

Open-Ended Customer Discovery Improves Entrepreneurial Capstone Project Outcomes

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Standard entrepreneurially focused capstone design courses rarely result in students being self-employed full-time in a startup company formed around their project post-graduation. To address this, we have developed, implemented, and measured the impact of an ABET Innovation Award recipient course: CREATE-X Capstone Design. For an entrepreneurial cohort of teams each semester, the course provides extensive resources, requires real, quantitative customer discovery and validation of a business thesis, and provides substantial and specific rewards and follow-on opportunities. We report on the structure and impact of the first five weeks, or one-third, of this one-semester course, in which students learn and perform open-ended customer discovery. Through a series of lectures, exercises, interviews with customers, mentor meetings, presentations and reports, the students iteratively and systematically converge on a business thesis. Student teams design and build working prototypes in the remaining weeks. Since launching the course in Fall 2018, 1465 students have enrolled from five majors amongst 264 teams. Twenty-six percent of these teams (68/264) work full-time for their startup companies after the end of the semester; they are collectively valued at over \$250M in 2025. At least 5/68 companies from the course, or 7%, have raised more than \$1M. These financial results make CREATE-X Capstone Design among the most value-creating courses offered at any university in the world.

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Introduction

Accredited undergraduate engineering programs commonly culminate in a capstone design course: an integrative course spanning 1-2 semesters in which student teams synthesize solutions to open-ended, real-world problems.¹ Projects are often sourced from industry partners^{2,3} and have succeeded at large scale.⁴⁻⁶

Many capstone engineering design courses in recent years have taken a new approach, focusing on entrepreneurship. Since 2007, 70 colleges, universities and ABET-accredited engineering programs have participated in the Kern Entrepreneurship Education Network.⁷ Prior papers describe the implementation of these entrepreneurship focused courses and their impact across disciplines, often including principles of lean startup-methodology for problem finding, customer discovery, and business plan creation through lectures, assignments and competitions.⁸⁻¹²

A lingering question, however, is whether the entrepreneurial approach effectively fosters self-employment, fund-raising, and commercial viability of products pursued in the course for any significant proportion of the teams. There is little published evidence of entrepreneurially focused capstone design courses which result—to any significant extent—in student teams

being self-employed full-time in a startup company formed around their capstone design project post-graduation. In 2018, CREATE-X Capstone Design at Georgia Tech was created in an effort to address this gap, with a course structure as reported in 2020¹³ which has continued with only minor modifications.

In this paper we detail the most salient difference in structure between CREATE-X Capstone Design and a traditional capstone design course—substantial time and effort dedicated to open-ended customer and problem discovery. As recognized by Shartrand and Weilerstein in 2011¹⁴, in contrast with a traditional capstone design course, an entrepreneurial course requires “a longer period of time to consider market opportunities provides a better foundation for idea generation and validation.” A 2015 paper records a student statement that a key concern against taking an entrepreneurship-focused capstone was “how to target [the problem they] do” and their survey of over 100 capstone program respondents agreed that customer validation should be of increased focus, with 89% of people marking “moderately important”, “important”, or “very important”¹⁵. Therefore, five weeks, or 33% of the single semester course are dedicated to open-ended customer discovery and problem finding in CREATE-X Capstone Design. Herein

we describe the structure of this phase of course, how it contrasts with traditional capstone courses, and the resulting outcomes that we have measured over the past eight years since the course’s inception.

Methods

In the CREATE-X Capstone Design course, student teams explore market demand and value proposition, and design and build prototypes of their invention ideas using evidence-based entrepreneurship as a foundation. The course offers a nurturing environment, with mentorship and financial support for these entrepreneurial teams, including lectures catering to the needs of a startup. This one-semester course comprises students from five majors: mechanical engineering, biomedical engineering, industrial and systems engineering, computer science, and electrical and computer engineering. The course structure includes weekly mentor meetings, course lectures, reports and presentations, and students present their results in an end-of-semester campus-wide exposition competition.

The single-semester course is split into three modules, each for five weeks: teaming and customer discovery; design, analysis and mockups; and prototype fabrication, testing and demonstration. Note that these are teaching modules, students iterate and cycle through the concepts throughout the semester on their own timeline. Critically, as shown in Fig. 1 while traditional capstone courses typically assign projects or problems to their teams, a significant fraction of this course is focused on open-ended customer discovery and problem finding.

For the first third of the semester (See Fig. 1A), students are instructed in “Customer Discovery”. In the first week, students self-form groups of 4-7 with classmates based on similar interests. The students then conduct in-person interviews with at minimum 100 people (potential customers) on the pain-points in their

everyday work or home life. Teams, with mentor support, then synthesize the interview comments in search for common signals amid the noise which may indicate the need for a novel solution to the “Problem”. Follow-up interviews distill into a final pain-point and value proposition that serves as the foundation for their project.

Design specifications, functional requirements, and prototyping strategy emerge from the customer discovery interviews. Students are taught to synthesize and translate lay descriptions of unmet needs into engineering design constraints and functional requirements. By emphasizing problem formulation alongside technical design and implementation, the course strengthens students’ ability to interface and communicate with non-engineers, reducing abstract needs to actionable solutions. The results suggest that prolonged engagement in problem discovery enhances design quality, student learning outcomes, and the likelihood of sustained project continuation beyond the academic setting¹⁶. We hypothesize, but have not shown, that students’ motivation and effort exceed those of the traditional Capstone Design course as result.

Students are taught (See Fig. 1B) to organize their problem statement and value proposition into a business thesis: “X will buy Y because Z,” where X is a customer segment, Y is a solution function, and Z the central issue or gap or opportunity that the solution addresses. Importantly, X and Z in this statement become largely fixed, while Y, the specific solution, is encouraged to vary throughout the prototyping steps later in the course.

Each week the students attend one 50-minute lecture and present a corresponding deliverable at a 30-minute meeting between their 4-6 person team and mentor (See Fig. 1B). Their top 3-5 ideas, nominated through customer discovery, are evaluated and evolve through these lessons, assignments, and mentor meetings. The series of lectures are paired to individual exercises which

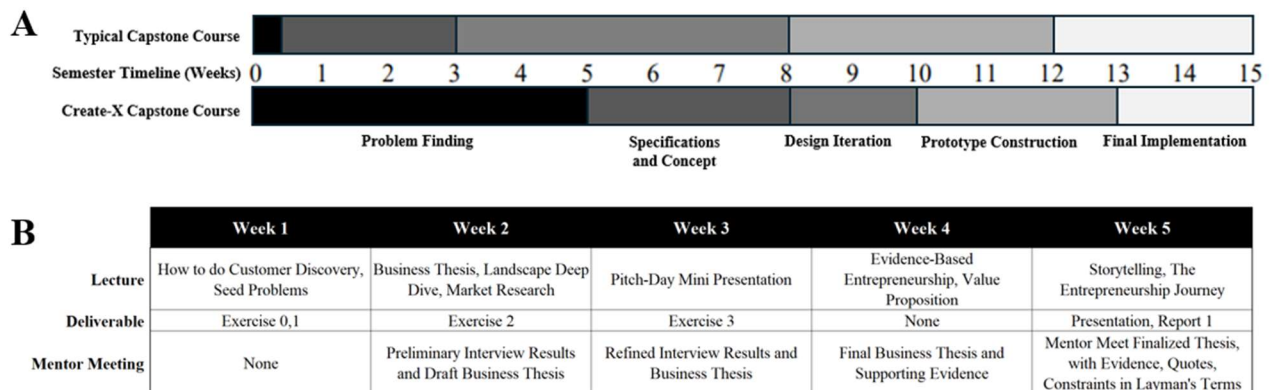


Figure 1. (A) Comparison between CREATE-X Capstone schedule and a typical single semester capstone schedule based on a collation of capstone schedules at Georgia Tech. Traditional capstone courses offer a curated list of pre-formed customers and projects, such that students can begin specifications and conceptual designs almost immediately. (B) Detailed CREATE-X Problem Finding weeks. Customer discovery and problem finding is scaffolded with lectures, deliverables, and mentor meetings.

guide the students through the customer discovery process, business thesis, problem brainstorming, assessing impact, analogues, pain points, market research and market landscaping. The students then collate their individual responses into a team response to present to their mentor in their weekly meeting. These exercises include prompts such as:

- *Create your startup’s business thesis following the form “X will buy Y because of Z.”*
- *In one sentence (<10 words), what is the problem being solved?*
- *Why do you think that this problem has not been solved?*
- *What do customers use today to solve these problems, and why is there still a gap?*

The students interactively test and refine the business theses each week, narrowing the customer segment and better defining the problem they will solve. Unsupported business theses are discarded and revised without attachment or emotion, using quantitative techniques such as scoring matrices, the business model canvas, and Pugh charts. Mentors provide personalized weekly guidance to ensure that through this process teams produce a final, evidence-supported thesis.

To measure the impact of the course, we record team composition such as size and majors, number of students, whether the project continues as a startup company, how much money is raised by investors, and post-money valuations. We archive course deliverables for ABET accreditation and analysis.

Results and Conclusions

The CREATE-X Capstone Design course was awarded the 2025 ABET Innovation Award, constituting nation-wide recognition of the innovation and impact of the course¹⁷. Since launching the CREATE-X Capstone Design course in Fall 2018, the course has enrolled 1465 students over 15 semesters. In this time, 26% of the 264 teams chose to work full-time on their startup companies following the course, as shown in Fig. 2.

We assert that extending problem-finding through the first five weeks of the class improves student outcomes by allowing them to thoroughly explore the problem space and interface with real people impacted by the problem to identify their functional requirements. By the end of the semester, the teams test their prototypes’ ability to solve the intended customer’s problem and decide if the project is worth growing into a startup.

If teams are interested in continuing the project after the semester ends, one of the primary resources is an automatic admission into the campus startup accelerator, CREATE-X Startup Launch. During the 12-week program, Startup Launch participants intern for themselves. Teams receive coaching and mentorship

from experienced entrepreneurs and notable Georgia Tech alumni and gain access to Atlanta’s rich entrepreneurial ecosystem to prove product/market fit.

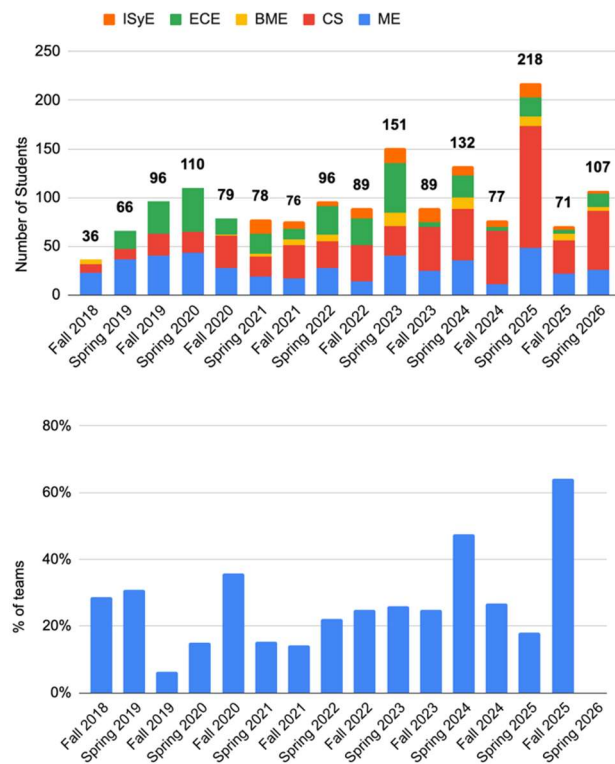


Figure 2. (Top) Over the past 7 years, each semester on average 97.7 students comprising 17.6 teams from 5 majors (totaling 1465 students on 264 teams) enroll in the CREATE-X Capstone Design course. **(Bottom)** Twenty-six percent of these teams (68/264) started working full-time for their startup companies after the end of the semester.

Over the semesters, teams have completed a multitude of projects, including a fully automatic tourniquet, an AI-aided virtual assistant for contractors on the go, and a tactile airport navigation device for the blind. One representative team from the CREATE-X Capstone Design Course is shown in Fig. 3. This team spent weeks driving to local farms to understand the physical difficulties, time, and expense involved in weeding around crops (See Fig. 3A), which led them to define the thesis, “*Small farms growing high value crops like fruits/vegetables and organic produce will purchase an adjustable weeding robot to reduce labor costs and improve crop yield*”, at the conclusion of the customer discovery module. Over the remaining 10 weeks of the semester, they then designed and built a fully autonomous robot to delicately navigate through crop rows and weed around crops (See Fig. 3B). At last check-in the team was intending to pursue their project as a start-up venture after the course.

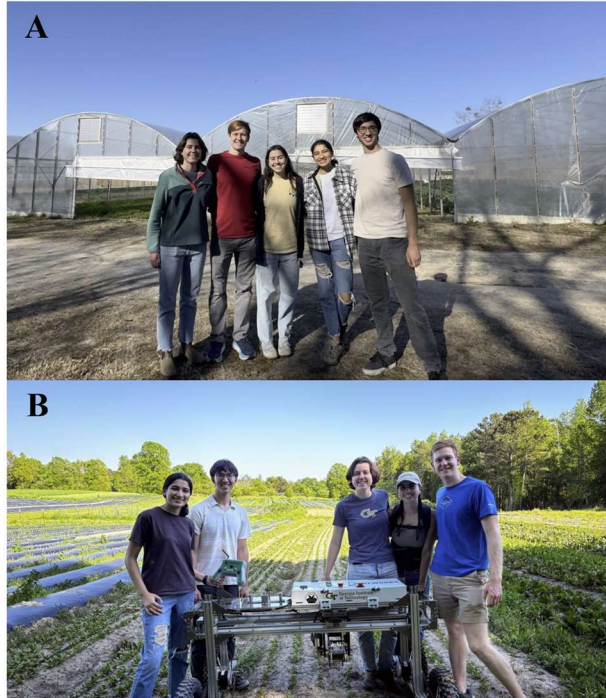


Figure 3. Photograph (A) of students interviewing in the field to identify customers with real, important, and unsolved problems. This team identified farmers with small-scale operations requiring hand-weeding as their customer segment. Students (B) demonstrate a robotic weeder which eliminates the need for weeding by hand, on one of the farms identified during their customer discovery process.

Of the 68 teams that have started working on their startup companies after the end of semester, their market valuation is more than \$250M as of year 2025¹⁸. Importantly, several commercially successful teams did adapt from their original business thesis. The customer discovery process gave them the confidence to be flexible and not fixate on their ideas, responding instead to the customer and market. Even those students who chose not to continue with a startup after the class gained *entrepreneurial confidence* and self-assurance in their ability to pursue their ideas and launch a value-creating startup company. Of these 68 teams, at least 5 to our knowledge raised more than \$1M each. These financial results make CREATE-X Capstone Design among the most value creating courses offered at any university in the world.

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