

Emerging Leadership Content in Capstone Design Curriculum at the University of Georgia

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Current literature in engineering education suggests that the typical engineering curriculum does not provide experiences representative of many of the challenges encountered in the professional work place. Because of institutional and other pressures to reduce the total number of credit hours required for graduation, engineering schools must focus classes emphasizing the technical aspects of engineering at the expense of other important topics including professional ethics, entrepreneurialism, leadership, and teamwork. This can lead to professional struggles for new engineering graduates as they may be unprepared to make the transition from the role of engineering student to that of a practicing engineer. As with most capstone courses elsewhere, UGA students solve the technical components of a design project, learn how to manage time and other resources, develop communication skills, and learn to work cooperatively with peers. In addition to these experiences, UGA capstone courses offer other learning experiences that help students understand their future role in the professional work place, develop confidence in their interpersonal skills (and not just their technical skills), create strategies to cope with stress from both professional and personal sources, and cultivate reasonable expectations for their early careers. Unique to this program are collaborations with UGA outreach entities with missions of developing leaders and solving community development issues all across Georgia. UGA students eagerly engage in this unique course structure, and faculty have confidence they leave campus well prepared to be effective, productive, and confident in their emerging careers.

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Introduction

Current literature in engineering education suggests that the typical engineering curriculum does not provide experiences representative of many of the challenges encountered in the professional work place^{1, 3, 4}. Because of institutional and other pressures to reduce the total number of credit hours required for graduation, engineering schools must focus on classes emphasizing the technical aspects of engineering at the expense of other important topics including professional ethics, entrepreneurialism, leadership, and teamwork which must then be learned on-the-job^{1, 2}. The objective of the engineering ethics and leadership program at UGA is to introduce, explain and reinforce engineering business and leadership principles through experiential learning design projects and student centric leadership training.

The University of Georgia (UGA) College of Engineering formed in 2012 offers undergraduate engineering degrees in Agricultural, Biological, Biochemical, Civil, Computer Systems, Electrical,

Environmental and Mechanical Engineering. Student enrollment in this new college has increased over 300% from 600 to over 2,200 students between 2012 and 2017. The newness of these programs offers unique opportunities to craft a curriculum comprehensively, addressing the technical engineering content required of graduates, while also incorporating professional skills required of graduates in the workplace. While students typically register for their specific degree program's capstone design course, the college has made significant effort to ensure that capstone design projects are performed in a comingled manner allowing for students from multiple degree programs to work on interdisciplinary teams.

The UGA senior capstone design course is a required two-semester, two credit hour per semester course. Multiple faculty coordinate the capstone design course with students teamed to work on the projects with a faculty mentor and an industry/faculty sponsor. In addition to the traditional design class,

all students participate in six to nine modules related to development of leadership skills taught by faculty from the J.W. Fanning Institute for Leadership Development at UGA. These instructional modules introduce many “professional” engineering and leadership development ideas to students – concepts that are not usually represented well in engineering curricula. While a pilot version of the Emerging Engineers Leadership Development (EELD) program was initiated in the 2016-2017 academic year for the Civil and Environmental Engineering degree programs, the leadership program has been implemented college wide such that all students enrolled in the capstone course sequence will have participated and completed the leadership certificate program.

Capstone Design – Description and Content

Senior College of Engineering students at UGA are required to enroll in a Capstone Design Project course. They work in assigned teams on design problems requiring the synthesis of material learned in previous engineering courses. Design teams work independently under the administration of the course instructors and in many cases with an engineering practitioner to complete an effective, creative and appropriate design addressing challenges with input and participation from project stakeholders. The student design solutions are open-ended and self-directed (with some guidance by a faculty advisor and engineering practitioner). Ethics, leadership, and collaborative engineering design are important aspects of projects, and ultimately the course, which receive significant lecture and student reflection time. Knight and Novoselich conclude that a more intentional treatment of leadership skills in engineering curriculum will better prepare students for meaningful roles in the workplace⁷. The UGA capstone structure includes two major areas for individual student development: training in the various leadership styles and real-world, client-based design projects.

Emerging Engineering Leadership Development (EELD) Certificate Program

The leadership certificate program is new for the 2017-2018 academic year, although a pilot program was initiated the previous year for the Civil and Environmental Engineering programs. Most UGA engineering students participate in six – one-hour learning modules administered by the J.W. Fanning Institute for Leadership Development – a UGA Public Service and Outreach unit dedicated to strengthening communities, organizations, and individuals across the state through leadership development, training, and education. Specific leadership training modules utilized college wide include:

- Creating My Leadership Vision,
- Exploring Leadership Styles,
- Making Group Decisions,
- Managing Conflict,
- Developing Personal Accountability, and
- Risk and Entrepreneurial Innovation.

In addition, the Civil and Environmental Engineering degree programs have three additional one-hour Fanning learning modules including:

- Working across Generations,
- Engaging in Community, and
- Communicating in a Virtual World.

The EELD program teaches that everyone has leadership potential and encourages students to develop personal leadership skills that can serve them regardless of their positional leadership role in their capstone group project and career. One goal of the EELD program is to help students understand leadership development as a personal journey of reflection and provide them with opportunities to use the skills being taught in their team projects and client interactions. Each session reinforces the need to recognize their own responses and choices and those of their peers and colleagues in communication, conflict, decision-making, and other topics, in order to be more intentional in how they lead and follow in real-world engineering contexts. The leadership modules were delivered in an interactive lecture format that included at least one activity or in-class assessment that allows students to consider an element of the leadership topic from their own perspective, as well as the perspectives of their peers. Leadership modules are preceded by an online activity referred to as the “Get in Gear” assignment which can include viewing a video, completing an assessment, or responding to a topic-specific prompt on the class discussion board. These “Get in Gear” assignments were designed to capture students’ thinking on the topic before the session as an informal pre-assessment that allowed for their own reflection and observation of their peers’ thinking as well. In addition, students were given a “Keep the Wheels Turning” assignment that asked them to consider how the concepts learned in the class session applied to their capstone project and future engineering work. Students were required to submit the “Get in Gear” assignments as part of their capstone grade, but the “Keep the Wheels Turning” assignments were for their own personal journey and not collected or included in the course grade. However, the intent was for the reflections from these assignments to feed into students’ final assessments.

Real-World, Client-Based Projects

Capstone design projects are solicited from industries, local and state agencies, and the Archway Partnership –

a unit of the UGA Public Service and Outreach created to facilitate local collaborations that empower communities to address long-standing and critical self-identified community and economic development needs. The benefits of including industry and practicing engineers as mentors to enrich the student experience are well understood^{5,6}, although difficult to consistently achieve. At UGA, the recruitment of projects, industry involvement and project mentors are greatly enhanced with help from the Archway Partnership. As part of student design projects, students maintain a continued dialogue with their external sponsors and mentors to include problem identification, determining design scope, providing periodic project updates, and presentation of the findings throughout the project duration. Client-student interactions occur through combinations of in-person client meetings, project site visits, phone conversations, email, and video-conferencing. This structure allows for students to gain experience with the engineering design process while gaining client negotiation and management skills valued by future employers. Sample projects have included a roadway connector to solve community traffic problems, a novel multiplexed aircraft instrumentation system, thermoelectric cooling for small satellite sensors, and master planning for multiple site developments. Over 70 design project teams with over 250 senior-level students have completed the capstone design course. Students engage with externally-based clients to assist in the development of the scope of work, conceptual design, and creation of a set of engineered documents meeting applicable codes and requirements for the project. Final reports and design documents include a final engineering design, project cost estimates and phased options for implementation, all of which are created in direct response to needs articulated by their clients.

Program Materials and Assessment

A program workbook was developed by the J.W. Fanning Institute for Leadership Development that is used by students during and outside the leadership modules. In addition, the J.W. Fanning Institute for Leadership Development faculty conducts presentations for each module, and online activities to prepare for each face-to-face session and to reflect after each session.

Methods of Assessment

The course instructors and partners use direct and indirect assessment to evaluate the desired outcomes that students understand their role in engineering practice and leadership. Assessments include both course instructors' and client's observations of students leadership skill development as well as a reflection

piece written by each student at the completion of the leadership development program. Students were given a survey at the end of the sessions to assess their understanding of the topics before and after the EELD program. In addition, they were required to complete essay questions to receive their final certificate. Items from the survey related to increased knowledge and skills like "I understand the difference in leadership and management" and "I have a personal leadership vision" indicated an overall increase, but more self-knowledge questions like "I am a good team member" and "I am a good communicator" showed more of a decrease. This decrease is seen as a positive outcome as it indicates students are recognizing their need to grow in these areas, and their responses to the essay questions for certification completion indicate that they are becoming more intentional about how they think about their choices and behavior in group interactions.

Currently, there is only preliminary feedback from the pilot program implemented in the Civil and Environmental programs in the 2016-2017 academic year, but these student surveys indicate the merits of this capstone structure. Specific questions and student responses from the course reflection survey include:

Describe your definition of leadership and include at least one example you encountered that illustrated your definition during the capstone course.

"I define leadership as a person's ability to make confident decisions that influence something greater than the individual. During the capstone course, each member of our team needed to become a leader at certain points in order to make decisions that influenced the entire team and our work. Leadership was witnessed particularly during client communication and project presentations."

"Leadership is an important quality trait that can be shown differently person to person. The key with leadership is understanding your own strengths and deficiencies to support a team to the best of your ability. Capstone has showed me how I personally can lead by example and work with others to maximize our capabilities."

"Leadership is service and facilitation. During this capstone course we were leading our clients by serving and facilitating group meetings and assignments to fulfill our requirements and complete the project."

Thinking about your experiences in the Emerging Engineering program, what do you think benefited you the most and why?

“I have benefited by learning about new strategies to communicate and deal with employees and other people in life after college. I feel that this program has allowed me to open my mind to emerging strategies for beneficial communication and leadership strategies.”

“I learned a lot about myself and the leadership qualities that I have and the ones that I need to work on.”

“This leadership program broadened my perspective of the working environment. By viewing challenging scenarios from new angles, I left my comfort zone and grew as an individual.”

“I have come away with a broader understanding of how our personalities influence our leadership traits and how to work better with others.”

“The Emerging Engineers Leadership Program has taught me to first understand my strengths and weaknesses and use them to advantage of a team by also understanding traits of my partners. Leadership can be shown in many ways, and this process has brought light to the ways each of us can lead best.”

“I think I have benefited by learning that being a leader does not always mean taking control and making all the decisions alone.”

An intentional method of determining efficacy of this new capstone program is being planned and organized. The final assessment results (both quantitative and qualitative) will be collected at the end of this inaugural academic year and presented to the Capstone community.

Summary and Concluding Remarks

At the UGA College of Engineering, senior capstone design curriculum was revised and adopted a two credit hour – two semester course sequence starting in 2016-2017. To provide students with leadership concepts and practices, a program of six to nine modules designed by the Fanning Institute was implemented in all eight engineering majors within the College. Informal feedback from students indicate that they are actively engaged in implementing the leadership techniques learned in their capstone design projects and the overall effectiveness of this capstone structure is beneficial. As the UGA College of Engineering is new, no formal assessments of capstone course efficacy have been carried out yet. However there are plans to evaluate the student learning outcomes through surveys in spring 2018.

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