CREATE-X: Toward student entrepreneurial confidence

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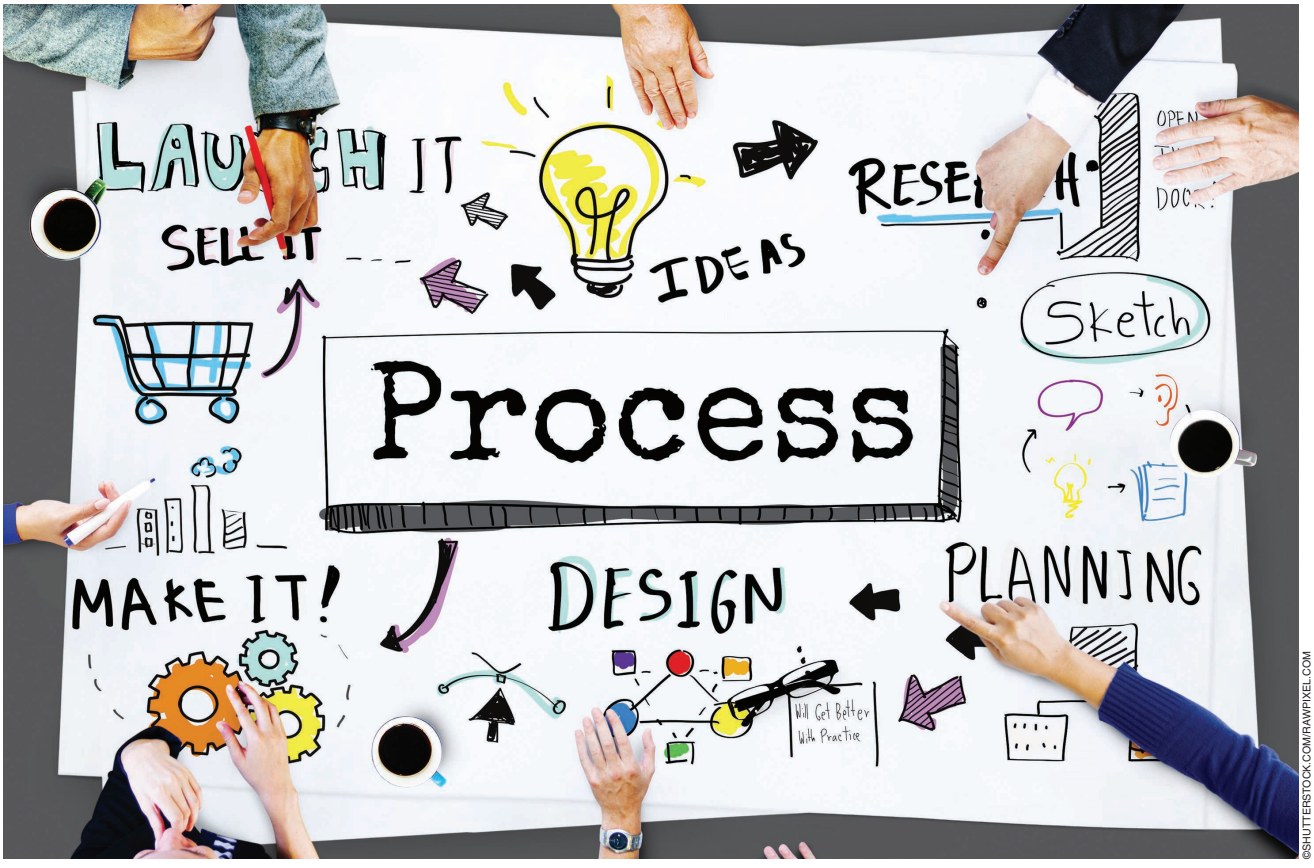

The characteristic inventiveness of the United States is critically dependent on leading technological institutions rising to the occasion to create the next generation of leaders who are entrepreneurial in their thinking. This is especially true given recent data showing the significant impact of independent entrepreneurs on the growth of free-enterprise economies.

The Georgia Institute of Technology's (Georgia Tech's) CREATE-X program is a visionary enterprise aimed

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at systematically nurturing entrepreneurial confidence as one of the signature attributes of Georgia Tech students. The broad goal of this initiative is to provide the knowledge, skills, abilities, and experiences that will give Georgia Tech students the confidence to actively create their own futures.

During the past several years, existing competitions, classes, and programs at Georgia Tech (e.g., the InVenture Prize, Invention Studio, and VIP Program) have significantly changed the culture as it pertains to entrepreneurial activities. However, the CREATE-X entrepreneurial confidence initiative is an opportunity to provide a mentored pathway to nurture this ecosystem and fully leverage and scale what we have learned to transform the experience. We report on the methodology, implementation, and results of a program at Georgia Tech over the past six years that has directly impacted 6,000 students and fostered the founding of 230 student-led companies valued at more than US$400 million.

CREATE-X consists of three programmatic themes: 1) LEARN, 2) MAKE, and 3) LAUNCH, as shown in Fig. 1. These themes offer a pathway consisting of curricular and cocurricular learning opportunities that, in total, give all interested students, regardless of major, the skills to value and pursue entrepreneurial opportunities that are real, not theoretical. In short, the program enables students to be "entrepreneurially confident." They gain experience overcoming barriers, including risk of failure due to technology ineffectiveness or infeasibility, poor product–market fit, financial needs, inability to find like-minded or complementary business partners, lack of collaboration with others, and many more.

CREATE-X programming gives experiential learning opportunities to teach and instill these lifelong skills. The initiative is unique because of the following core philosophies:

- Students explore entrepreneurship through the ultimate experiential learning mode—launching their own start-ups with seed funding, legal assistance, and intensive coaching.
- The key elements of CREATE-X are curricular—students receive credit that can count toward graduation.
- Faculty members play a prominent role in the delivery of all programs—those that don't have an entrepreneurial background are provided training.

Methods

Underpinning the CREATE-X program is a series of elective courses. While these courses are complemented by cocurricular opportunities within CREATE-X, it is this curricular foundation that represents the majority of our efforts and impact. These courses are nonlinear in that any student can enroll in any course to assist themselves in their journey toward a value-creating enterprise. They are organized according to the themes in Fig. 1.

LEARN: Creating student entrepreneurs

The LEARN theme fosters an entrepreneurial mindset and related skills for all Georgia Tech students. LEARN involves promoting and developing a diverse set of activities that increase students' exposure to unmet market needs, providing students with opportunities to generate unique and valuable ideas as a team. They have the opportunity to learn start-up vocabulary and processes, identify a market need, develop an idea that addresses that need, and build an enthusiastic team interested in pursuing that idea. LEARN enables students to understand and use the language and practice of entrepreneurship while simultaneously offering mentoring opportunities. There is a particular need to create a pathway for what happens after a student team has developed an idea that may impact society positively.

Start-Up Lab

Start-Up Lab (COE 2701, CS 2701, and MGT 4803) is an introduction to technology ventures/start-ups in a 3-credit-hours course. The course teaches evidence-based entrepreneurship. Different elements of technology venture creation are introduced, including opportunity identification and validation, ideation, customer discovery, market analysis, minimum viable product development, business models, intellectual property, and capital raises.

Students discover a compelling value proposition or thesis by going out and interviewing hundreds of people. They commit 6 h a week outside of the class time to be successful. Start-Up Lab is a unique course because it allows teams of students the opportunity to create a zero-risk start-up. The students are curious about entrepreneurship, and many of them want to launch companies.

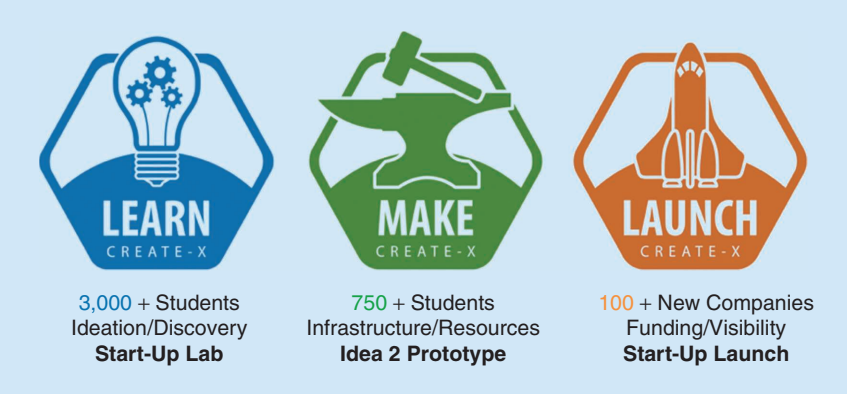

FIG1 The CREATE-X initiative. Three curricular themes provide a pathway that supports students, from those who are curious about start-ups (LEARN), to those who can turn their invention ideas into prototypes (MAKE), to those who are ready to receive resources to start a company (LAUNCH).

By taking the course, the entrepreneurial process is demystified by giving them a framework in which to test their ideas with potential customers.

The course is also unique because we both encourage and applaud failure. The vast majority of our students realize that their ideas would not make successful companies, and they are relieved to learn this fact in a class instead of in the market.

Invent

Invent (GT 2803) is a one-semester introductory course that raises students' awareness of how to "find" a problem, state it clearly, and approach its solution in a creative way. Students are then prepared to pursue ideas by participating in follow-up activities.

In this 3-credit-hours lecture–discussion course with homework assignments, students build the skills needed through in-class exercises and assignments. They develop "habits of the mind" that will serve later as they identify real problems and seek to create and test creative solutions to those problems. Invent is often the first exposure students have to entrepreneurship. Thus, the focus of the course is twofold: to introduce and practice a problem-finding mindset and introduce the culture of innovation at Georgia Tech.

As a part of the first course focus, students learn about the "invention canvas," a simple tool that guides them in the invention process. The invention canvas divides the undertaking into four distinct steps (discovery, problem identification, solution generation, and build/test). As the semester progresses, students walk through the invention canvas, practicing each step along the way in small teams. By the end of the course, they have walked through the invention canvas multiple times and are able to find real and important problems as well as start to attack and solve these problems.

For the second aim of Invent, student, faculty, and guest speakers introduce the culture of innovation at Georgia Tech through guest lectures, campus tours, and in-class activities. Students learn about intellectual property, funding mechanisms, and start-up best practices. Invent is traditionally offered to first-year students and not restricted by major; thus, this course draws a wide variety of students who are eager to learn about entrepreneurship and invention.

MAKE: Technology innovation and solution building

A subset of the LEARN student population (although not required as a prerequisite) advances to participate in the MAKE component and develop concrete ideas for the creation of prototypes or other proof-of-concept activities that are designed to validate the ideas developed during the LEARN phase. In addition to invention, design, assessment, modification, and testing, MAKE also incorporates structured processes, such as customer discovery and validation, to objectively establish the potential value of any particular idea.

The iterative process of ideation, customer discovery-driven hypothesis testing, product requirements learning, pivoting, and customer validation is a relatively new approach to entrepreneurship and an important new component of MAKE. Students who have ideas and want to move forward also need support—space, facilities, infrastructure, and access to mentors. MAKE provides students with the tools and resources necessary for the long process of moving from the conception of an idea to determining the merit of that idea and if it can serve its stated "customers" in a financially viable, sustainable fashion.

Idea to Prototype

Idea to Prototype (I2P) (major designation 2699 and 4699) is a research course in which student invention teams receive faculty mentors, guidance, seed funding (US$500 minimum per team), and additional university resources to build functional prototypes of their ideas. Students apply for the course with their team and a clearly identified and validated start-up problem. They earn 3 credit hours of undergraduate research or, for graduate students, an "I2P Fellowship" for each semester they enroll in the course (up to 6 credit hours, or two semesters, maximum). Faculty mentors meet with teams weekly, while the teams design and build their inventions independently using funding and space provided by CREATE-X. They exhibit their prototypes and compete for prizes at an end-of-semester showcase event.

Capstone Design

Capstone Design [Major designated Capstone Design or Junior Design course substitution in mechanical engineering (ME), industrial and systems engineering, electrical and computer engineering (ECE), biomedical engineering (BME), and computer science (CS)]: In this one-semester course, student teams design and build prototypes of their invention ideas and explore whether there is a market demand and value proposition for them. This is done in a nurturing environment, with mentorship and financial support for these entrepreneurial teams, including relevant lectures catering to the needs of a start-up.

This one-semester course comprises students from five majors. The basic structure includes weekly mentor meetings, course lectures, reports and presentations, and an end-of-semester campus-wide exposition competition. This course aligns with the Senior Capstone Design syllabus, accreditation requirements, and learning objectives. Successful students spend 10 h/week or more on the course.

LAUNCH: Creating successful start-ups

The LAUNCH component constitutes taking acquired skills from the LEARN and MAKE components to the next level, with the goal of Georgia Tech leading the nation in the number of funded student start-up enterprises. This component encompasses seed funding, further

customer discovery, and advanced prototyping. The LAUNCH approach leverages much of what is emerging organically among the student body in both entrepreneurship and interdisciplinary design. LAUNCH is a more ambitious and systematic effort that reaches more students and creates a critical mass around a life skill, enriching our students' futures and enabling them to create their own jobs.

Start-Up Launch

A 12-week summer intensive-internship class, recorded on student transcripts (at 0 credit hours), Start-Up Launch is a student-focused program for teams to work on their start-up ideas. Teams admitted into the program are eligible for a US$4,000 grant initially and a US$20,000 of investment funding from a start-up investment fund, established and managed outside of Georgia Tech, for this specific purpose. A major portion of the seed investment fund is spent by the teams on product design, customer discovery, minimum viable product, infrastructure, prototyping, customer validation, market research, travel, customer meetings, and online presence.

Student teams leverage Georgia Tech infrastructure, such as the Invention Studio and cost centers. Each team also receives pro bono legal services and networking opportunities with other early-stage start-ups. Teams are coached by a specialized group with entrepreneurial experience, have office space on campus, and receive a crash course in evidence-based entrepreneurship. An end-of-term demonstration (Demo Day) serves as a focal point for the start-ups to pitch to the Georgia Tech community and investors at the Fox Theatre.

Over the past few years, CREATE-X has instilled thousands of students with entrepreneurial confidence. Given Georgia Tech's status as one of the top educational institutions in the country, it is anticipated that the initiative will be mirrored and adopted at other peer institutions across the country, and, thus, the proposed effort will truly have a profound impact on university education as a whole in the United States.

More than 6,000 students from 38 different majors have been involved with CREATE-X through all of its programs.

Learning outcomes, metrics, and evaluation

The following learning outcomes are woven into the five CREATE-X courses with varying degrees of emphasis and sophistication: students will

- learn and demonstrate evidence-based entrepreneurship, as exemplified by customer discovery, business theses, and value proposition
- define real-world, important, unsolved problems
- design and build working prototypes of their invention ideas
- pitch their ideas to multiple stakeholders.

The key outcomes and metrics used to evaluate the impact of CREATE-X courses are as follows:

- student engagement, as measured by the number of students participating
- the number of student-led companies created and continuity of these companies
- faculty interaction with students as mentors and coaches
- the percentage of students self-reporting increased entrepreneurial confidence at the end of the semester versus the prior year.

In addition, we have gathered qualitative evidence of course effectiveness in the form of end-of-semester survey comments (self-reported lessons learned and feedback) from students who have participated.

Results

More than 6,000 students from 38 different majors have been involved with CREATE-X through all of its programs. CREATE-X has consistently engaged with 1.5 times more students year over year, exceeding our internal growth targets and representing all six colleges (see Fig. 2).

The pilot Start-Up Lab in spring 2014 consisted of 30 students; subsequent offerings of the class each have had at least 100 registrations, with proportional representation from ECE, BME, ME, and the College of Computing (CoC). The class is currently cross-listed among COE, CoC, and MGT, and the intention is to cross-list the class in the College of Design and other colleges in the near future. The 90–100 students are split among four sections with a common curriculum but with separate instructional teams (lead instructor, coinstructor, and undergraduate teaching assistant). Web-based video content to introduce concepts is complemented by instructor and student meetings and presentations, as shown in Fig. 3.

The Invent course began in spring 2018 and has consistently enrolled approximately 40 students across two sections, representing 11 different majors. Thus, this course provides a veritable entrepreneurial foundation for Georgia Tech students.

In I2P, 40–60 teams, comprising approximately 100 students, are accepted into the course each semester. Over the past five years, a total of 364 teams comprising 894 students from 16 majors have participated. At the end of the semester, student teams present their prototypes to the public, with prizes given in front of hundreds of attendees, as shown in Fig. 4. Beyond the awards, this event is an opportunity for students to receive feedback on products that might go on to become a successful start-up venture.

CREATE-X Capstone Design enrolls approximately 100 students per semester on teams of, on average, 5.5 students. Teams were 4.5 times more likely to win awards at the

exposition as compared to the population of all Capstone Design teams across campus. CREATE-X teams have won awards, including Best Interdisciplinary and Best Mechanical, in both spring 2019 and fall 2019. This shows an external validation of the success of this approach to the Capstone course, as teams are judged alongside all other Georgia Tech Capstone projects by external visitors, including corporate executives.

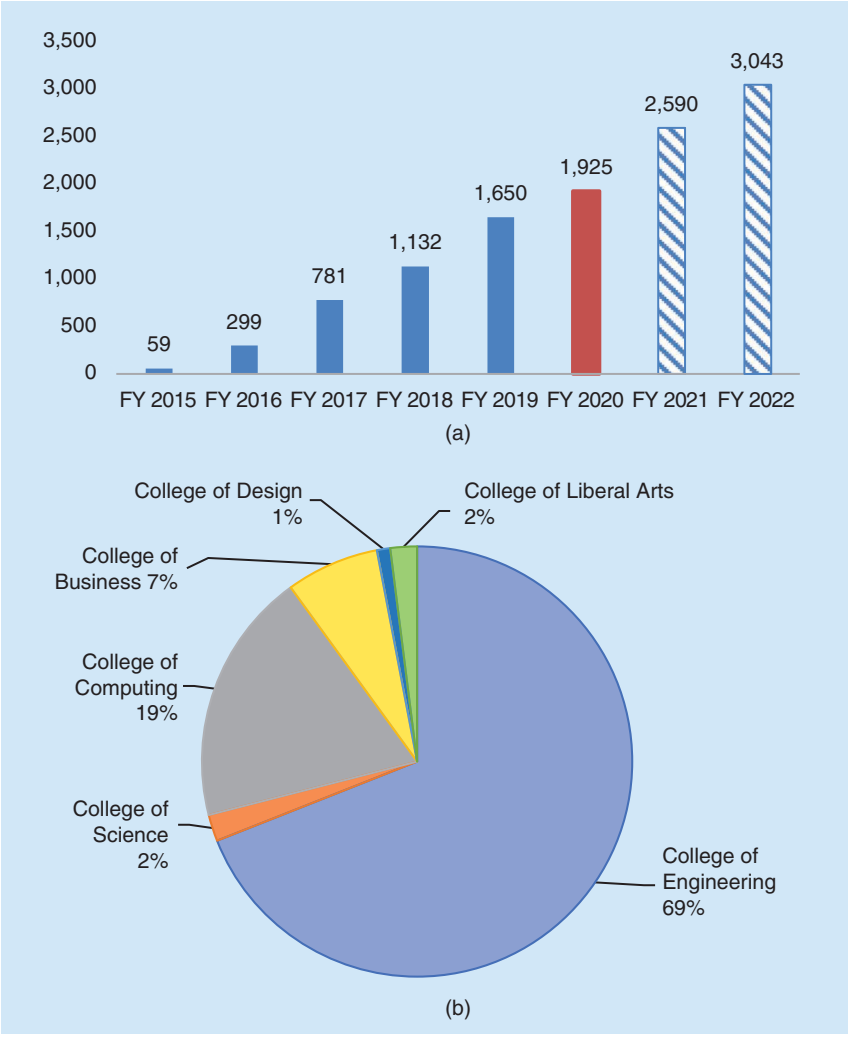

FIG2 (a) The number of students in CREATE-X for each fiscal year (FY) since inception, (b) representing all six colleges.

FIG3 Students participate in team discussion about start-up ideas in the Start-Up Lab, a LEARN course within CREATE-X.

Six of the 19 teams (32%) that participated in CREATE-X Capstone in fall 2018 and spring 2019 started working full time for their start-up companies in the summer of 2019 in the CREATE-X Start-Up Launch program postgraduation. In contrast, only 1% of the non-CREATE-X Capstone teams participated in Start-Up Launch (2/143 non-CREATE-X teams).

Over the past six years, the Start-Up Launch program has directly fostered the founding of 230 student-led companies, valued at more than US$400 million. The Demo Day culminating event is depicted in Fig. 5. Approximately 15% of teams that apply are admitted due to capacity, time, and cost. The number of teams that apply and are admitted has increased approximately 1.5 times year over year, as shown in Fig. 6. These start-up companies are also diverse: 21% have Black/Hispanic founders, and 35% have women founders.

Since our initiative's primary objective is to engage with students, it is imperative that the program be as close to the students as possible. The involvement of interested faculty, consequently impacting curriculum, is a key requirement to establish a scalable program. Faculty mentors and coaches worked with students one on one as well as in teams throughout the year. Some faculty members gave guest course lectures as well. Altogether, 76 faculty members from all six colleges were engaged in CREATE-X courses, as shown in Fig. 7.

Qualitatively, we have gathered evidence of course effectiveness. The critical course elements that we hypothesize contribute to achieving the goal of start-up company self-employment are as follows:

- a cohort effect, with entrepreneurial teams isolated from non-entrepreneurial teams
- providing extensive resources (money, office and fabrication space, mentoring, and time) so

that the only limitation is the students' ideas and energy
- requiring legitimate, honest customer discovery and validation of the business thesis and value proposition
- making clear the substantial and specific rewards and follow-on opportunities for incubation, funding, mentorship, and competition to continue under university auspices and beyond
- trusting the students, empowering them (e.g., to spend the money as they see fit), and explicitly encouraging them to take a chance on their ideas to make an impact on the world.

For example, end-of-semester surveys consistently support two outcomes:

- Students now have the ability to converse with people outside of their social circles, which is useful as they advance their career searches and build professional networks.
- Since they are required to discuss their business idea with many potential customers, students gain entrepreneurial confidence due to the process we teach them.

Surveys have shown that more than 85% of our students appreciate the courses and would recommend them to friends. Almost all students (97%) who completed Start-Up Lab in fall 2017 and I2P in spring 2018 expressed increased entrepreneurial confidence on the end-of-semester survey. Several teams from each course cohort go on to launch companies with CREATE-X Start-Up Launch.

We have also been encouraged by comments from students on end-of-semester surveys. For example, comments from anonymous students in CREATE-X courses capturing the essence of the program include the following:

- "This course has potential to really transform education. I often hear people saying how pointless university is becoming and how you never really use what you learn in school. This made going to university worth it because it

FIG4 Students demonstrate and explain prototypes of their inventions created in I2P, a MAKE course within CREATE-X.

FIG5 The end-of-summer Start-Up Launch Demo Day event in the Fox Theatre in Atlanta, Georgia. More than 900 participants attended in person, and 1,000 watched online.

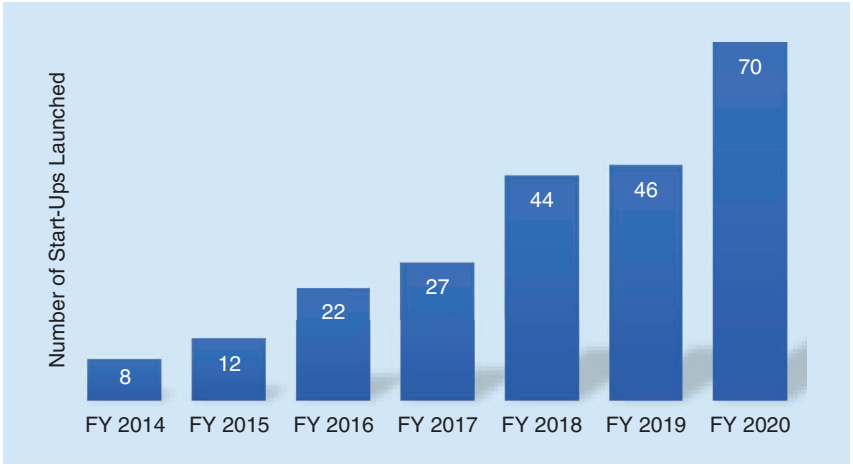

FIG6 The number of start-up companies launched by CREATE-X since inception. These 230 companies are collectively estimated to be valued at US$400 million.

CREATE-X's defining programs are curricular, but they are complemented by a variety of extracurricular activities.

was the only class to actually transform how I see problems in the world and how I can actually use the knowledge gained in school to make a difference."

- "I had an awesome time in this course and I'm really excited to see how it transpires in the future for other students and what comes out of it. I feel more motivated to become an entrepreneur, and I see the world through a different lens. I'm really thankful for the effort put into this class by the CREATE-X group, and I hope to work with them again in the future years to come!"
- 'The freedom and control each team had on their project was a nice change and also humbling. Not being micromanaged is eye opening to how you actually operate. I was so used to planning according to a rubric and knowing exactly what I had to do, but this class shook that up a bit and made me actually think critically."
- "This course allows you to decide where you want to focus your efforts on."

Some of the companies from the Start-Up Launch program have been remarkably successful. Selected "graduate" highlights over the years include the following.

- Gimme Vending offers supply chain management software to vending machine operators for ensuring increased driver compliance and efficiency as well as accessing cash, inventory, and service data in real time. Gimme has raised more than US$2 million in funding.
- FIXD offers a hybrid hardware–software solution for automobile owners. FIXD has sold more than 1 million units of their product, which is available for sale on Amazon.
- Stord creates more efficient warehousing of goods by matching shipper demand with warehousing supply. The team has raised more than US$15 million to scale its business.
- Grubbly Farms uses locally grown, sustainable, protein-rich feed for chicken farms. The company is serving farms in the state of Georgia and is postrevenue. Grubbly participated in the TechStars New York City program and has raised more than US$4 million in funding.
- Sora Schools is reinventing high school education for homeschooled kids by using individualized project-based learning and experiential methods. It has raised US$2.7 million in venture funding.
- Gatherly empowers world-class online events by enabling users to seamlessly move between parallel video conversations. The company has more than 200 paying customers.
- Crescendo develops an interactive music trainer that boosts the confidence of a student learning to play music. Its apps are available on the Apple App Store and Google Play; one of its apps was featured as the "App of the Day." It was acquired by Ultimate Guitar.

When fully scaled, CREATE-X is anticipated to achieve the following goals:

- One hundred percent of students seeking this path will be entrepreneurial in their thinking and possess entrepreneurial confidence.
- All students at Georgia Tech will participate in some part of the LEARN–MAKE–LAUNCH funnel.
- There will be 300 new student-led enterprises created every year.

Yearly, we continue to track the percentage of students who self-report entrepreneurial thinking and confidence, success of LAUNCH teams relative to their LEARN/MAKE preparation, and number of teams and students in each of the program elements.

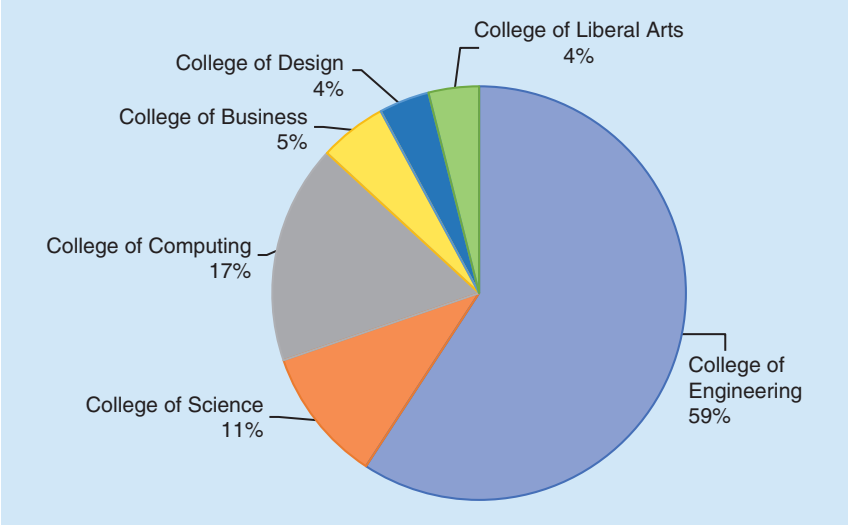

FIG7 Faculty participation across colleges at Georgia Tech, totaling 76 faculty.

Broader context

CREATE-X is surrounded by other entrepreneurial activities that are underway at Georgia Tech. CREATE-X is institute-wide and is open to all students, regardless of major. We seek entrepreneurially inclined faculty from as many departments as possible to participate in the program, thereby attracting diverse students. The funnel shown in Fig. 8 represents the other activities within Georgia Tech that dovetail into CREATE-X.

Already, we are seeing a growing role for CREATE-X Capstone Design (MAKE) among the larger Senior (Capstone) Design ecosystem. A healthy balance of industry,

research, and entrepreneurial projects can be offered by these complementary Capstone courses. In addition, the concepts taught in Start-Up Lab (LEARN) have been integrated into three other courses and are on track to influence many more. Specifically, the customer discovery process is taught as part of Senior Design. Business thesis development is taught in ECE Junior Design. Furthermore, a new graduate course, Tech Ventures, was developed by adapting the content from Start-Up Lab.

There are also opportunities for CREATE-X students to interface with industry. For example, Deep Start-Ups is an extracurricular seminar series in which industry leaders present the most urgent problems their industry faces, which can prompt students to tackle them. Industry sponsors to CREATE-X, such as Amazon and Keysight, often provide materials and supplies, mentorship, or critiques and evaluation at end-of-semester events, such as the I2P Showcase, Capstone Expo, or Demo Day. Some of the Capstone Design teams have industry partners who plant the seeds of the problem that the start-up company tackles.

CREATE-X's defining programs are curricular, but they are complemented by a variety of extracurricular activities. These include Deep Start-Ups (a seminar series with industry leaders), Legal Buzz (pro bono legal service sessions with lawyers), Start-Up Academy (a half-day workshop crash course on evidence-based entrepreneurship), Start-Up Ideas (a pitch session for students to CREATE-X mentors), Meet Your Cofounder (a student meet-and-greet session with potential team members pitching ideas), and Info Sessions about CREATE-X. These activities are each held two or three times per semester.

Approximately two thirds of all CREATE-X students participate in some of these extracurricular activities, totaling approximately 500 students per semester. In many cases, the ideas and teammates germinate in these activities and then enter the CREATE-X curricular pathway.

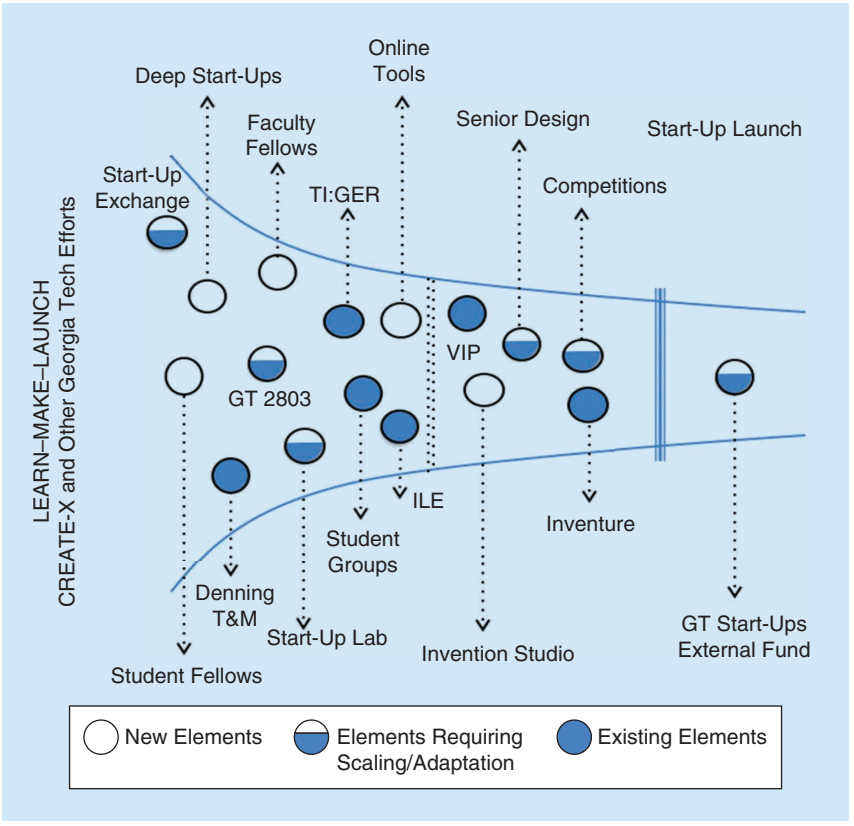

FIG8 The synergies between CREATE-X and other Georgia Tech programs. The funnel width represents the number of students participating, and the horizontal axis represents the maturity of their ideas, or entrepreneurial confidence. TI:GER: Technology Innnovation: Generating Economic Results; ILE: Institute for Leadership and Entrepreneurship (and Social Impact); T&M: Technology and Management.

CREATE-X is organized and led by a group of approximately 10 people. The thought leadership and lead roles were primarily filled by faculty from its initial conception by Dr. Raymond Vito, but, as the program has grown, non-tenure-track staff and faculty have also made hugely impactful contributions. Faculty have had a key role because they are able to both reach students and engage fellow faculty instructors in large numbers as well as convincingly lead university direction and fundraising efforts. CREATE-X has a director (Sivakumar) and three associate directors (Saxena, Harris, and Forest), one for each curricular theme, along with advisors and support staff. The program was initially embedded in the College of Engineering and recently migrated to the Provost's Office, given its campus-wide reach and impact. An advisory board of entrepreneurial alumni and friends of Georgia Tech aids with goal setting and accountability.

Conclusion

Georgia Tech's vision is to define the technological research university of the 21st century. Building upon current momentum and mounting student interest and enthusiasm, the institute has the opportunity to prepare students to embrace entrepreneurial confidence, a mindset and skill set that will enable them to be the leaders of tomorrow. CREATE-X is enabling Georgia Tech to realize, in part, its vision to infuse an entrepreneurial mindset across all colleges and, once fully realized, will forever transform the educational experience for generations of Georgia Tech students.

About the authors

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Christopher Klaus is an American technology entrepreneur. He was founder and CTO of Internet Security Systems, a company that he started in the early 1990s and then sold to IBM in 2006 for US$1.3 billion. He has a long relationship with Georgia Tech. He invigorates the future of technology at Georgia Tech by supporting CREATE-X.

Steven W. McLaughlin (sm140@gatech.edu) earned his B.S.E.E. degree from Northwestern University, M.S.E. degree from Princeton University, and Ph.D. degree from the University of Michigan. He is the provost and executive vice president for academic affairs at Georgia Tech, Atlanta, Georgia, 30332, USA, and cofounder of CREATE-X. He joined the School of Electrical and Computer Engineering at Georgia Tech in September 1996. From 2017 to 2020, he served as the dean of the College of Engineering and the Southern Company Chair. From 2012 to 2017, he served as the Steve W. Chaddick School Chair in the School of Electrical and Computer Engineering.

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