
AC 2012-4369: CAPSTONE DESIGN HUB: BUILDING THE CAPSTONE DESIGN COMMUNITY

Dr. Marie C. Parette, Virginia Tech

Marie C. Parette is an Associate Professor of Engineering Education at Virginia Tech, where she co-directs the Virginia Tech Engineering Communications Center (VTECC). Her research focuses on communication in engineering design, interdisciplinary communication and collaboration, design education, and gender in engineering. She was awarded a CAREER grant from NSF to study expert teaching practices in capstone design courses nationwide, and is Co-PI on several NSF grants to explore design education. Her work includes studies on the teaching and learning of communication in capstone courses, the effects of curriculum on design cognition, the effects of differing design pedagogies on retention and motivation, and the dynamics of cross-disciplinary collaboration in both academic and industry design environments.

Prof. Susannah Howe, Smith College

Susannah Howe, Ph.D. 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 international capstone community and served as Co-chair of the 2010 and 2012 Capstone Design Conferences. 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.

Prof. Steve Blair, University of Utah

Dr. Peter Rogers, Ohio State University

Peter Rogers is Professor of Practice, Engineering Education Innovation Center, the Ohio State University, Columbus, OH 43210. Email: Rogers.693@osu.edu. Rogers joined the university in Oct. 2008, bringing with him 35 years of industrial experience. Beginning with a foundation in product development leadership in the robotics industry, Rogers continued with assignments in contract research working at Battelle, Edison Welding Institute, and founding his own consulting business. The last third of his industrial career included leadership roles in engineering, sales, and manufacturing in the electronics, sensors, and controls industry. Prior to joining the university, Rogers founded a second company and created an inspection product and service targeting the public transportation industry. Throughout his career, Rogers has developed products using an innovative process consisting of multidisciplinary teams focused on understanding customer needs and converting them to commercially viable products and services. He brings this experience to the university where he leads the effort in developing company-sponsored, product-oriented capstone design programs. As part of the mission of the Engineering Education Innovation Center (EEIC), Rogers has led the development of an ABET-approved curriculum for a year-long Capstone experience. With a focus on providing students with a broader experience base, the multidisciplinary program applies teams of engineers, business, design, and other students to work with Ohio companies to help them be more competitive. Teams apply a company's core competencies to help develop new products and markets. This experiential learning emphasizes real-world problem solving, professional communication and ethics, teamwork, and implementation of a formalized design process. Additionally, Rogers has created the Social Innovation and Commercialization initiative by collaborating with business, engineering, and design colleges. This program applies multidisciplinary student teams to define, design, and commercialize products for people with disabilities. Partnering with local non-profit organizations, teams define unmet problems working with people with various disabilities, problems that can be solved with an innovative product. The student teams apply a co-design process working with end users to fully understand the problem and to assist in the overall design and validation process. The educational goal is to provide experiential learning with a social outreach. The social goal is to produce product income to help non-profit partners become self-sustaining while improving the independence of people with disabilities. Rogers earned his Ph.D. at the University of Massachusetts, Amherst, focused on mechanical engineering and manufacturing. He has presented a number of industrial conference papers and holds several patents. He is currently the Co-chair of the organizing committee for the 2012 Capstone Design Conference and a member of the CDHub web development team. He holds the position of Professor of Practice at the Ohio State University.

Prof. Junichi Kanai, Rensselaer Polytechnic Institute

After seven years with the Information Science Research Institute, University of Nevada, Las Vegas, where he was an Associate Research Professor, Junichi Kanai joined Panasonic Information and Networking Technologies Lab in 1998. He was a Senior Scientist developing and transferring new technologies to product divisions. From 2002 to 2004, he was a manager at Matsushita Electric Corporation of America (Panasonic), providing system integration and software development for clients. Kanai joined Rensselaer Polytechnic Institute (RPI) in 2004. He is currently Associate Director of the O.T. Swanson Multidisciplinary Design Laboratory and Professor of Practice of in the Electrical, Computer, and Systems Engineering Department. His responsibilities include managing the operation of the design lab and optimizing the experience for students working on engineering design projects.

Dr. R. Keith Stanfill, University of Florida

R. Keith Stanfill holds the academic rank of Engineer and serves as the Director of the Integrated Product and Process Design (IPPD) Program for the Industrial and Systems Engineering Department at the University of Florida (UF). 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 faculty in 1999 as the IPPD Associate Director and was promoted to IPPD Director in 2001. IPPD is an experiential multidisciplinary design program where teams of students complete real projects for sponsoring companies and agencies. Stanfill has recruited more than 250 industry-sponsored projects and directed the efforts of more than 1,600 senior-level engineering and business students for the IPPD program. In 2003, he helped create the Integrated Technology Ventures (ITV) program and serves as Chair of the ITV Board of Directors. The ITV program exposes students to the realities of technology start-up companies while assisting UF researchers in commercializing their technological innovations. Virtual companies comprised of engineering, business, and law students identify market opportunities, develop business plans, and produce prototype systems. Each ITV team is led by an experienced entrepreneurial CEO and features hands-on guidance from engineering, business, and law faculty. Prior to joining UF, Stanfill spent 10 years with United Technologies where he designed gas turbine hardware for fighter aircraft, served as a key resource to the Carrier Corporation New Product Development Council Steering Committee, facilitated Design for X (DFx) workshops internationally, developed business process linkages between new product development and lean manufacturing, and developed and implemented manufacturing systems software. His interests include technology transfer, product development, design education, DFx, and entrepreneurship. He is a registered Professional Engineer in the state of Florida and is a member of the American Society of Mechanical Engineers, the American Society of Engineering Education, the Institute for Industrial Engineers, the UF Faculty Senate, and the UF College of Engineering Faculty Council. He has served on the organizing committee for the 2007, 2010, and 2012 Capstone Design Conference. He volunteers his time as a judge in the Alachua Region Science and Engineering Fair and the Junior Science, Engineering, and Humanities Symposium, as well as serving as the booster club President and volunteer goalkeeper coach for the Buchholz High School Lady Bobcats soccer team.

Dr. Glen A. Livesay, Rose-Hulman Institute of Technology

Capstone Design Hub: Building the Capstone Design Community

Abstract: Capstone design courses are common across engineering programs nationwide. Yet, many departments and programs rely on one faculty member or a small handful of faculty members to teach their capstone design course. As a result these faculty members find themselves isolated, with limited mechanisms for sharing ideas and networking with peers who have similar responsibilities and concerns. This paper reports on the ongoing efforts to support the broader capstone design community through the development of the Capstone Design Hub (CDHub) as a web resource for capstone design programs. The features and structure of the CDHub are being developed through capstone faculty input, including results from a survey of the capstone community. To build awareness of the CDHub as well as to solicit additional feedback from the community, this paper describes development of the hub to meet community needs, initial population of the hub with resources focused on communication, and plans for continued expansion of the hub.

Introduction: The Need for a Capstone Hub

The inaugural National Capstone Design Course Conference was held in June 2007 to bring together, for the first time, a broad range of capstone design faculty from across the country and even internationally. About 170 faculty, students, administrators, and industry representatives discussed, shared, and learned about capstone design throughout the conference. The enthusiasm from this conference led to a second conference in June 2010; the 2010 Capstone Design Conference included roughly 200 attendees from 89 institutions, representing a wide spectrum of engineering disciplines and capstone design programs. The 2012 Capstone Design Conference is scheduled for May 30-June 1, 2012, and plans are in place to hold such conferences biennially with the conference themes evolving to promote continued discussions and collaboration.

One outcome of the 2010 Capstone Design Conference was consensus recognition of the need for better documentation and dissemination of effective practices and other resources across multiple aspects of capstone design programs. Recent survey results suggest that capstone faculty do not tend to actively participate in discussions around design education, whether through attending conferences or education-based workshops, reading design education literature, or engaging in the scholarship of teaching and learning through publishing.¹ As a result, the extensive body of scholarship on effective design teaching that has been presented at conferences such as ASEE and published in academic journals has failed to make its way into capstone classroom practice in any sustained or systemic way.

Yet surveys also show a high consensus around core topics, including communication, as well as commonalities in team structures, desired learning outcomes, and course goals,²⁻⁴ suggesting that many faculty could benefit from shared resources, and that new capstone faculty in particular may not need to "reinvent the wheel" when they take on capstone courses. Given these course commonalities, the relative isolation of capstone faculty within departments, and the atypical nature of the capstone learning environment that depends more strongly on mentoring than traditional lecturing, the authors of this paper are developing a Capstone Design Hub (CDHub), with initial funding from the Engineering Information Foundation. The CDHub is intended to serve as a web resource for capstone faculty to provide centralized access to effective tools and

practices developed by teachers and researchers across the country, beginning with tools to facilitate the development of students' communication skills, as discussed below.

Design of the Hub: Requirements and Specifications

Overall Goals

The CDHub is being designed to serve the needs of a variety of constituents, including

- Professors and instructors of capstone design courses
- Faculty advisers/coaches for student capstone design teams
- Industrial and external sponsors/liaisons for capstone design projects
- Students participating in capstone design projects/teams
- Academic staff who support capstone design programs.

To meet the needs of these audiences, the CDHub will include a wide range of resources, including

- Sample syllabi
- Sample assignments, including assessment rubrics, guidelines for providing feedback, and tips for implementation
- Videos or related teaching modules for common topics
- Effective practices for mentoring teams
- Strategies for engaging industry sponsors (including sponsor contracts, non-disclosure agreements, and related documentation as well as tips for facilitating the sponsor/team relationship)
- Project success stories with strategies for effective practice
- Discussion forums to facilitate collaboration and sharing of ideas among faculty

Feedback and Contributions from the Design Education Community

Additional items may be included in the CDHub based on the results of a capstone community survey being administered in Spring 2012. The survey focuses on materials related to communication, but also addresses the degree to which respondents envision using and contributing to the CDHub. Questions solicit information regarding the content areas users would like to see (e.g. written reports, oral reports), the types of information they need (e.g. assignments, grading rubrics, research studies), use of the CDHub as a way to find and support multi-institution collaboration, and willingness to contribute materials to the hub.

Once the site goes live, the CDHub will solicit user-generated content, but in order to keep the site usable for the wide variety of capstone faculty, submissions will be structured to provide easily searchable metadata, and all submissions will be reviewed by an editorial team/moderator for appropriateness and completeness of metadata. Importantly, a critical issue for CDHub users is not just *finding* information – search engines easily yield thousands of hits on any topic – but finding *useful* and *effective* information that meets their needs and provides sufficient context to support successful implementation and adaptation. The generation of metadata and the review of submissions are intended to support these goals.

Design of the Hub Structure

To begin the design of the CDHub structure, the development team reviewed a variety of existing hub sites, including but not limited to those associated with educational endeavors. The hubs reviewed included

- NanoHub
- e-Corner
- CLEER Hub
- NCIIA
- WAC Clearinghouse
- TED
- Wikipedia
- Edutopia
- Engineering Pathway
- Concept Inventory Hub
- NI Academic
- NI Developer Zone

The development team evaluated the hubs based on accessibility of content, aesthetics and ease of use, credibility, and features that aligned with the CDHub goals. Two hubs that emerged as strong models were Stanford's eCorner (<http://ecorner.stanford.edu/index.html>) and NI Academic (<http://www.ni.com/academic/>). Desirable site features that emerged from this review include the ability to support user-generated content, a horizontal navigation structure and layout, hierarchical organization by topic, the inclusion of video resources, and a keyword search feature that allows users to access content not easily visible from the top-level navigation. Given the scope of resources planned for the CDHub, ease of navigation and the ability to quickly access relevant information are critical.

Phase 1: A Focus on Communication

As noted earlier, a grant from the Engineering Information Foundation is supporting initial development of the CDHub and preliminary population of the hub with resources focused on teaching and learning of communication in capstone design courses. Communication is consistently among the top five topics capstone faculty report teaching,^{2,3} and it is the most frequent means of assessment in capstone design courses⁴; given its centrality, it promises to serve as a useful introduction to the CDHub for many capstone faculty.

In providing tools to support communication teaching and learning, the CDHub will provide general research-based guidelines for assignment design, feedback, and assessment, as well as specific samples covering a range of common documents and audiences. Figure 1 presents a preliminary view of possible topics that the development team hopes to include, stratified by both project phase and target audience.

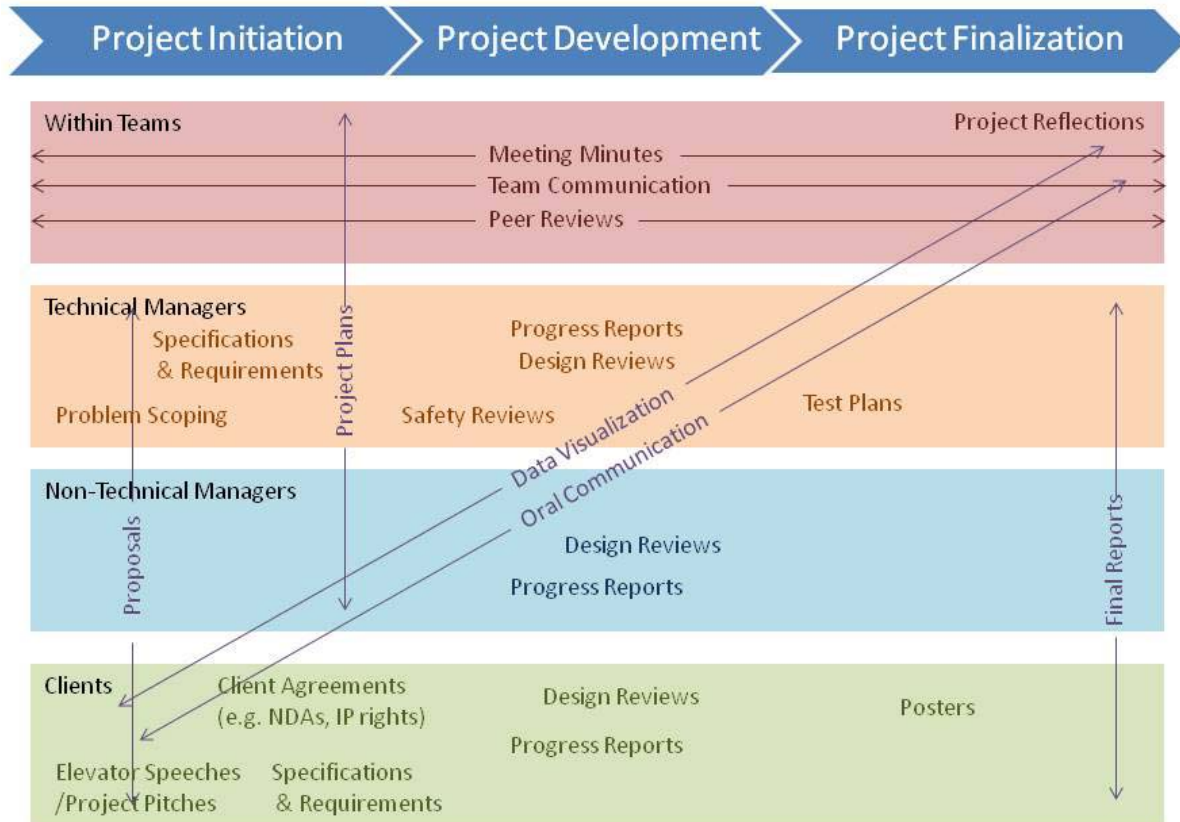


Figure 1: Potential Communication Topics Supported by the CDHub

The development team will use the results of the capstone community survey to prioritize topics, solicit exemplar resources, and begin populating the CDHub with content. Ongoing feedback from the community is critical to monitoring the value and usability of the CDHub as it develops into a meaningful site for the design education community. The inclusion of implementation reports (i.e. information from faculty of where and how they used particular tools, along with the results) and user rating systems will help structure this feedback and provide a means to support the development of a dialogue among design faculty.

Conclusions and Next Steps

In creating the Capstone Design Hub, the development team seeks to create an electronic resource that can both support individual faculty as they teach capstone design courses and build a strong peer community that enables capstone design faculty to engage with one another to advance design education more broadly. The CDHub will also provide continuity between the biennial capstone design conferences and serve as a repository for exemplar capstone resources. Reports such as the Carnegie Foundation's recent book, *Educating Engineers: Designing For the Future of the Field*,⁵ consistently emphasize the need to integrate professional practice into the curriculum. Capstone educators have long been leading the way in this effort, and the CDHub is a critical tool for sharing and disseminating our expertise.

Acknowledgements

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