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Board 247: Designing Learning Environments for Knowledge, Skills, and Mindset Development

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Designing Learning Environments for Knowledge, Skills and Mindset Development

Abstract

In our efforts to develop more holistic engineers with entrepreneurial mindset, faculty in the School of Civil and Environmental Engineering at Georgia Institute of Technology have been exploring what it takes to create and refine effective learning environments for knowledge, skills and mindset development. This poster discusses promising approaches being implemented to support such development and identifies emerging effective practices, challenges and future work. In particular, we address the following questions: (1) How can we develop effective learning environments for knowledge, skills, and mindset development to enhance engineering and broader learning outcomes? (2) What pedagogies appear to be more effective in advancing multiple learning objectives simultaneously? And (3) What are effective strategies for engaging the broader community in a changing culture that incorporates mindset development alongside knowledge and skills development? Supported by an NSF RED grant and a KEEN grant, this work presents intermediate results from an ongoing effort to increase student engagement and retention at each stage of the degree.

Introduction and Literature Review

Curriculum reevaluation in the School of Civil and Environmental Engineering at Georgia Tech has been motivated by a decrease in retention rates of first- and second-year students. In 2017, 50% of students who started in Civil or Environmental Engineering (CEE) changed majors or left the institution in their first two years [1]. A similar trend exists nationally, with 40%-60% of engineering students in generally dropping out or changing major [2]. Recent reports internally [3] and from professional associations [4]–[6] have highlighted the need for holistic engineers, i.e., engineers who can integrate cognitive, affective, and interpersonal skills and apply them effectively in problem-solving and design. Supporting this is the development of an entrepreneurial mindset (EM) in the context of engineering. Engineering students who have an entrepreneurial mindset curiously explore and challenge existing solutions, make connections between their lived experiences and various areas of study, and habitually seek out opportunities to create value [7].

Curricular change is a nuanced process that is heavily influenced by existing culture and organizational structure [8], [9]. Three questions that outline our approach are explored in this poster:

1. How can we develop effective learning environments for knowledge, skills, and mindset development to enhance engineering and broader learning outcomes?
2. What pedagogies appear to be more effective in advancing multiple learning objectives simultaneously?
3. What are effective strategies for engaging the broader community in a changing culture that incorporates mindset development alongside knowledge and skills development?

Methods

In order to incorporate mindset development more effectively alongside of knowledge and skills development, a multifaceted approach is necessary. Initiatives at three levels were pursued to effectively create change: individual instructors and their courses, connected courses and the student experience across the curriculum, and the collective organization of the School.

Individual instructors and course are the most direct and obvious way that the students experience change within the curriculum. Faculty interested in incorporating EM and holistic education into their courses did so by engaging in relevant faculty development workshops, both internal and external to the institute. The faculty are also working toward rewarding innovation in education. Additionally, experts specializing in new pedagogical approaches were invited into classrooms for focused skill development.

Building on a collection of instructors interested in change, we designed a set of vertically-integrated courses to create a cohesive learning experience across four years in the major [10]. The purpose of this "spine" was twofold: to engage the students in CEE-specific content in the first two years to support retention, and to have dedicated courses with a compounding curriculum of EM and holistic skills development. While all courses cover a variety of CEE content, they are linked by specific skills and mindsets which are developed with increasing nuance and maturity as the students move through the courses.

To create lasting change, the organizational structures must also be supportive. Two initiatives took place at this level. First, a School-wide climate study was conducted to assess sense of belonging, engagement, and perception of support in the undergraduate students, graduate students, and faculty and staff in the School. Second, modifications to the School's strategic vision were made to reflect a mission of EM and holistic education.

Results

Results presented in the poster represent a work in progress. These are the preliminary results and strategies we have used in this ongoing change process.

RQ1: How can we develop effective learning environments for knowledge, skills, and mindset development to enhance engineering and broader learning outcomes?

Our approach to addressing this question lies primarily in the design and implementation of the vertically-integrated courses. The instructors for the courses collectively determined five threads to link the courses together. "Thread" in this case is defined as program continuity that supports student development over the course of their studies to become a holistic engineer with entrepreneurial mindset through focused teaching and learning. The threads identified include professional identity development, problem identification and solving, communication skills, team development, and stakeholder awareness and engagement. In the case of communication skills and team development, specialized faculty support the instructors in each course. Elements supporting each of these threads exist in each of the courses, increasing in maturity across the first three courses, and culminating in application of these skills in the fourth-year course: Capstone Design.

RQ2: What pedagogies appear to be more effective in advancing multiple learning objectives simultaneously?

To address this question, individual instructors are given the opportunity to engage with specific pedagogies identified to support holistic engineers and EM: problem-based learning, the 3Cs of entrepreneurially minded learning, value sensitive design, and story-driven learning. Problem-based learning is an approach to problem solving that is primarily student-driven and is rooted in real world scenarios [11]–[13]. The 3Cs are curiosity, connections, and creating value and compose the entrepreneurial mindset, which helps students understand the importance of opportunity and impact of design [14], [15]. Value sensitive design focuses on including human values throughout a design process [16]. Finally, story-driven learning encourages students to be reflective of their learning experience [17]. It also helps solidify a student's identity as an engineer and build empathy with their peers and others [18]. Individually, these approaches are valuable ways of engaging the whole student. For instance, we combined team development with story-driven learning to help students to productively process failure, especially failure in teams.

RQ3: What are effective strategies for engaging the broader community in a changing culture that incorporates mindset development alongside knowledge and skills development?

Two initiatives within the organizational structure of the School of CEE that support a cultural change. First, the results of a School-wide climate study showed the current perceptions of belongingness and engagement of students, which supported the changes that were already implemented and motivated continued change. Second, the School's strategic vision was updated to reflect a new focus on the development of EM. It also recognized holistic education as a way to foster a sense of belonging in the School and the CEE profession. Through this, the School recognized EM and holistic education as priorities, extending the impact and involvement of faculty to the rest of the School, instead of a dedicated few working in isolation.

Discussion and Future Work

These strategies not only represent a way of integrating cognitive, affective, and interpersonal skills into an engineering curriculum; they also serve to bolster existing learning outcomes, particular those from ABET. Learning outcomes surrounding the 3Cs have been linked to various ABET student outcomes [19]: teaming and story-driven learning to understand failure support ABET student outcome 5, and value sensitive design can be leveraged to address ABET student outcome 4. This, combined with a comprehensive approach leveraging individuals, connected courses, and organizational structures, increases the likelihood of effective curricular and cultural change.

Next steps for this project involve a continued focus on requiring all four vertically-integrated courses in the curriculum and scaling up. Currently only two are required courses, while the other two are electives. As these courses become more integrated, the need for consistent instruction across instructors increases as the classes become larger or require more sections.

Conclusion

This poster represents ongoing work towards curricular and cultural change in the School of Civil and Environmental Engineering at Georgia Tech. We are using an approach that addresses change at three levels to increase the likelihood of the changes becoming established. So far, there has been support from organizational structures and changes in individual courses support existing learning outcomes.

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