embedded Systems with NI myRIO* (led by National Instruments representatives) and *Hands-on Workshop with Matlab, Simulink, and Raspberry Pi* (led by MathWorks representatives). All workshops provided opportunities for in-depth learning of new tools, methods, and best practices.

The 2016 Capstone Design Conference included many sponsors and exhibitors including the American Society for Engineering Education—Design in Engineering Education Division (DEED), ASTM International, IEEE, National Instruments, VentureWell, KEEN, OnShape, PMI, and Verity Design Learning. Many of the sponsoring organizations sent representatives to the conference who not only exhibited products and services of interest to capstone design faculty and students, but facilitated workshops and/or participated in panel discussions and networking activities.

The first day of the conference featured a keynote address called *The 2015 Capstone Design Decennial*

Survey: Current Practices and Trends over Time. Susannah Howe, Design Clinic Director in the Picker Engineering Program at Smith College, presented data from the 2015 national survey of capstone design programs and compared the results to the national surveys in 1994 and 2005. The presentation prompted discussion as the audience discussed the trends.

The 2016 conference continued the tradition of student involvement, reflecting students' key role in capstone design. Based on previous successful conferences, the organizing committee created two main paths for student participation in the 2016 conference: (1) capstone design project posters and (2) student panelists. Twenty-five student projects, representing a breadth of engineering disciplines, were selected from a pool of nominated projects. Additionally, eleven students served as panelists on the conference panels, one of which was entitled *What I Wish I Had Known* and featured students exclusively. Student involvement was again made possible by the generosity of multiple conference sponsors. Sponsorship funds offset the costs of student travel, helped pay conference expenses, and made reasonable registration fees possible.

In addition to poster, panel, and workshop sessions, the conference incorporated a wide range of networking activities and conversations. On the morning of the first day, the conference opened with a plenary session including a high-energy juggling activity in groups; the first day ended with an informal social gathering over microbrews to connect newer members of the capstone design community with more seasoned colleagues. The next morning featured two workshops, optional local tours and activities, and "office hours" with a current NSF DUE program director. Lunch on the second day was conducted in "Birds of a Feather" style, in which attendees joined groups according to topics of interest proposed in advance by session attendees. The third morning started bright and early with an optional run/walk around the OSU campus. The conference organizers also offered a series of "Quests" (and associated prizes) throughout the conference to encourage participants to fully experience the conference, make social and networking connections, explore local activities, and have fun. The conference concluded with an all-conference session that recapped the highlights of the conference and began a discussion of next steps.

4. Conference attendance and feedback

The 2016 conference was attended by approximately 200 people from five different countries. This included faculty, students, administrators,

industry and government representatives, and other interested stakeholders. The academic participants represented nearly 90 universities. Multiple engineering and other technical disciplines such as aerospace, biomedical, civil, chemical, computer, electrical, environmental, industrial, mechanical, and software engineering were represented, as well as industrial design, computer science, business, and others.

According to responses to the conference survey collected after the closing session, attendee feedback was very positive overall. Many attendees commented that the conference was well-organized and that they really enjoyed and learned from the experience. Attendees most appreciated networking opportunities, interactive session formats, diversity of panels and workshops, benchmarking and getting advice, and open discussion and collaboration. Some of the new and useful ideas that attendees stated they would take away from the conference and implement were as follows: systems engineering principles, reflection in capstone, peer evaluations and performance reviews, weekly team progress summaries, the transition vs. culmination philosophy for capstone, ethics in capstone, resources in place of textbooks, and new methods for ideation and design. Regarding take-aways, several attendees noted they had "too many to list". Attendees suggested multiple ideas for even more effective meetings, including providing more breaks and open time for discussion, coordinating more formal networking, including a capstone "open mic" and/or lightning round session for quick sharing, adding an app for the conference schedule, and planning more sessions with/for students and capstone support staff. Multiple attendees commented that they were already looking forward to the next conference.

5. Next steps

Future Capstone Design Conferences are planned for alternating (even-numbered) years, with the next conference to be held at Rochester Institute of Technology, Rochester, NY, June 4–6, 2018. During odd-numbered years, informal gatherings of the capstone design community may be held during the summer meeting of the American Society for Engineering Education (ASEE). These informal gatherings at ASEE include opportunities for networking within the capstone design community and discussion of future conference sessions ideas and structure. Feedback from previous conference attendees will also be considered to continuously improve the experience of future conference attendees. After each biannual Capstone Design Conference we plan to publish a special issue of a journal

showcasing the best papers and sessions from that conference, just as this issue of *IJEE* represents highlights from the 2016 Capstone Design Conference. Our long-term goal is to grow the community

of capstone design faculty and staff, industry sponsors, and other stakeholders, so as to enable continuous improvement of capstone design education.

Patsy Brackin is a Professor of Mechanical Engineering and Director of Engineering Design at Rose-Hulman Institute of Technology. She earned a B.S. and M.S. in Nuclear Engineering from the University of Tennessee, and a Ph.D. in Mechanical Engineering from Georgia Institute of Technology. Dr. Brackin is also a licensed professional engineer. She has been very active in ABET Accreditation and has held a variety of volunteer roles with ABET. Her current passion is teaching design in a studio setting throughout the curriculum. The studio setting integrates multiple disciplines, including humanities and social sciences, while students solve authentic design problems.

Susannah Howe is the Design Clinic Director in the Picker Engineering Program at Smith College, where she coordinates and teaches the capstone engineering design course. Her current research focuses on innovations in engineering design education, particularly at the capstone level. She is invested in building the capstone design community; she is a leader in the biannual Capstone Design Conferences and the Capstone Design Hub initiative. She is also involved with efforts to foster design learning in middle school students and to support entrepreneurship at primarily undergraduate institutions. Her background is in civil engineering with a focus on structural materials. She holds a B.S.E. degree from Princeton, and M.Eng. and Ph.D. degrees from Cornell.

Peter Rogers is a Professor of Practice, joining Ohio State in October 2008. He applies 35 years of industrial experience in developing and teaching experiential, multidisciplinary learning. Rogers developed a multidisciplinary capstone design course, a social innovation and commercialization program, and the Integrated Business and Engineering Honors program. All programs focus on developing industry-sought learning outcomes by applying teams to solve open-ended problems—gaining skills in critical thinking, professional communication, ethics, business acumen, risk taking, and teamwork. Multidisciplinary teams, including engineers, business, design, and other students, develop products and markets in client-sponsored projects. Rogers earned his PhD at the University of Massachusetts, Amherst focused on mechanical engineering and manufacturing.

R. Keith Stanfill is the Director of the University of Florida's Integrated Product and Process Design Program—an industry-sponsored multidisciplinary capstone design and build course. IPPD is celebrating 22 years of success, with 16 of those years under Dr. Stanfill's leadership. He received his B.S., M.E., and Ph.D. degrees in mechanical engineering from UF in 1985, 1991 and 1995, respectively. He joined the UF Industrial and Systems Engineering faculty in 1999 as the IPPD Associate Director and was promoted to IPPD Director in 2001. In Fall 2013, he joined the Engineering Innovation Institute. His interests include technology transfer, entrepreneurship, product development, design education and Design for X. Dr. Stanfill has over ten years' industrial experience with United Technologies Corporation and is a registered professional engineer in the state of Florida.

Steven Beyerlein is a Professor of Mechanical Engineering at the University of Idaho where he has played a leadership role in the development of an inter-disciplinary capstone program over the last twenty years. Dr. Beyerlein earned a B.S. in Mechanical Engineering from the University of Massachusetts, an M.S. in Engineering Science from Dartmouth College, and a Ph.D. in Mechanical Engineering from Washington State University. Since joining the University of Idaho in 1987, Dr. Beyerlein has been an active participant in a long line of engine development and demonstration vehicle realization projects supported by the National Institute for Advanced Transportation Technology. He has also been highly engaged in a variety of research teams focusing on assessment of design learning, peer mentoring, active learning pedagogies, and faculty development for project learning.

Junichi Kanai is the Associate Director of the Design Lab and Professor of Practice in the Electrical, Computer, and Systems Engineering department at Rensselaer Polytechnic Institute (RPI). He has been teaching multidisciplinary engineering design courses and supervised over 100 capstone design teams since 2004. Dr. Kanai brings a variety of practical industrial experience to undergraduate courses as he draws from his experience as a research scientist, manager of a research group, and manager of a product development group of an international company. His current research focuses on adapting teaching strategies to a rapidly changing student population. Dr. Kanai received his BS in Electrical Engineering, and M.Eng. and Ph.D. in Computer and Systems Engineering from RPI.

Jim Vallino has academic and industrial experience across a broad range of engineering disciplines. His academic training includes a BE in Mechanical Engineering from Cooper Union, an M.S. in Electrical and Computer Engineering from the University of Wisconsin—Madison, and after more than 16 years in industry, an M.S. and Ph.D. in Computer Science from the University of Rochester. While in industry, he did both hardware and software product development and industrial research. Since 1997, he has been a faculty member in Rochester Institute of Technology's Department of

Software Engineering, serving as chair, undergraduate program coordinator, and the leader of four accreditation reviews. Since 2002, he has coordinated the Software Engineering Senior Project program. In 2010, he received RIT's Eisenhart Award for Outstanding Teaching.

Scott E. Palo is the Victor Charles Schelke Professor of Aerospace Engineering Sciences and the Associate Dean for Research in the College of Engineering and Applied Science at the University of Colorado Boulder. His research focuses on studying the near earth space environment, constructing small satellites to conduct space physics and developing scientific instruments for unmanned aerial systems. Dr. Palo has worked closely with student design teams to design, build, test, launch and operate multiple small satellites. His educational interests focus around hands-on experiential learning and include both graduate and undergraduate team based design courses. Dr. Palo earned a B.S. in electrical and computer engineering from Clarkson University and M.S. and Ph.D. in electrical engineering from the University of Colorado Boulder. He is a senior member of the IEEE, an associate fellow of the AIAA and a member of URSI and Sigma Xi.