

GEORGIA TECH

ENGINEERS

Vol. 1, Issue 1

Summer / Fall 2013

The MOOC Man

**How ECE's Magnus Egerstedt taught
robotics to 40,000 students***

***while sitting alone in a studio**

Mission Statement

Georgia Tech Engineers strengthens the bonds between CoE's students, faculty, staff, alumni and friends by sharing the stories that link them. CoE is Georgia Tech's largest college, and Georgia Tech Engineers promotes a sense of community among its diverse members. While the magazine showcases research and study, it also focuses on the people behind those endeavors, reminding everyone in the College what makes it exemplary.



ROB FELT

Dear Friends of the College of Engineering,

Like a proud parent, it gives me great pleasure to introduce you to the inaugural issue of our College of Engineering magazine. Georgia Tech does a great job covering general news and research here on campus, but we wanted to offer you something more. We wanted to give you a behind-the-scenes glimpse of the faculty, staff, students, and even alumni who comprise this extraordinary community. We want you to be a part of their lives, to see the people who make this College what it is. This is a chance for you to get to know these individuals and what motivates them—the “back story,” so to speak.

There is so much happening, so many compelling individuals to write about, and so many ways we are touching the future. This is a chance to show our pride, our aspirations, and our commitment; to show ourselves as the creators and problem-solvers that we are.

Take a moment and read about some of these amazing engineers from Georgia Tech. Not only will they make you proud, they'll make the profession proud as well.

Gary S. May
Dean

In our world, we like to draw lines in the sand. You stand either with us or against us. You are either an earnest outsider or the consummate insider.

Dichotomies can be useful, but the best vantage point often lies in the in-between.

Last year, I joined Georgia Tech's engineering college as a writer and editor. That means I'm still rather new around here, and there are times when I feel the newness acutely. (Where's that one building again? And what's that professor's name?) But Tech and the College of Engineering were never unfamiliar to me. I grew up in and around Atlanta, and while my own background is in journalism, my sister is a GT engineering graduate.

I'm now the editor of CoE's new magazine, and in this issue—our inaugural edition—I wanted to draw on my perspectives as both outsider and insider. Many of this magazine's readers will have longtime ties to the College and Georgia Tech, but I hope the stories and photographs featured here can lead everyone to something new.

In this issue and others, we'll cover programs you may not know about, and we'll introduce you to faculty members at the top of their fields. But you'll also find the things you already know and love about CoE—the impressive alumni, the ambitious students, and the quirky charm.

Most of all, I hope, this publication will strengthen your connection with the College. We'll offer plenty of stories about our work, and we'll also highlight the people behind it—the ones who make CoE what it is. Whether you're a loyal alumna or a just-arrived freshman, I think you'll like what you find here.

Lyndsey Lewis
editor@coe.gatech.edu

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GEORGIA TECH ENGINEERS

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DEAN
Gary S. May

DIRECTOR OF COMMUNICATIONS
Kay Kinard

EDITOR
Lyndsey Lewis

CONTRIBUTING WRITERS
Michael Baxter, Collin Brown, Katie Brown,
Ashley Daniel, Abby Robinson, John Toon,
Ben Wright

CONTRIBUTING PHOTOGRAPHERS
Nick Burchell, Rob Felt, Jay Gallman,
Alex Hubbs, Mike Koenig, Stanley Leary,
Gary Meek, Zach Porter

GRAPHIC DESIGNER
Sarah Collins

CONTRIBUTING DESIGNER
Rachel Maloney

CONTRIBUTING ARTIST
John Lau

ASSOCIATE DEANS
Sue Ann Bidstrup Allen
*Associate Dean for Faculty Development
and Scholarship*

Stephen DeWeerth
*Associate Dean for Research
and Innovation*

Laurence Jacobs
Associate Dean for Academic Affairs

John Leonard
*Associate Dean for Finance
and Administration*

ADDRESS
225 North Avenue
Atlanta, Georgia 30332-0360

PHONE
404.894.3350

WEBSITE
www.coe.gatech.edu

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SYLLABUS

CoE is a giant college spanning a broad array of disciplines. In Syllabus, we spotlight one of the College's programs.

FIRST PERSON

A member of the CoE community speaks in his or her own words.

OUTLIERS

Engineers are more than just their work, and some of them have interests or hobbies you might never expect.

MAKING IT HAPPEN

We look at how CoE alumni turn their lofty ambitions into reality.

GOING GLOBAL

Our engineers work around the world, and we chronicle their successes abroad.

POP QUIZ

A brief interview that won't count against your final grade.

➔ With Prox-1, GT Gets First-Ever Spaceflight Mission

Jason Frieman has always had big goals. When he was growing up, he wanted to become an engineer. (He's now working toward a Ph.D. in Georgia Tech's aerospace engineering school.) And, of course, he wanted to send something into space.

"It kind of has been something I've always dreamed about since I was a kid," he said. Now he's making that dream come true, too.

As part of the Prox-1 team, Frieman is among the students working on what is said to be GT's first-ever spaceflight mission. Prox-1, a satellite mission, won the University Nanosat Program (UNP) competition, which means it will receive an Air Force launch slot as a secondary payload.

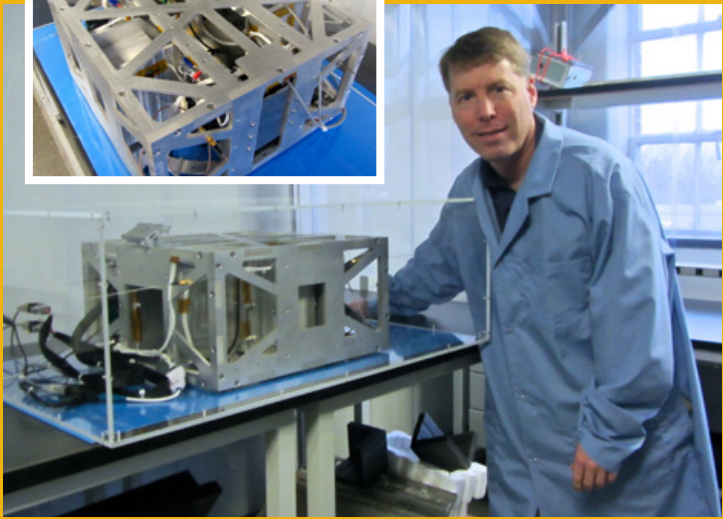
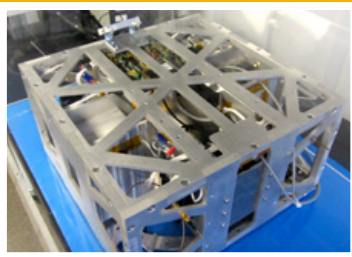
Prox-1 is designed to demonstrate automated trajectory control in low-Earth orbit relative to a deployed CubeSat. David Spencer, Prox-1's principal investigator, explained that most proximity operations to date have had ground controls behind them—that is, people on earth have to do the bulk of the work manually.

"They're effectively joysticking the spacecraft," said Spencer, a professor in the Guggenheim School of Aerospace Engineering (AE).

But Prox-1 uses a technology called AutoNav, whose infrared imaging is key to orbital determination and trajectory control. When it's launched around 2015 or so, Prox-1 will first release a separate satellite (the CubeSat), and it will then demonstrate its automated abilities to trail the CubeSat and circumnavigate it.

The entire mission is expected to take about six weeks.

—LYNDSEY LEWIS



ALEX HUBBS



ROB FELT

➔ ISyE Student Is a New Face of Engineering

Mallory Soldner, a Ph.D. student in the Stewart School of Industrial & Systems Engineering, has been selected as the Institute of Industrial Engineers representative for the 2013 New Faces of Engineering, a program that honors promising young engineers contributing to society.

Soldner, along with the other honorees, was profiled in a special section of USA Today during National Engineers Week, Feb. 17 – 23.

Soldner is passionate about effecting change both locally and globally and focuses her research on practical applications with societal impact. Since 2009, she has served as a research assistant for the Georgia Tech Center for Health & Humanitarian Logistics (HHL), where she works to develop innovative applications of operations research techniques to practical health and humanitarian topics.

Her work with HHL led Soldner to become involved in collaboration efforts with the United Nations World Food Programme as a research affiliate in 2010, a relationship that is creating a foundation for continued collaboration between the World Food Programme and Tech.

Soldner spent the past summer in Rome, Italy, where she was given the lead on developing business requirements and designing the dashboards for the World Food Programme's Supply Chain Key Performance Indicator project.

—ASHLEY DANIEL

➡ Study Shows Pollution Doesn't Affect Rate of Cloud Droplet Formation

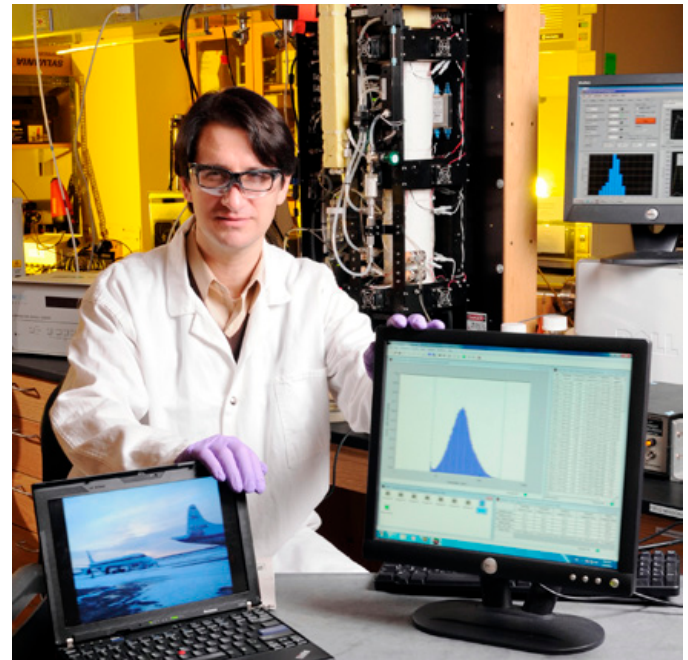
Organic coatings on particles don't seem to significantly affect the rate at which cloud droplets form, Georgia Tech researchers recently reported.

This finding, published in the journal *Proceedings of the National Academy of Sciences*, is based on droplet formation measurements, both aerial and ground-based, from 10 different areas. They include Atlanta, the Gulf of Mexico, and Los Angeles.

Scientists originally believed that particles coated in a mixture of combusted petroleum and biomass, or "goop" as it is often referred to, would form droplets at a slower rate than other particles; however, this study suggests differently.

"It turns out that it doesn't matter how much goop you have—or don't have—the droplets take the same time to form," said Athanasios Nenes, a professor in the School of Earth and Atmospheric Sciences and the School of Chemical and Biomolecular Engineering.

— KATIE BROWN *and* JOHN TOON



GARY MEEK



PHOTO PROVIDED BY THE WOODRUFF SCHOOL

➡ Georgia Tech and ME Awarded \$2.3 Million for Heat Pump Project

Georgia Tech and the Woodruff School of Mechanical Engineering (ME) were recently awarded \$2.3 million from the Department of Defense to develop a highly efficient absorption heat pump for military use.

The Department of Defense-Navy and Department of Energy Advanced Research Projects Agency-Energy announced a total of \$8.5 million in energy investments. The awards are part of a program funded by the Operational Energy Capabilities Improvement Fund.

All five of the chosen projects are designed to improve the efficiency of heating and air conditioning systems on the battlefield. The Tech project's principal investigator is ME Professor Srinivas Garimella.

The absorption heat pump—an air conditioner and heater in a single unit—is novel in that it can be integrated with a diesel generator. In addition to being very energy-efficient, it would also be smaller than most pumps and could be mass-produced for a low cost.

By using the exhaust heat from a diesel generator—which is normally wasted—to provide heating and cooling, the pump could lower the amount of energy used for heating and cooling at forward operation bases by 50 percent.

Georgia Tech is the only university to have received an award; the other energy projects are being developed by private companies.

— LYNDSEY LEWIS

➔ ISyE Develops Model to Assess Vulnerability in Food Supply Chain

To address a potential agroterrorism threat, researchers at the Stewart School of Industrial & Systems Engineering are developing a model of food supply chains that federal agencies and corporations can use to determine how best to protect the nation's food supply from intentional acts of biological, chemical, physical, or radioactive contamination.

"Our goal is to help make sure food products are safe from farm to fork by identifying food supply chain designs that ensure a high level of system productivity, while mitigating the risk posed by intentional attacks on the food supply chain by intelligent adversaries," said Professor Alan Erera.

Erera leads the six-year, \$1 million research project that began in 2010. The project is funded by the U.S. Department of Homeland Security's National Center for Food Protection and Defense. Erera and Professor Chip White are using an optimization-based methodology to predict the probability of terrorist attacks at specific points in food supply chains and prioritize interventions and countermeasures based on their capability to mitigate risk and economic utility.

The researchers are currently using the model to identify the vulnerabilities in the food supply chain for liquid eggs. Preliminary results from the model have shown how the liquid egg supply chain could be better protected from an attack through investments and adaptability in the production process.

During the remaining years of the project, the researchers plan to expand the utility and authenticity of their model by conducting additional case studies using other food products.



ISTOCKPHOTO

– ABBY ROBINSON



ROB FELT

➔ Scientific Journal Led by ChBE Professor Wins PROSE Award

ACS Catalysis, an online peer-reviewed scientific journal published by the American Chemical Society, was awarded the Association of American Publishers' 2012 PROSE Award for Best New Journal in Science, Technology & Medicine. Professor Christopher Jones, from the School of Chemical and Biomolecular Engineering (ChBE), is the journal's editor-in-chief.

ACS Catalysis publishes experimental and theoretical research and reviews aimed at solving urgent global challenges, drawing its content from the disciplines of heterogeneous, homogeneous, and enzymatic catalysis.

Jones is the New-Vision Professor at ChBE and an adjunct professor in the School of Chemistry and Biochemistry.

"ACS Catalysis was launched amidst a crowded field of catalysis journals, but was the first (along with a journal of similar scope from the Royal Society of Chemistry, which was launched in parallel) to be published by a major scientific society without a commercial, for-profit publishing partner," Jones said.

Much of the journal's success, he added, is due to superior submissions and a quick publication time, aided by its online-only format. "We have been fortunate to attract a large number of submissions from around the world and publish papers by top authors in every area of catalysis," he said.

– KATIE BROWN

50%

of MSE's Fall 2012 freshmen were women

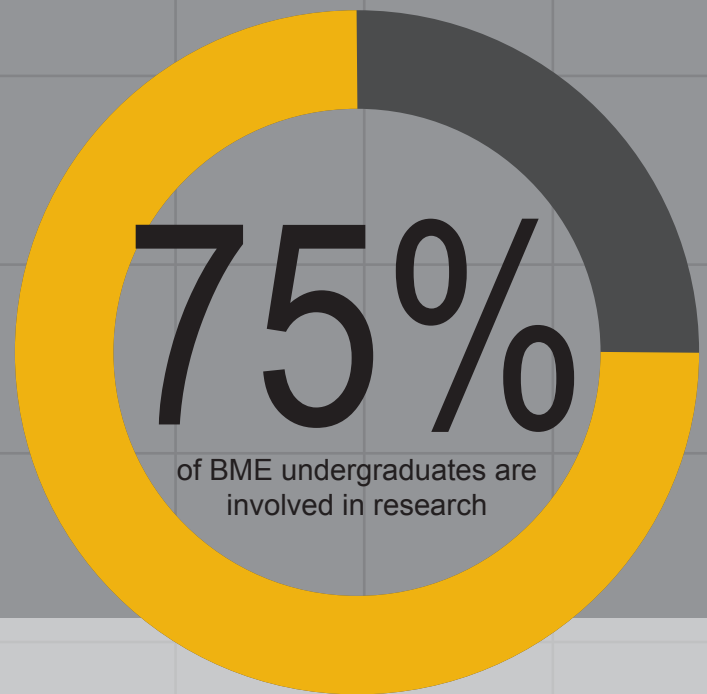


2 million

Square feet assigned to CoE

[22]

Number of years the ISyE graduate program has been ranked the No. 1 program of its kind by U.S. News & World Report



of BME undergraduates are involved in research

181

President's Scholarship recipients from CoE during the 2012-2013 year

26%

of CoE graduates live in Georgia

19.4%

growth in CoE's enrollment since 2007

Impress Your Friends & Change the World: A Field Guide to Majoring in Nuclear and Radiological Engineering

by LYNDSEY LEWIS

WE KNOW YOUR TYPE. You're an overachiever with dreams of bettering the world. You came to Georgia Tech with the best grades and the longest resume, and you're seeking a major that offers intellectual rigor and ample job opportunities. Oh, and fat paychecks down the line are a plus.

Here's a novel idea: Try nuclear and radiological engineering (NRE).

Wait a minute, you think: Don't most nuclear engineers huddle in bunkers designing bombs? Or: Isn't nuclear engineering kind of dangerous?

No and no. Today's nuclear engineers are at the forefront of clean energy and medical breakthroughs. Jobs are abundant, and you'd better believe they pay well. Read on to discover everything you need to know about NRE.

The best part about nuclear engineering? Maybe, just maybe, you can save the world doing it.



You will not sprout another arm. First things first: Studying NRE is not hazardous to your health. Peace Stegall, a second-year NRE major from Roswell, Ga., hears a lot of myths and half-truths about her field. Lots of people, she says, assume that nuclear engineering work might lead to dangerous levels of radiation exposure, but that's not the case.

"You're not going to grow a third arm if you work in a nuclear power plant," Peace says.

Engineers take plenty of safety precautions, and at Georgia Tech, students learn from the best. Professors' interests run the gamut from reactor design to radiation oncology.

You will do amazing things. Ever toured a nuclear power plant? Tech's NRE majors have. Students in the program take "field trips" to plants around the region, where classroom subjects spring to life. When Peace visited the Edwin I. Hatch Nuclear Plant, located near Baxley, Ga., she was in awe.

"The cooling towers kind of took my breath away," she says.

There are also opportunities to mingle with other budding nuclear engineers. Sheree Tamaklo, a fourth-year NRE major from Anderson, S.C., traveled to Las Vegas in early 2012 for the American Nuclear Society's student conference.

And back on the home front, NRE students find their major offers constant stimulation. Nuclear engineering builds on the planks of related disciplines, such as mechanical engineering, and then tosses radiation into the mix.

"You're on the cutting edge of technology," says Erik Pearson, a fourth-year NRE major from Louisville, Ky.

...

Jobs? Yeah, we got 'em. Consider this: Georgia has four nuclear reactors, and two new ones are under construction for operation in 2016. But the nuclear workforce itself is growing older. In fact, says Dr. Glenn Sjoden, a nuclear engineering professor at Tech, half of current workers are expected to retire over the next eight years.

"The job market is going to go crazy for nuclear engineers," he says.

Twenty-five percent of the state's power is nuclear, meaning lots of opportunities for graduates in energy production. And according to the U.S. Bureau of Labor Statistics, the median salary for nuclear engineers in 2010 was just under \$100,000.

If you're ready to get started now, there's co-op and internship work for students, too. Erik, for example, spent last summer interning at Southern Company, which invited him back for another internship in summer 2013.

Other students pick NRE because they're interested in areas like medical physics. And, because NRE majors have a strong grounding in engineering basics, they can also find roles in other fields.

"Nuclear isn't something that pigeonholes you into a certain career in a certain industry," Erik says.

...

You'll make a ton of friends. No, really.

NRE is part of the Woodruff School of Mechanical Engineering—the biggest of Tech's eight engineering schools. But in 2011, the NRE program itself enrolled fewer than 200 undergraduates.

That means students get to know each other really, really well. They study together, hang out together, and support each other through coursework and job searches.

"The camaraderie, I would argue, is stronger than any other major on campus," says Chris Kingsbury, a fourth-year NRE major from Clermont, Fla. Sheree jokes that NRE majors form their own "nuclear family."

With so few students, everyone gets plenty of time with professors, who are, Chris says, "always willing to help you."

...

Everyone will be impressed by your major (and where you studied).

Sheree gets a kick out of people's reactions to NRE. "I go back home and I tell people, 'I'm studying nuclear engineering,' and their mouths drop," she says.

It's an impressive field, and Tech is among the best places to learn about it. Recently, the Institute opened the Radiation Science and Engineering Lab, which features top-of-the-line radiotherapy equipment for students to train with. And, the federal energy department awarded Tech \$6 million to develop a concept for an inherently safe high-power light water reactor.

Then, of course, there's the strength in Tech itself. U.S. News & World Report ranks its engineering college as No. 5 in the country among universities offering doctoral degrees.

"To know that you're going to be part of an illustrious alumni group, to know that you're going to have connections in the future—it's just a great thing," Erik says.

...

Finally, you will transform the world.

Here is the bottom line: Nuclear engineers are poised to solve "the big three problems of society," Sjoden says.

You've already heard about their role in energy. Nuclear power doesn't produce any greenhouse gases, making it a clean alternative to electricity sources like coal.

What you may not know is that engineers are also needed in the fight against nuclear terrorism, and that NRE students, particularly those who pursue medical physics, could someday help cure cancers. Tech's program prepares students for any path they hope to follow.

"We learn the energy side," Chris says, "and we learn how to use it and apply it in the medical sense as well."

The possibilities are dizzying. Not long from now, you might be at the front lines of homeland security or redefining the limits of medicine.

It all begins at the same starting point: an NRE degree from Georgia Tech. ■



From Paper Planes to Engineering

by COLLIN BROWN

Name:
Collin Brown

Major:
Aerospace Engineering

Graduation year:
2010

Hometown:
Baltimore, MD

Most memorable Tech experience:
Winning the American Helicopter Society Student Design Competition with a group from his senior design class

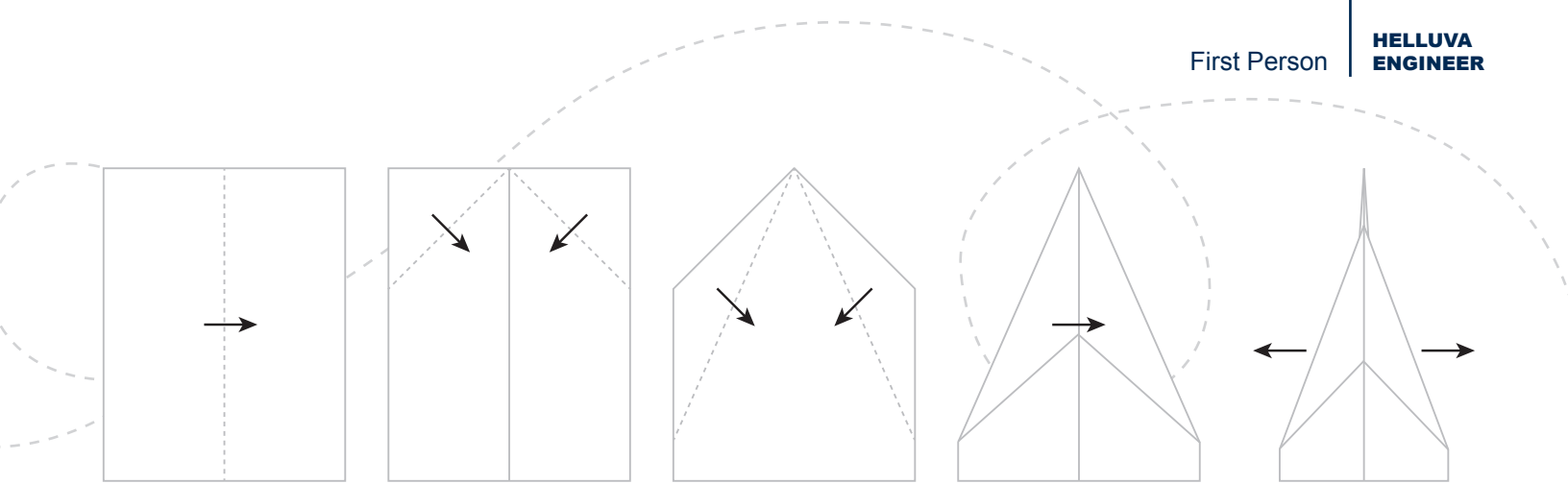
After graduating from CoE, alumnus Collin Brown found that the value of his education extended beyond his degree.

GROWING UP, MY FAVORITE MUSEUM WAS THE NATIONAL MUSEUM OF THE U.S. AIR FORCE.

I learned how to draw forced perspective by drawing L-1011s, Lockheed jetliners. I owned a toy collection of Legos and Micro Machines, and I took up model building and played flight simulators. My first science fair project tested which of several different wing shapes worked best on paper airplanes.

On top of all that, my grandfather was a Georgia Tech engineer. The cosmos left no other choice for me.

My name is Collin Brown, and I proudly display my Georgia Tech aerospace engineering degree above my computer. But these days, I'm a software engineer, completing computer projects with a dash of aerospace tossed in. While the cosmos may have guided me at Georgia Tech, the College of Engineering showed me more.



Ready to design the perfect airplane? Before growing up to be an engineer, Collin Brown spent childhood days testing wing shapes for paper planes.

CoE caused me many sleepless nights. Homework assignments, projects, quizzes and tests. Books to read. Experiments to perform. Questions to ask. Always a new how. Hard work, but with rewards. The constant challenges develop skilled and very versatile engineers.

As an aerospace engineering student, I realized I was getting an education in physics, math, programming, chemistry and other subjects. All these pieces add up to a solid aerospace education, but they don't limit students to aerospace alone. I realized I could be a better engineer if I knew more about everything else. Would my aerospace education, conversely, make better at everything else?

My best times at Tech were the late nights, gathered around a table with friends and united against the latest quandary. Eventually, study groups inevitably became discussion groups. We would solve air travel delays and invent perpetual motion. Then we'd find a flaw. Using skills acquired in the classroom, we could actually debate our solutions.

We would leave our study table tired, loaded down with questions, and in need of a professor with answers. The professors did their part and were always willing to hear an interesting idea (and then typically enlighten us as to why the idea wouldn't work).

To me, Georgia Tech's engineering college is where questions are rewarded with the means to answer questions rather than the answers themselves. Of course, the crux of this equation is more questions—tools to make more tools.

*My best times at Tech were
the late nights, gathered
around a table with friends
and united against the latest
quandary.*

In my first job out of college as an embedded software engineer, I had to perform tasks I had little previous experience with. My manager, patient and kind, thought this inchoate Tech CoE grad could handle the task. And after many questions and hard work, I feel I have become a software engineer. About a week in to that first job, I realized that Georgia Tech had prepared me very well. All those classes that forced me to seek out new tools were paying off. I knew a lot more than I thought—and what I didn't know, I was confident I could learn.

I'm two years into my career as a software engineer and I love it, and I'm also excited to see where the future takes me. Thanks to my education at CoE, I know I'm ready for whatever lies ahead. ■



**Are you a CoE graduate interested in sharing stories from your time at the College?
Send an email with your name, major and graduation year to editor@coe.gatech.edu.**

Dance

ISyE Professor Finds Rhythm in Numbers &

By KAY KINARD

IT IS CALLED THE UNBRIDLED DANCE. DRAMATIC BUT ELEGANT; SOPHISTICATED YET PASSIONATE.

Born in the lesser quarters of Buenos Aires and Montevideo in the late nineteenth century, tango is danced worldwide from Quais de Seine in Paris to Pudong of Shanghai, China. From all walks of life, individuals and couples flock to the flowing melodies. In the sea of dancers, moving with explicit synchronization is Dr. Nicoleta Serban, a professor in the Stewart School of Industrial & Systems Engineering.

As part of her work, Serban travels cross country and around the globe to present her research, interact with other researchers, and participate in study-abroad programs, among other things. She describes herself as an experienced data analyst who is passionate about developing statistical methodology in any research domain from molecular biology to predictive health. But wherever in the world she finds herself, she seeks out the comfort of the milongas, which is the name given to tango dance reunions: her second passion in life.

"This is actually one of the best ways to meet people when you travel," says Serban. "It is a safe way to go out in a new city and interact with the local community. With tango you are never alone. Everyone there comes for one reason: It is all about the dance."

Tango, it seems, has some very set rules. The invitation to dance is extended by the man and most often through eye contact. You may wonder if language might be a barrier, but as Serban explains, "You don't necessarily need to talk to engage. It is really all about eye contact, and a few words in between dances."

The milongas also serve as a microcosm of society. "All walks of life are found," says Serban. "Teachers, professors, students, truck drivers, business executives, everyone. The only important thing is to dance well." Age, race, ethnicity, where you come from, profession and education are of no importance. There is no discrimination except at the level of the dancing.

For a professor who works with numbers all day, the tango provides another research opportunity. "Social intelligence is learned on the dance floor," says Serban. "The psychology of social interaction is evident. Tango is complex not just in the dance but in the way it is conveyed."

Has tango taught the professor anything she could use at Georgia Tech? "One of the most valuable things I have learned from tango is how to follow," says Serban. "I am not used to following. As an academic, I am more prone to leading, in the classroom and in my research. But in tango, you close your eyes and let yourself be led. Feel the moves, feel the dance. The context of following, for me, is extremely challenging but is valuable in dealing with people in and outside of work."

To become a professor takes patience, so perhaps the tango is the perfect dance for this statistician. "Everyone can do it but it also takes a persistent personality to be good at tango," explains Serban. "It takes about two years to be comfortable as a dancer. It takes about four years to tango well and as much as 10 years to be really good at it."

Serban received her B.S. in mathematics and her Ph.D. in statistics at Carnegie Mellon University. Before joining Tech, her research focused on nonparametric statistical methods with application to molecular biology. Since then she has shifted gears and moved toward research areas more relevant to industrial and systems engineering. She has developed statistical methodology and applied statistics to industrial economics and degradation modeling in engineering systems, with a recent focus on healthcare access and predictive health. Her life of studies, research and travel has had one constant: the tango.

Unsurprisingly, Serban likes order, details, precision and complex reasoning. All those things are found in tango.

"There is so much complexity in the steps, the rhythm, and in the dance partners," she explains. "They all dance different moves, each one has his style, and the best dancers communicate their moves very subtly. That is why the tango, when well performed, is so hard."

Berlin and Buenos Aires ranked at the top of her best places to tango.

"Each place seems to have a different style, but once you understand tango, any place is like home. I have danced in Bucharest, Ljubljana, Shanghai, Paris, London, and more. Language—no problem," adds Serban. "The language is the dance." ■



MIKE KOENIG

A Family Affair

by LYNDSEY LEWIS

JUST WEST OF GEORGIA TECH, IN ONE OF ATLANTA'S HIPPEST NEIGHBORHOODS, A FEW TECH ALUMNI SHUFFLE INTO THE RESTAURANT BOCADO.

All are young, and all are slightly underdressed for the setting. But as they take their seats at a table, their comfort with one another is immediately obvious: They laugh at private jokes and discuss the merits of Bocado's burger.

These are some employees of Verco Materials, a Georgia Tech spinoff company. They're smart and industrious, sure, but they're also close friends with an easy camaraderie. Oh, and every Verco employee is a Tech graduate.

Led by Dr. Robert Speyer, a professor in Georgia Tech's School of Materials Science and Engineering (MSE), Verco manufactures armor and other products using boron carbide, one of Earth's hardest materials. Verco has developed methods to make it even harder. Everyone who works there takes a hands-on role in the synthesis process, which means, Speyer says, that all employees need to be "hardworking people" with great intelligence.

Which probably explains why everyone was plucked from Tech. (All but one of the five full-time employees have MSE degrees.) Once their professor, Speyer is now their boss, and staff members are friends both in and out of the office.

Is it weird? Is it cool? Employees say it's mostly the latter.

"I work with my best friends, which is awesome," says Mark. A Verco employee since 2008, Mark is the only team member without a background in materials science. (He majored in mechanical engineering at Tech.)

But he's just as key to the operation as everyone else. In fact, one of Mark's favorite things about the job—a sentiment echoed by his coworkers—is participating in every step of the building process. Because Verco is still a fledgling company,

all of its employees do a bit of everything. (That includes unglamorous tasks like machinery cleaning.)

The armor prototypes developed by Verco can provide effective protection in combat, but what makes them special is that they do so at less weight, and they can also contour well to body parts traditionally viewed as tougher to fit (such as limbs). All the employees are dedicated to the company's mission with seemingly evangelical fervor.

"Everyone takes ownership of the place," Speyer explains.

The Verco nerve center, a squat building not far from Bocado, doubles as both an office and a factory. Stroll in one day and you might see employees putting boron carbide powder into a giant press in an early step to create armor. (There's a reason no one wears typical office attire.)

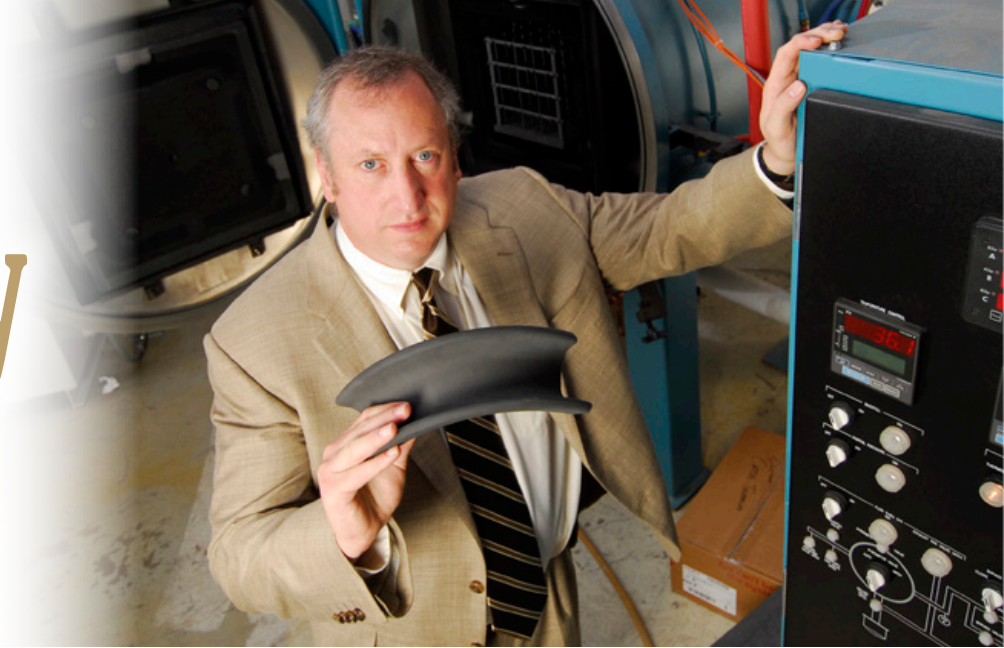
"I know that the actual work I do has a large effect on the company as a whole," says Gabriel, a Verco engineer and machinist who began work as an undergraduate MSE major. While Speyer always has the final say, many decisions are made by the whole team.

Mark, the ME graduate, was enthusiastic about the job before his first day even began. He became interested in Verco's work after seeing it featured on the History Channel. Though he didn't know Speyer at the time, he sought him out to ask about opportunities, and Speyer eventually hired him.

Now, he says, he's thrilled to be part of a team whose members are so close that they spend time together off the clock.

Verco's lead engineer, Schenck, has a Ph.D. in MSE, but like the rest of the group, he's young and exudes excitement about his position. Already, he's at the forefront of a company whose work could change the way the military is outfitted.

Not to mention, he adds, that "it's kind of nice coming to work and knowing you get to spend the day with some of your best friends." ■



MSE professor Robert Speyer leads Verco Materials.


GARY MEEK

The SCOOP

The New York Times **Science**

WORLD U.S. N.Y./REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION ENVIRONMENT SPACE & COSMOS

Researchers Put Sense of Touch in Reach for Robots



Department of Biomedical Engineering/Georgia Institute of Technology

In a video produced by the robotics lab at Georgia Institute of Technology, a robotic arm is shown adjusting a blanket.

By JOHN MARKOFF
Published April 28, 2013

Finding and reaching for objects by touch in your pocket, in the dark or among items on a cluttered table top are distinctly human skills —

FACEBOOK TWITTER

“...A group of roboticists in the Department of Biomedical Engineering at the Georgia Institute of Technology, led by one of Dr. (Rodney) Brooks’s former students, has developed a robot arm that moves and finds objects by touch.” – The New York Times, April 28, 2013

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Posted: 11:31 a.m. Friday, May 3, 2013

EDU ATLANTA

Canine creation a winner

ChewBots dog toys take InVenture Prize competition for 2013

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By Laura Raines
For EDU Atlanta

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“Dogs deserve a little more creativity,” Chris Taylor said in his presentation during the finals of Georgia Tech’s InVenture Prize competition in March. The junior mechanical engineering major was talking about ChewBots, the fully automated robotic dog toys that he invented.

Apparently the judges agreed with him; they awarded Taylor first prize in the competition. He hopes to manufacture ChewBots for the commercial market and the prize will definitely help. He won \$20,000 in cash and a free U.S. patent filing for his invention.

“Georgia Institute of Technology neuroengineer Steve Potter...developed a method for growing neurons in a dish containing electrodes to better understand how the brain responds to information.” – Discovery News, April 17, 2013

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BIOTECHNOLOGY

Brain in a Dish Controls Power Grid

APR 17, 2013 03:12 PM ET // BY ALYSSA DANIGELIS



A Global Vision for Clean Water

Georgia Tech graduates tackle one of engineering's biggest challenges

by BEN WRIGHT

PHOTOGRAPHS PROVIDED by TOHL

TOHL INC. WAS DESIGNED TO ADDRESS A SPECIFIC problem: how to transport water when disasters leave an area's infrastructure unusable. But three years later, it's grown into a global company that aims to make clean water accessible to everyone.

The idea behind TOHL, which stands for Tubing Operations for Human Logistics, was conceived by Apoorv Sinha in 2010 when he was a chemical and biomolecular engineering (ChBE) student at Georgia Tech. When earthquakes ravaged both Haiti and Chile just weeks apart, Sinha heard media reports of aid pouring in but getting stuck in ports due to destroyed supply chains. Thousands of bottles of water couldn't be delivered to the people who needed them most because roads were impassable. Bothered by the situation, Sinha met with his adviser, ChBE Professor Matthew Realf, to discuss how to overcome the challenges of distribution in a devastated area.

The solution that came to Sinha involved coil tubing he had seen used in oil fields when he worked in Kuwait.

"In the oil field you have point A and point B and you can't build pillars or structures to support the tubing," explains Sinha. "It has to be one piece that is that long. In disaster relief we saw the same parallel. We saw point A and point

B—a place which has the materials you want and a place that needs them, and there's nothing in between to connect them because the roads are gone or the bridges are broken, or whatever other reason. We saw that parallel and thought if coil tubing can do this under high temperature, high pressure conditions in the oil field, it should be able to do the same in logistical bottlenecks as well."

Realf suggested recruiting a civil engineering student to help develop the idea, so Sinha called on former calculus classmate and friend Ben Cohen. Together they developed a method to quickly install a pipeline of flexible tubing using a helicopter.

With an idea in place they recruited ChBE student Melissa McCoy, who had the experience needed to help develop a business plan. She in turn helped recruit Travis Horley, a public policy and international affairs major who had worked in South America and who suggested applying for funding through Startup Chile. It was sound advice, and late in 2011, Startup Chile awarded the group \$40,000 in funding to get their concept off the ground.

With financing secured, TOHL went to Chile in March 2012, filed a patent, incorporated the company, and prepared to test its technology.





Top: Testing water quality at the source before an installation.
Bottom: The TOHL team celebrates with local partners after a successful installation in San Jose de Maipo, Chile.

“What we actually filed a patent for,” explains Cohen, who is now TOHL’s president and CEO, “is the process of installing pipeline via helicopter in long segments via the methodology we use, which is a large spool attached to a cargo hook on a helicopter with one homogeneous piece of tubing rolled on the spool. The helicopter flies with the spool suspended from the hook and deploys the tubing as it flies along virtually any terrain, other than power lines.”

TOHL pitched the technology to various aid organizations prior to testing it, but the group was told either the technology wasn’t needed or that it wouldn’t work.

“It’s kind of funny,” says Cohen. “We put together an animated video of how we expected the technology to work, and even when we showed people that video they didn’t think it was going to work. They didn’t think it would be possible to lay a pipeline with a helicopter because of the different forces at work.”

The skeptics were wrong: The initial test was a resounding success, installing a kilometer of 25-millimeter high-density polyethylene tubing via a spool suspended from a helicopter in just nine minutes. Eight hours later, the solar-powered

pumps that power the system were up and running and water was flowing.

With the technology proven, Cohen sees tremendous opportunity for TOHL’s product. While the technology was developed for problems caused by natural disasters, Cohen and Sinha have realized that it also has applications in parts of the world where access to water is a daily problem even at the best of times.

So they’re working with local governments and water companies in countries including Chile, Peru, South Sudan and India, where their solution offers a fast and cost-effective alternative to installing miles and miles of traditional pipes. Looking beyond water distribution, TOHL is also exploring ways its technology could be used in the mining and marine salvage industries to transport fluids to and from work sites.

With TOHL poised to sign contracts with a range of new partners, the trio of engineers who launched the company credit Georgia Tech for putting them in a position to succeed.

“I think access to human capital was one of the key points,” says Sinha. “As much as you can get done by yourself, you definitely need a solid team to move forward. All of us who have been involved as team partners have been very crucial, and the only reason we were able to get them on board was because of Tech. Having an adviser like Dr. Raelff initially and then a team of myself, Ben, Melissa, and Travis, that’s something that could only happen at Tech, where you have engineers with completely different backgrounds. The fact that Tech can pull students from different parts of the country, as well as the world—that was a huge benefit for us. That was definitely one of the reasons TOHL is growing globally, not just in Chile but in all different parts of the world.”

“I think at Georgia Tech I really found that if you wanted to take initiative and get something done that there was support here for you,” adds McCoy. “I think at some universities it’s hard for students to get any traction or to get much help. I found that at Georgia Tech if you just asked people would sit down with you.”

An engineering education from Tech was invaluable, Cohen says.

“If I hadn’t gone to Georgia Tech and received that training,” he says, “I know for a fact we wouldn’t be as far along as we are now.” ■

Check out this video from TOHL to see its technology in action.







THE MICK JAGGER OF MOOCs

With a new type of engineering class, ECE Professor Magnus Egerstedt has a chance to educate thousands. Can he pull it off?

STORY *by* LYNDSEY LEWIS
PHOTOGRAPHS *by* ZACH PORTER
ILLUSTRATION *by* JOHN LAU



THERE IS A PROBLEM WITH THE ROBOTS.

PROFESSOR MAGNUS EGERSTEDT EYES THEM WITH DISMAY. HIS ROBOTS, ROTUND LITTLE THINGS THAT WOULDN'T LOOK OUT OF PLACE IN A ROOMBA AD, ARE MISBEHAVING. THEY'RE CRAWLING TOWARD TWO SILVER CASES IN THE MIDDLE OF THE FLOOR, BUT JUST BEFORE REACHING THEM, THEY'RE SUPPOSED TO SENSE THE OBSTACLES AND SKITTER AWAY.

The demonstration is the highlight of Egerstedt's lecture; it is the center ring of this particular circus. A professor in the School of Electrical and Computer Engineering (ECE), Egerstedt is teaching a class on robot control, and the point of the course tends to be lost if the robots in question are going rogue.

Toward the cases they go, but wait! They're sliding this way and that way. They come to halting stops or turn dizzily, and some of them don't recognize the cases at all and slam into their shiny edges. HAL 9000 these robots are not, but their predicament is looking dire.

It's as if they're drunk—and in a way, they are. The robots, all Khepera IIIs, have infra-red sensors that are sensitive to light, and they're suffering beneath the harsh glare of studio lamps. This isn't a typical classroom lecture—these robots are starring in a massive open online course, or MOOC.

Egerstedt is teaching in a familiar way, but the setting is different. There are no students present, and instead of a classroom or lecture hall, the lesson is being given in a studio with a jungle of lamps overhead. Every move Egerstedt makes is recorded for online broadcast, and his robots are not taking kindly to the extra light. Frustrated, Egerstedt calls out to Brian Wilson, the instructional media producer who is filming the lesson.

"Brian, can we do it again?" he asks.

"I'm just going to keep rolling," Wilson replies.

"Yeah," Egerstedt says. "Till it works."

And it does work eventually, and when it does, the effect is sublime. Egerstedt turns triumphantly to his student assistant, Jean-Pierre de la Croix.

"Yeah!" he exclaims. "Robotics is so easy, man."

A MOOC is a special type of online class. Available to anyone with an

Internet connection, most MOOCs offer college-level material via pre-taped lectures, and course enrollments can swell to tens of thousands of students. The premise is simple: Bring higher education to the masses by cutting through academia's red tape and, most tantalizingly, offering many courses (including Egerstedt's) at the low, low cost of free.

Like other universities, Georgia Tech has embraced the promise of MOOCs, and the Institute offers them across a growing array of disciplines. But a newly hatched breed of pedagogy brings risk, and as MOOCs multiply around the country, observers express both excitement and skepticism toward them.

Egerstedt is a believer, and he's also a guinea pig. Few engineering MOOCs have sprouted thus far. There is no blueprint for this course, Control of Mobile Robots, and no backup plan when Egerstedt's recording sessions, like the one with the silver cases, do not go quite as expected.

None of that dampens his enthusiasm. He wants to be, he says, a Mick Jagger-like figure of the robotics world.

Can he pull it off? Can he become a rock star of online education, spreading the gospel of robotics to students around the globe? More pressing is the question of what students will take from his lectures: No one who enrolls in his course, even those who do exceptionally well, will receive university credit for their efforts.



Magnus Egerstedt, ECE's Schlumberger Professor, teaches robotics and controls at Georgia Tech. Control of Mobile Robots, offered through the Coursera platform, is his first MOOC.

Still in their infancy, MOOCs are stirring debate in newspapers, magazines and blogs galore. This is the story of one MOOC—and the man who would be Mick Jagger.

"A CHANCE TO DO GOOD"

There is perhaps no one better suited to teach a MOOC than Magnus Egerstedt.

He is impossible to dislike. His excitement for his work is palpable. And, maybe most important, he is unafraid of the unexpected.

"I am not an expert on MOOCs," he said. "I just happen to be doing it."

Egerstedt, originally from Sweden, has worked at Georgia Tech for 12 years. Recently awarded ECE's first-

ever Schlumberger professorship, he typically teaches senior- and graduate-level courses on robotics and controls, and robots are the epicenter of almost everything he studies. His CV features work with self-driving cars and humanoid robots, but his recent research focuses on swarm robotics.

Ask him to tell you about it sometime; when he discusses his latest projects, he's animated and eager to explain details. Through his work in swarm robotics (or, to put it a simpler way, robots moving in groups), Egerstedt studies animal behavior, applying lessons from the natural world to the artificial one.

"I've always been fascinated by schooling fish and bird flocks," he said.

There is strength in numbers. The power of a single robot—even an expensive one—can be dwarfed by dozens of cheaper beings' capabilities. Imagine, for example, the tattered landscape left behind by a big earthquake. In the rush to find victims, a hundred inexpensive robots might be able to comb through wreckage faster and more efficiently.

"The question there is cooperation," Egerstedt explained. This is the sort of thing he could talk about all day. He is fueled first and foremost by Starbucks coffee, but he also thrives on an unsinkable enthusiasm for his work.

Which, in a way, explains his foray into MOOCs. Egerstedt loves teaching robotics, and he decided MOOCs could give him the chance to share that passion with thousands.

"There is something fundamentally satisfying," he said, "about having all these people across the world learning something that they otherwise wouldn't learn."

Jean-Pierre de la Croix, a Ph.D. student studying under Egerstedt, appears as an assistant in some of his MOOC videos.

Egerstedt was first yanked into the MOOC world in early 2012, when he heard a talk by Udacity cofounder Sebastian Thrun. Udacity is one of the three major startups offering MOOCs; the others are edX and Coursera (the platform that eventually hosted Egerstedt's MOOC). Michael McCracken, director of online course development and innovation for the Institute's Center for 21st Century Universities (C21U), learned that Egerstedt had been contemplating a MOOC of his own.

By this point, Tech had a contract with Coursera, and Egerstedt had laid the foundations for the class he hoped to teach.

"I knew the story I wanted to tell," he said. And so his course was born.

He began filming lectures and demonstrations on robot control in Fall 2012. Collaborating with one of Georgia Tech Professional Education's instructional designers, as well as C21U, Egerstedt created a seven-week course broken into bite-size pieces. Each week of material was given its own theme and divided into eight or so "sublectures" between about five and 11 minutes long.

In addition to their cosmetic distinctions, MOOCs differ from traditional classes in their basic structure. If you take an on-campus course at Georgia Tech, you could find yourself in a lecture hall for hours at a time, listening to a professor cover multiple topics during a single session. Tech MOOCs, meanwhile, demand content in a more easily digestible form. Forty-five minutes to present a new concept? Nope—you've got just 10. To ensure students are grasping the material, each week's lessons are capped with a quiz.

One of the most vocal proponents of this teaching model is Rich DeMillo, the director for C21U (and one of Georgia Tech's key MOOC experts). In 2011, he published a book called "Abelard to Apple: The Fate of American Colleges and Universities," which examines the future of higher education. It has a chapter about MOOCs, which DeMillo originally thought was "a very way-out concept."

After the book's release, he continued investigating their usefulness and efficiency, and one of the things he appreciates most about GT MOOCs is the way they are delivered. Teaching lessons in small doses, he says,



incorporates the principles of “mastery learning,” a concept developed by educational theorist Benjamin Bloom. The idea is that everyone can learn when content is fed a little bit at a time and students are constantly tested.

“That is better than the normal classroom,” he said, “and we know this because there’s 100 years of educational research that show it.”

Egerstedt admits that after years of educating via longer lectures, he initially struggled to adjust to a new format. But by early 2013, when he was wrapping up MOOC filming, he had fallen into an easy rhythm. Though his PowerPoint slides offered a compass for each lesson, Egerstedt improvised almost all his lectures as he gave them.

The class was due to start Jan. 28. To promote it, Coursera released a trailer of sorts on its website, featuring footage of Egerstedt and some friends: a Khepera, a humanoid robot, and

a drone. (Certainly no other MOOC previews boasted the same James Bond flair.)

“I look very much forward to seeing you enrolled in Control of Mobile Robots in the not-too-distant future,” Egerstedt told viewers.

Still, concerns bubbled in his mind. MOOCs are a gamble—some have failed, resulting in suspension or cancellation. And he wondered whether engineering coursework, in which practice can be just as important as theory, might prove unadaptable for MOOCs. Engineers, he noted, “develop theory not because we’re mathematicians, but because theory helps us solve real-world problems. That can get lost in the video shuffle.”

But when he peeled the worries away, Egerstedt found a dozen shimmering opportunities. He wanted enrollees to find intellectual stimulation and think more analytically, but his greatest

wish was to catapult students into new worlds, igniting lifelong interests in both robotics and engineering.

“I truly believe there is a chance to do good,” he said.

By the time his MOOC began in January, nearly 40,000 students had registered.

THE MAKING OF A MOOC

In 2012, Focus Features released a new film adaptation of Leo Tolstoy’s “Anna Karenina.” The movie hinged on a lavish conceit: Much of the action was filmed as if taking place on a stage.

Grand ballrooms served as sets; elegant décor was reduced to mere props. The overarching plot, however, remained largely the same.

Instructional media producer Brian Wilson oversees filming for one of Egerstedt’s final MOOC lectures.



This retooled “Anna” drew mixed reviews. Critics praised its stars’ performances, but some admitted they were turned off by the theatrical motif. In a review for Australia’s Special Broadcasting Service, the critic Don Groves wrote that the film’s “artifice creates an invisible wall between the cast and the viewer, frequently working against the sense of realism and blunting the emotional intensity.”

In a sense, much of the criticism levied against MOOCs is similar. Without a conventional classroom environment, some say, the courses could lack intellectual spark.

Of course, many of the students in Egerstedt’s MOOC might never get to physically sit in his classroom anyway. In the months before the class started, he faced an email deluge from prospective students around the world. Excited messages poured in from South America, from Europe, from Southeast Asia, and the sentiments from across linguistic and geographic borders were the same: We want to take your class!

Other emails were written closer to home. Egerstedt read notes from American undergraduates and even some from younger teenagers, and a few high school robotics groups asked if their members might benefit from the lessons.

Egerstedt found these questions slightly worrisome. It is a truth universally acknowledged that robots are cool, but he had bigger things in mind for his MOOC.

“There is going to be a level of mathematical sophistication,” he said, “that is hard for a student.”

Watering down his material was out of the question. The Coursera website offered a warning of sorts, recommending that potential Control of Mobile Robots students bring a background in calculus and linear algebra. Far from an occasional guest, math played a starring role in lectures and quizzes. Here’s a question pulled

directly from one of the MOOC assessments:

In Week 6, we used a point-robot model, $\dot{x}=u$, $x \in \mathbb{R}^2$, to describe the robot dynamics. But, the actual robot is nonlinear. So, when implementing the behaviors, we have to map the point-robot input $u=[u_1, u_2]$, onto the real control signals, i.e., onto (v, ω) in the unicycle case. Which of the following control designs would make a unicycle model mimic the point-robot model reasonably well?

1. $v=\|u\|$, $\omega=K(\text{atan}(u_1/u_2)-\phi)$, $K<0$
2. $v=u_1$, $\omega=u_2$
3. $v=\|u\|$, $\omega=K(\text{atan}(u_2/u_1)-\phi)$, $K>0$
4. $v=\|u\|$, $\omega=K(\text{atan}(u_1/u_2)-\phi)$, $K>0$
5. $v=\|u\|$, $\omega=K(\text{atan}(u_2/u_1)-\phi)$, $K<0$

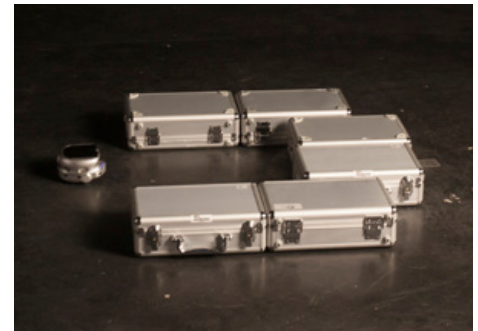
The course’s point, Egerstedt stressed, was not to simply “build a Lego robot and do some random stuff.” To offer his audience the same level of content that Georgia Tech students would get, challenging math had to remain a staple. But that invites another question: Why should an institution like Georgia Tech (or any university, for that matter) give away its best stuff for free?

As a prominent MOOC advocate, DeMillo has faced that question again and again.

“To me, that is actually the least interesting discussion to have,” he said. The people throwing themselves into MOOCs—the course planners, the professors, the administrators—are “taking the long view.”

“The worst thing you can do is make a short-term opportunistic decision when you’re not quite sure what the 10-year picture is going to look like,” he said.

DeMillo sees Tech translating a portion of its course catalog into MOOC form. The possibilities are enticing: MOOCs could be distributed to high school students, he said, to acclimate them to college work in the same way an Advanced Placement curriculum does. The advantage of using a MOOC over



In a controls demonstration for one of Egerstedt’s online lectures, the Khepera III robot avoids hitting obstacles even as it slides close to them.

To offer his audience the same level of content that Georgia Tech students would get, challenging math had to remain a staple.



Although his PowerPoint presentations guide him, Egerstedt improvises his lessons as he gives them.

an AP course, however, is that “we can tailor the MOOC to better match the Georgia Tech curriculum.”

On a more philosophical level, DeMillo stresses, the courses can redefine the very idea of what good teaching is. And that’s where Egerstedt comes in.

“Magnus is a very infectious guy,” DeMillo said. “He comes to the subject with a lot of enthusiasm, and it shows up well in these online courses.”

It shows up well in person, too.

Control of Mobile Robots generated excitement around the world, but Georgia Tech students—the ones who are right here in Atlanta and working toward an engineering degree—stood to benefit as well. Egerstedt teaches a course called Embedded and Hybrid Control Systems, or ECE 4555. During past semesters, the class has proceeded as many engineering classes do: Egerstedt devoted some sessions to lecturing and others to hands-on experiments. But for his Spring 2013 group, he decided to shake things up a bit.

Big swaths of ECE 4555 material overlap with Egerstedt’s MOOC. Given that, then, he decided to try a “flipped classroom,” in which students watch lectures online to free up class time for discussion and hands-on work.

Ryan Bahr is one of those students. A bright and chatty Tech senior, Bahr has an easy smile and a penchant for robotics. (You’re apt to find him browsing diydrone.com, a forum for enthusiasts of unmanned aerial vehicles.)

Bahr, an electrical engineering major from Peachtree City, hopes to one day work in radio frequency engineering. ECE 4555 is the second course he has taken with Egerstedt, and when he signed up, he didn’t know online lectures would be part of the experience. Unlike the MOOC, this section of ECE 4555 came with a prerequisite class and built on earlier material.

With Egerstedt’s online lectures teaching the basics, his ECE students were free to spend class time

applying their knowledge in robotics experiments. Bahr pointed out the benefits of learning engineering this way.

“In some classes, you just always talk about it,” Bahr said. “Being able to use it once on a real live object makes it 10 times more useful in the real world, in my opinion.”

TWO REALITIES

As Egerstedt’s MOOC and flipped course progressed, the physical world and the digital one sometimes mirrored each other in unexpected ways.

On a bright Thursday afternoon, a classroom in Tech Square filled with students. A whiteboard, so big it ate up an entire wall, beckoned with equations in red, blue and black marker. There were no desks; the thirty or so students who eventually wandered in bunched together on the floor.

These were the students of ECE 4555, a tiny sampling of Control of Mobile Robots' thousands of enrollees but the only ones participating in the flipped course. After watching Egerstedt's lectures online, the students tackled a new robot-control project each week with both Egerstedt and graduate assistants on hand to offer guidance. Tuesdays were for writing code; Thursdays were for testing it on unsuspecting robots.

This week's assignment: Program a Khepera to travel a predetermined path, hitting a series of goal points marked on the floor with tape. Without desks or chairs, some students sprawled belly-down on the floor like swimming frogs; others leaned against the wall and stared into laptop screens.

Egerstedt, dressed in his typical blazer-and-dark-jeans uniform, opened the class by soliciting questions. Then the experiments began, with graduate assistants Jean-Pierre de la Croix and Amy LaViers standing nearby to help out. (LaViers, another MOOC co-star, led a video lecture each week to help prepare students for quizzes.) Egerstedt worked his way through the room, peering at students' code and watching their robots jolt to life.

Divided into groups, the students chatted among themselves as they awaited Egerstedt's evaluation or sent Kheperas zipping around the floor. Between the robots and the budding programmers, the room hummed with energy, which is just the way Egerstedt likes it.

"The turns are way faster than the linear velocity," he advised one group upon scanning their work, "which means you are going to end up slipping a little bit." Back to the drawing board: The students huddled to tweak their code.

Another group mastered the assignment on the first try. Their Khepera strutted confidently along its assigned path, while Egerstedt, overjoyed, whipped out his iPhone to shoot video.

"That is picture-perfect!" he gushed. "That was fantastic!"

A big benefit of the flipped class was the immediate feedback it offered Egerstedt. Through his on-campus students, he could quickly gauge how his online lectures were being received — which concepts were well elucidated and which might need some clearing up. But his favorite part of the class, he said, was that it allowed more time for hands-on work with students.

"People seem so engaged," he said, "and it's so exciting and the projects are going so well."

Bahr was enjoying the flipped format, too. He was glad for more time to work with robots, which gave him and his classmates a chance to create their own robotics projects toward the end of the semester.

"Overall it's really awesome," he said.

How could the MOOC compete with that? Egerstedt's video lessons, though laced with his humor, were typically subdued affairs. But the class, he quickly discovered, was much larger than his presentations.

In a lecture for his MOOC's second unit, Egerstedt appeared against a

black backdrop. Seated behind a desk, he addressed his thousands of students about the necessity of testing controls with a simulator.

Toward the end of the lesson, he again used a Khepera that, just like in the ECE 4555 session, was programmed to slide across the floor and hit a goal point. As it moved, Egerstedt offered commentary like a sports analyst.

"As you can see, the turn was nice — there were very few, or little, oscillations here," he observed.

Cheep, cheep, cheep. The machine ambled toward the tape.

"And the Khepera is making it very nicely all the way to the turquoise goal point," Egerstedt concluded. "So, we will call that a success."

Without any students to witness the success in person, his proclamation was greeted with silence. But on the Internet, MOOC participants were buzzing.

On the Control of Mobile Robots website, students took to discussion boards to trade tips, share questions, and chat about the





THE GOLDEN OPPORTUNITY

Five days a week, Collin Brown drives to work at a small industrial park in suburban Cincinnati. In his job as a software engineer, he sifts through computer code and debugs programs.

But for two months, Brown devoted his precious weekend hours to another type of engineering. As a sort of extracurricular pursuit, he enrolled in the Control of Mobile Robots class and found himself enamored with the material.

“The class really helped bridge theory to reality and then to practice,” he said. “Now I want to learn more and run out and build my own robot.”

A graduate of Tech’s Guggenheim School of Aerospace Engineering, Brown is also a science lover, a trivia buff and curious about the mechanisms behind everything. Participating in Egerstedt’s MOOC, he said, offered a way to learn something new and build his resume at the same time.

Even though the class didn’t award official credit, students who completed it successfully (averaging a score of 60 percent or above on all quizzes) received a certificate from Coursera. Brown, who liked to gobble several videos at a time and aced nearly every quiz, earned a seal of distinction on his certificate to honor his performance.

And he wasn’t the only one.

By the time Control of Mobile Robots ended in mid-March, nearly 4,300 people had passed it, and about half of those did well enough to merit the seal of distinction. Participation levels fluctuated during the course’s seven weeks, but when the MOOC closed, more than 40,000 people were registered. (Not everyone who enrolled tried the quizzes—some just wanted to watch lecture videos, read forums or observe unnoticed.)

“There is appetite for serious content. There is a clear niche for these upper-level engineering courses.”

MAGNUS EGERSTEDT



course. Egerstedt, LaViers and de la Croix monitored the forums regularly, looking for chances to offer help or clear confusion. But to Egerstedt’s surprise, students were finding ways to support each other.

If a poster expressed frustration with a concept, another user might chime in to explain it. Just like on other Internet boards, students could “vote up” pertinent questions and “vote down” less relevant remarks. This system helped Egerstedt and his assistants better assess where their expertise was needed.

Meanwhile, in-person study groups sprouted in countries around the world, and on Twitter, students used the hashtag #conrob to discuss the class. A student-run website with extra robotics resources—including YouTube videos, math help and a Khepera simulator—appeared as well.

At Georgia Tech, Egerstedt directs a lab called the Georgia Robotics and Intelligent Systems Laboratory, or GRITS Lab. The name of the student-operated site: GRITS Group.

“It’s quite wonderful,” Egerstedt said, “to see this community emerging.”

Egerstedt noted that teaching a MOOC allowed him to reach more students in seven weeks than he had in his entire Georgia Tech career.

“This is fun, and you have impact beyond your wildest dreams,” he said.

Teaching advanced engineering to a class of thousands is bound to attract some attention. Even before the MOOC ended, its successes were drawing notice: With a higher-than-usual retention rate and plenty of positive feedback in online forums, Control of Mobile Robots became a beacon of the MOOC universe.

Egerstedt was invited to speak at conferences around the country, which he found “satisfying and a little surreal.” In March, he was one of three featured speakers at a conference in San Diego. The other two lecturers: Coursera’s founder and the director of edX.

Though his class was quickly trumpeted as a model for engineering MOOCs, Egerstedt tried to maintain a realistic tone in his speeches. He didn’t hide, for example, the fact that a few participants fired personal attacks at him and his teaching assistants early in the course. He didn’t mind being a target himself, but seeing his graduate students subjected to inflammatory remarks was upsetting.

“That pissed me off to no end,” he said.

But the negativity melted fast, and by the course’s end, its forums hosted praise for both Egerstedt and his graduate students. Though he earned a kind of personal fame, Egerstedt

wanted to place his victories in a broader context: He hoped his class’ success would prove that not only were MOOCs and flipped courses viable, but that they could work with concepts steeped in high-level math and engineering.

“There is appetite for serious content,” Egerstedt said. “There is a clear niche for these upper-level engineering courses.”

That’s where he thinks Georgia Tech and the College of Engineering can shine.

Universities around the world are scrambling to construct their own MOOCs, and wading through the increasingly crowded pool can be daunting. But Tech specializes in engineering classes that teach highly sought skills. With the right finesse, Egerstedt maintains, GT can create MOOCs that few other institutions can match, and that in turn will strengthen the Institute’s brand around the globe.

“It’s a golden opportunity we should take,” he said.

His Control of Mobile Robots students seemed to agree. As the course drew to an end, a discussion thread about a follow-up class materialized, and it grew into one of the board’s most popular threads. Its title: “WE WANT CONTROL OF MOBILE ROBOTS 2!!!!”

Dozens of participants signed their names to pleas for a second class, with some listing their home cities as well. The geographic diversity was astonishing: Students came from Savona, Italy; Accra, Ghana;

Montreal, Quebec; Lima, Peru; Karachi, Pakistan; Guanajuato, Mexico; Boulder, Colorado. (And the list went on.)

Egerstedt is indeed planning a second course, and he’s also making a few revisions to the first one so that it can be offered again. (The University of Hawaii has expressed interest in using it for its own flipped class.) Not too long from now, thousands of new enrollees will be learning about robot control from Egerstedt.

Some of his inaugural MOOC students, meanwhile, were reluctant to say goodbye. In the final days of the course, they flooded the forums with thank-you notes for Egerstedt, de la Croix and LaViers. A few of the messages posted:

- “I really loved this course! Excellent material and really fun to follow. Thank you Professor Egerstedt and all other people involved in this project too.”
- “Your obvious enjoyment of the topic was inspiring, even awesome.”
- “Thank you Prof Magnus Egerstedt, Amy and JP. It was great and fun learning from you guys.”
- “It’s been 40 years since I last looked at modern control theory. If I’d had a teacher like the Prof all those years ago, who knows how my life would have changed.”

And then, tellingly, one student wrote this:

“Dr. ME = Rock Star!!! Keep changing the world for the better by equalizing education...” ■

ONLINE MASTER OF SCIENCE
IN COMPUTER SCIENCE

OMS CS

Offered in collaboration with Udacity and AT&T

Diplomas Via MOOC >>>

In May 2013, Georgia Tech announced the launch of a groundbreaking new program: an advanced degree offered entirely in MOOC format. Collaborating with Udacity and AT&T, Tech will offer the new Online Master’s of Science in Computer Science for under \$7,000. The program is the first of its kind from an accredited institution and will accept students to matriculate in Fall 2014.





In the AIR WE BREATHE


A look inside Dr. Sally Ng's custom aerosols lab

STORY *by* BEN WRIGHT
PHOTOGRAPHS *by* NICK BURCHELL

IT STARTED WITH A SKETCH IN A
NOTEBOOK.

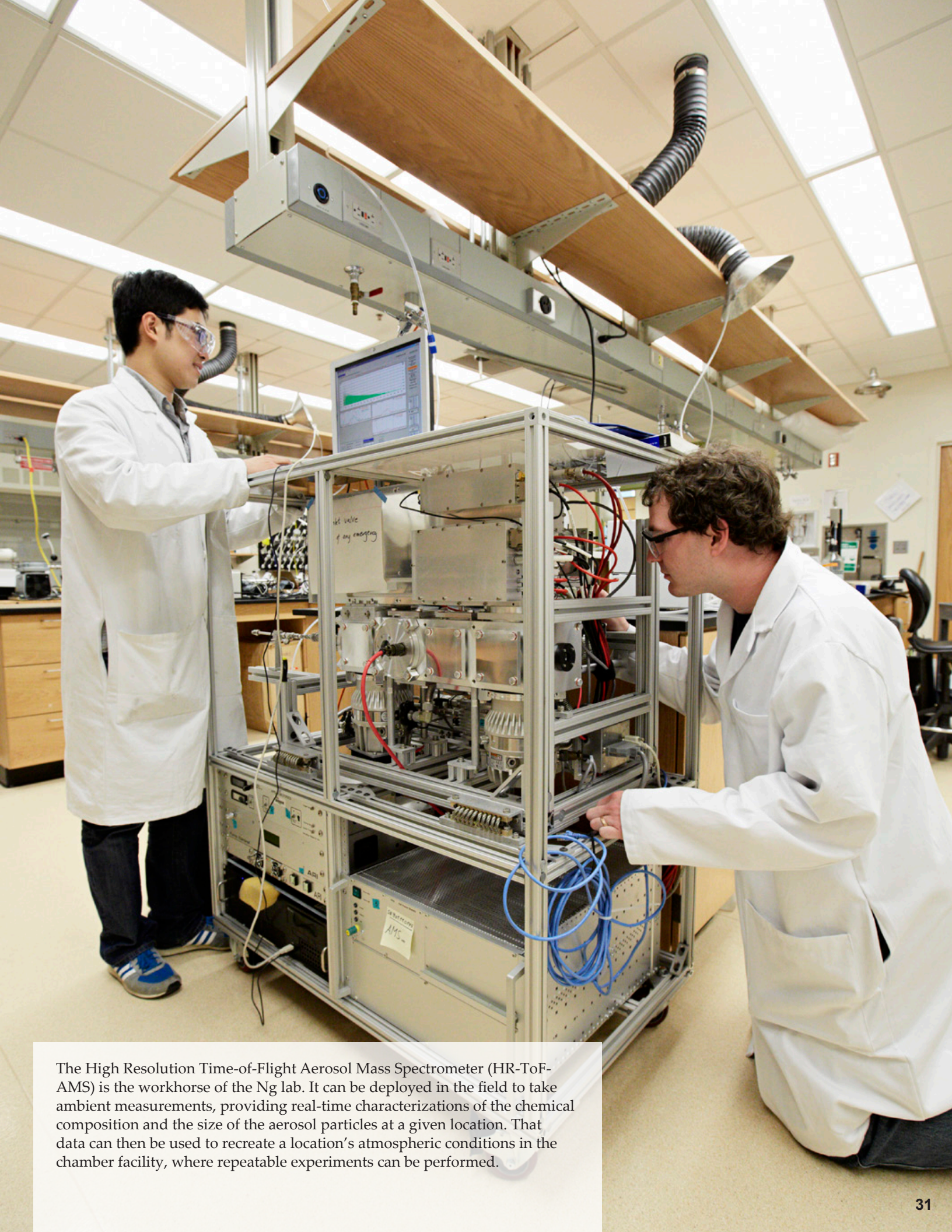
With no design or construction experience to speak of, Dr. Nga Lee (Sally) Ng, an assistant professor in Georgia Tech's School of Chemical and Biomolecular Engineering, designed and built a one-of-a-kind aerosol research space in the Ford Environmental Science & Technology (ES&T) Building in under two years. While we know that aerosols, which are essentially nanoparticles suspended in the air around us, influence both the environment and our health, little is known about how human activity affects aerosol formation or evolution. Ng hopes to change that by studying how biogenic and anthropogenic aerosols react and interact with each other, but to do that she had to build something that has never been built before.

The Georgia Tech Indoor Chamber Facility (GTICF), as it has been named, is a 21x12 foot climate-controlled enclosure. It houses two flexible Teflon chambers suspended from the ceiling, which are surrounded by both UV lamps and sunshine fluorescent lamps, and is a strange and beautiful world unto itself.


The image shows the interior of a laboratory chamber. The walls and ceiling are covered in a highly reflective, crinkled silver material, likely aluminum foil or a similar thermal insulation. Several horizontal strips of bright green tape are applied across the reflective surface. On the right side, there is a metal frame structure with a white cylindrical component attached. The overall appearance is that of a specialized, controlled environment for scientific research.

The array of lights surrounding the chambers allows Ng and her staff to conduct research under conditions never before studied. The existing body of aerosol research has been confined to the UV range and a standard temperature of about 20 degrees Celsius.

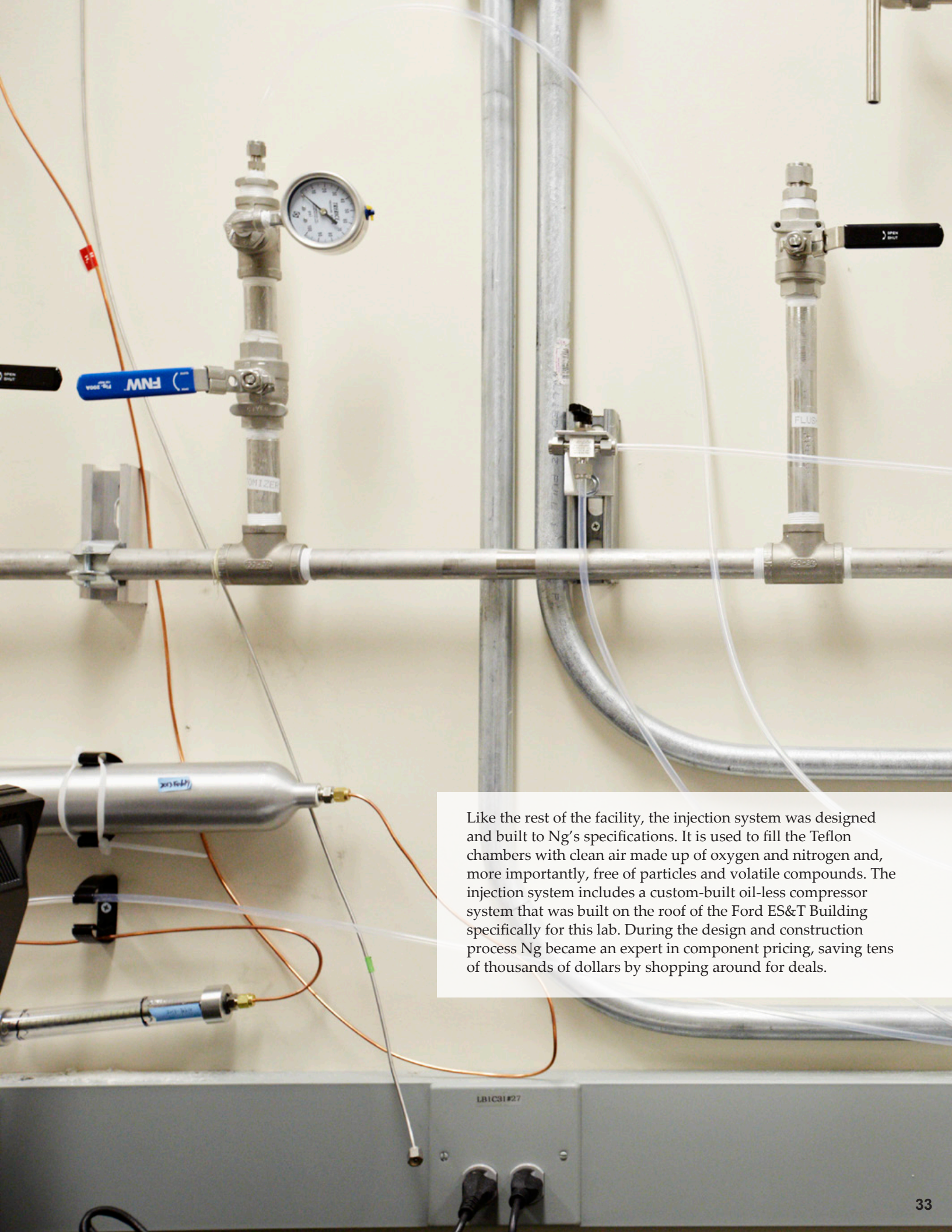
Thanks to the unique light setup and the precise climate controls, the GTICF is the only facility in the U.S. that can generate aerosols under low temperatures and a light spectrum that captures the full range of photochemistry in a well-controlled environment. This provides a unique opportunity to investigate aerosol formation and chemical and physical properties under conditions that were not previously accessible to researchers.



The High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) is the workhorse of the Ng lab. It can be deployed in the field to take ambient measurements, providing real-time characterizations of the chemical composition and the size of the aerosol particles at a given location. That data can then be used to recreate a location's atmospheric conditions in the chamber facility, where repeatable experiments can be performed.

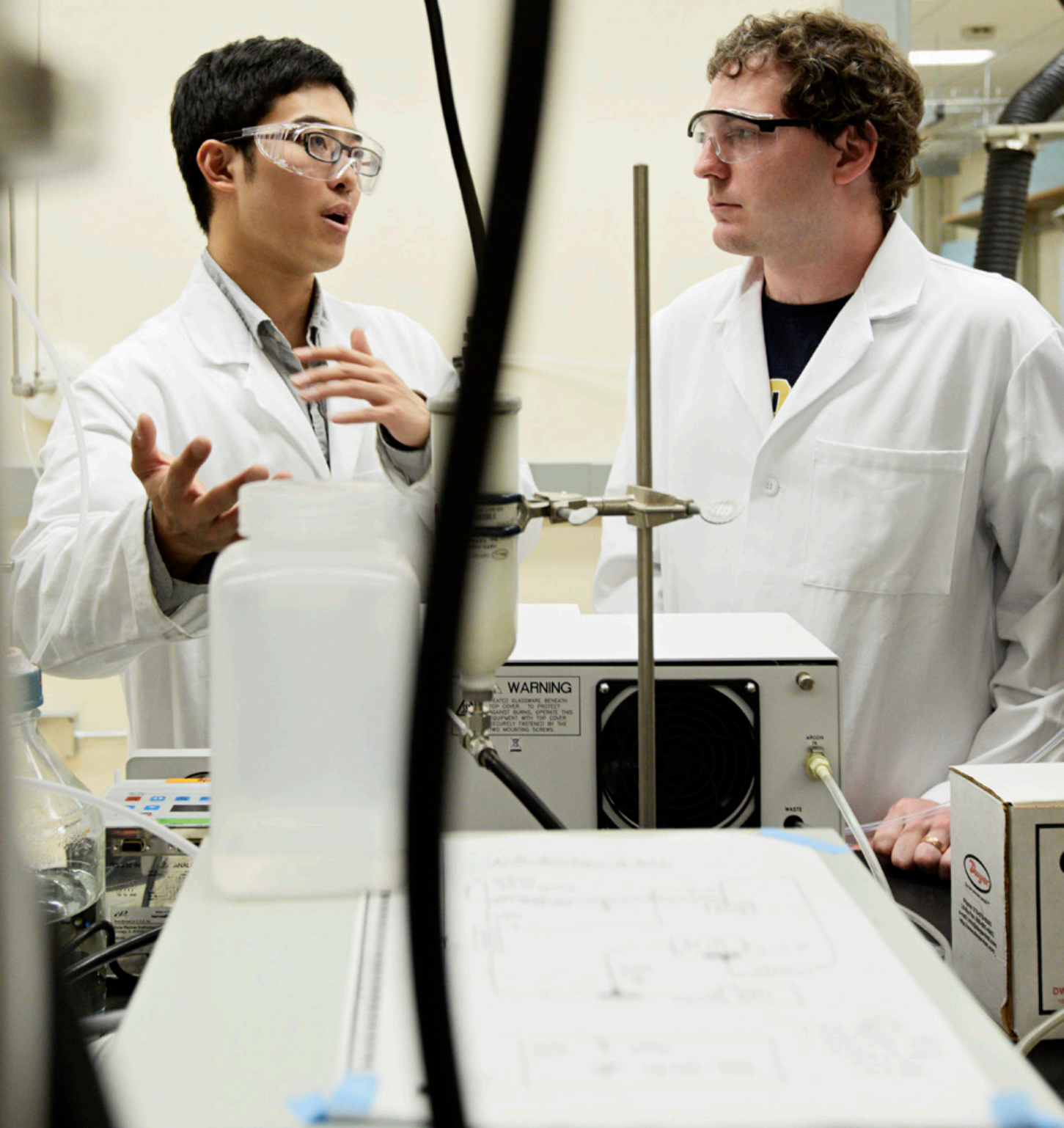


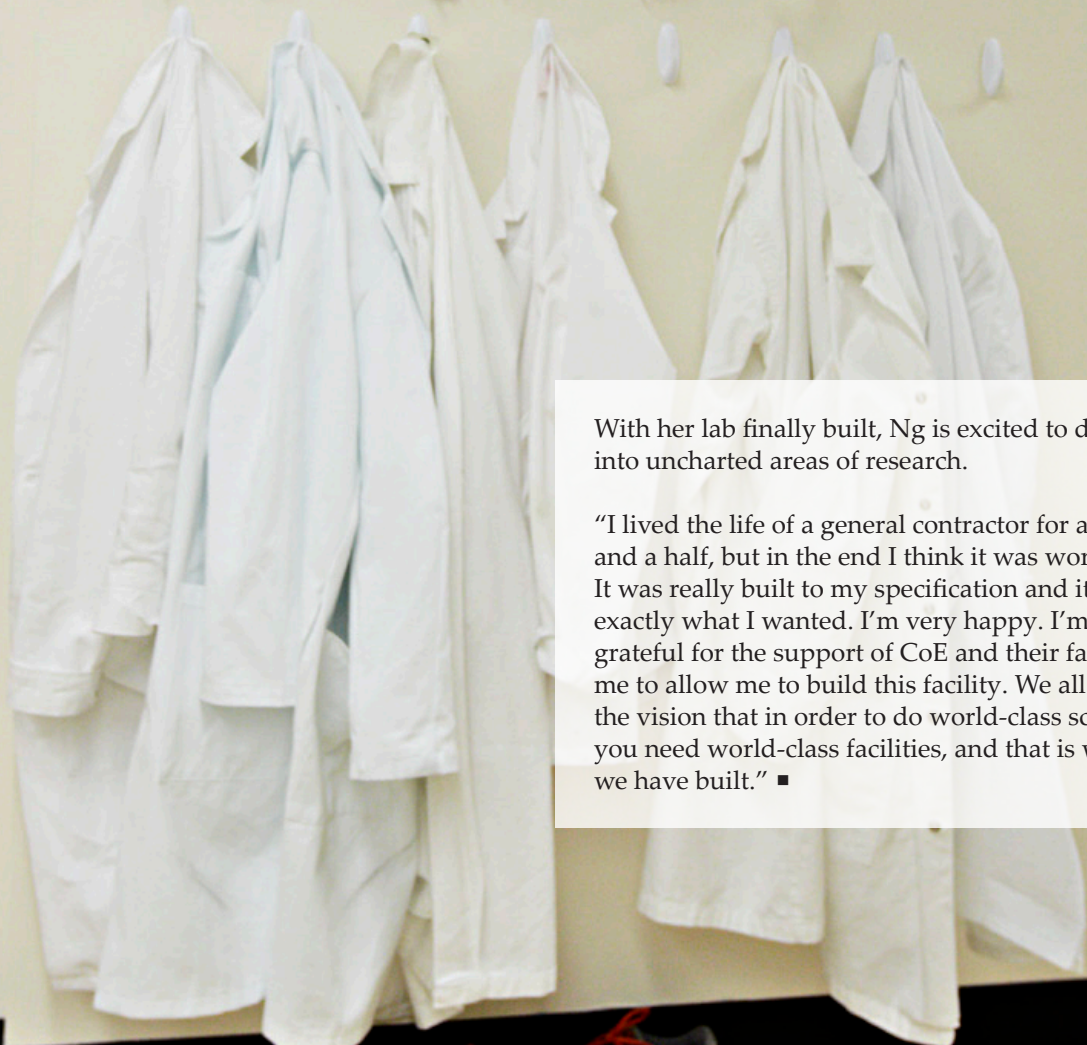
While a tremendous effort was made to make the two Teflon chambers as similar to each other as possible, they each have their own traits and characteristics. One of the first tasks for graduate students Christopher Boyd (*center*) and Lu Xu is to calibrate the chambers so that the variations can be accounted for when conducting research.



Like the rest of the facility, the injection system was designed and built to Ng's specifications. It is used to fill the Teflon chambers with clean air made up of oxygen and nitrogen and, more importantly, free of particles and volatile compounds. The injection system includes a custom-built oil-less compressor system that was built on the roof of the Ford ES&T Building specifically for this lab. During the design and construction process Ng became an expert in component pricing, saving tens of thousands of dollars by shopping around for deals.

Xu and Boyd will have their hands full over the coming months as they conduct field analysis with the HR-ToF-AMS around Atlanta and North Georgia in conjunction with the Southeastern Center for Air Pollution and Epidemiology (SCAPE), a joint project with Emory University and the Environmental Protection Agency. They will also travel to Alabama to take samples as part of the Southern Oxidant and Aerosol Study, which includes more than 40 other institutions and organizations.





With her lab finally built, Ng is excited to delve into uncharted areas of research.

“I lived the life of a general contractor for a year and a half, but in the end I think it was worth it. It was really built to my specification and it is exactly what I wanted. I’m very happy. I’m very grateful for the support of CoE and their faith in me to allow me to build this facility. We all share the vision that in order to do world-class science you need world-class facilities, and that is what we have built.” ■



A Deeper Connection

INTERVIEWS by MICHAEL BAXTER
PHOTOGRAPHS by NICK BURCHELL

Women and minority students share outside-classroom experiences that shape their education—and their view of engineering

SOME ENGINEERS SEE THEIR LIFE'S WORK AS ALL ABOUT THE SOLUTION.

Others have a more expansive view—they're driven to make an impact, but it's the experience, the journey and the collaboration with others that make engineering such a rewarding career.

This latter view describes some of the CoE students who participate in Women in Engineering and Engineering Education Outreach.

Through these two programs, students gain a wide range of interpersonal experiences—teaching and learning, networking and advising, taking in and giving back. Over time, these experiences not only round out the students' engineering education; they also connect them to the profession in a deeper, more personal way.

That's important, as both programs were designed to promote diversity in engineering. Women in Engineering challenges and inspires women to achieve their fullest potential as engineers and celebrates their accomplishments and successes. Students meet and listen to leading

women in the industry, participate in peer-to-peer mentoring and open the eyes of pre-college students to the wonder and possibility of engineering itself.

Engineering Education Outreach, or EEO as it's known on campus, supports underrepresented minorities, transfers and non-traditional students throughout their academic journeys. In EEO, outreach is a two-way street. For example, students may gain financial assistance to conduct research and participate in other learning experiences. Or they may staff an array of hands-on activities that engage middle and high school students in engineering, such as the Summer Engineering Institute, an intensive three-week residential program for underrepresented juniors and seniors.

Both WIE and EEO reflect the College's commitment to diversity. But the students' words speak to the programs' greatest value: a broader view of engineering and a better understanding of what they can contribute to it.

—MICHAEL BAXTER



Zakiya Seymour

Doctoral candidate in
environmental engineering

Hometown: Brunswick, Georgia

Involved in: Engineering Education
Outreach

Taught high school students about
water filtration in EEO's Summer
Engineering Institute

Nearly every day I showed my students a picture of a young Haitian boy dipping a bottle into dirty water. They had to build a prototype of a working water filtration system, and I told them, "We're working on something to save this boy." The day they tested the prototypes of their filtration systems, it was so real to them. They knew it had to work to help that boy.

Still, I reminded them, if it doesn't work, we have to redesign it—you can't be the company that designs faulty filters. They realized the seriousness of the issue.

The high school students had to learn the principles of filtration, and they had to conceptually construct their own filter analysis. They had to make sure all of the requirements in the country were met. For example, India has a huge problem with arsenic in ground water. They had to understand this, and design for it. They also had to think through marketing and distribution.

I threw a loop in there and asked them to design hand-washing techniques and devices. They didn't build a prototype for the hand-washing device, but they did have to have a conceptual design. They had to make sure people had access to soap, and the soap wouldn't get stolen. And they had to ensure

they washed their hands and not re-contaminate them.

I tested each group one by one. When I saw their faces at the moment they realized their filters worked, it was the most special teaching experience. You could see how excited they were. It's like they were thinking, "I actually did something, and it worked."

When you incorporate project-based learning into the classroom, and you make the students responsible for their work, you're training them to be engineers, and you want it to work. It taught me how important it was to have project-based experience.

When I saw (the students') faces at the moment they realized their filters worked, it was the most special teaching experience.



Nancy Kim

Senior majoring in
biomedical engineering

Hometown:
Flowery Branch, Georgia

Involved in: Women in
Engineering

Gives back by mentoring
and serving in the
community

It's so interesting to hear younger Tech students talk about their experiences. It reminds me of when I was in their shoes. When you're so focused on a situation, you can't see the solution. Now that I've been through it, I can see the bigger picture.

On my path, I haven't solved every single issue the best way. Some things actually didn't work out for me. I can share those experiences with my mentee—just being able to give that advice helps them out a lot. That's something a lot of people around me have given me. I want to do that for others now.

I help a lot of other students informally, but officially I have one mentee. I meet with her once or twice a month. I'll look over her resume for co-op. Sometimes she talks about problems she might have—if it's something I can help with, I give her suggestions.

Networking is one other benefit of the Mentors & Mentees mentoring program. In my freshman and sophomore year, I didn't know the value of networking. During my internship, it came to me why networking was so important. I feel like Women in Engineering provides so many opportunities to network, both within your school and outside.

I'm also active in Team Buzz—it's a community service organization. A lot of people at Tech did a lot of community service in high school, but they may not do it at Tech. Team Buzz helps them get involved.

My friend and I went with Team Buzz International and did events in Singapore and Beijing. In Singapore, there was this organization that helps mentally disabled kids. We actually got to go to this facility and play games with them, take them on a treasure hunt and do other activities. It felt like such a great way to give back.

Johnny Worthy

To help retention rates among first-years and transfer students, there's something called the Louis Stokes Alliance for Minority Participation. It's LSAMP. They promote research for undergraduates—set up meetings with professors, provide resources to help fund research positions, all to provide research experience.

Over the summer, I got to work in the lab of Dr. Raghu Pucha, who models nano-composite materials. The goal is to use computational models to predict electrical properties, mechanical properties and stress of these composites, which are mostly carbon nanotube-reinforced polymers.

I was in the lab eight hours a day. I learned so much—for example, that silicon particles can increase the strength of a magnesium alloy disproportionately. The addition of 1 percent of silicon carbide particles can bring a 15 percent increase in the strength of a magnesium alloy.

I also learned that documentation is the best thing you can do. When it came time to make presentations, I found I hadn't documented everything. So I had to go back and spend time getting results all over again.

After my summer research was over, the people with LSAMP told me about a conference in Puerto Rico. I submitted an abstract from my summer work and was selected to present at the conference. I had presented in more informal settings, but never at a conference. What was really interesting was hearing presentations that overlapped with my work. I got a broader view of materials science.

My name was listed as one of the authors on the research article, which was published in the *Journal of Composite Structures*. My plans now are to go to graduate school and work with NASA or SpaceX in extraterrestrial space applications.



Senior majoring in aerospace engineering

Hometown: Rock Hill, South Carolina

Involved in: Engineering Education Outreach

Conducted research as an undergraduate and presented findings at a conference

Amanda West

Sophomore majoring in computer engineering

Hometown: Clinton, Maryland

Involved in: Women in Engineering

Learned from Georgia Tech students — both in high school and as a Tech student



The summer before my junior year in high school, before I applied to Tech, I participated in the Summer Engineering Institute. I was part of a group of students who created a mock company that made a prototype robot. Our company was called 911Botics, and the idea was our robot would rescue people. So, say there was a fire—our robot would gather all inhabitants through beeping and motion and light, and lead them out of the house.

We modified an AmigoBot to have that capability. It was really intense—we were coding on Linux and had to do

it really quickly. The first assignment was to get the robot to move in a square in four moves. But we were in high school and didn't know anything about robots. The program had a lot of good bonding exercises as well. Sleep was rare—we got maybe five hours a night!

When I look back at that experience, it seems really hard. I didn't know I could learn something that fast. But because of that program, I fell in love with Georgia Tech.

Now, as a student, I have a mentor through Women in Engineering. If you want to improve yourself, you can ask

your mentor for help. This past week, for example, I had a social question—how would I respond to something socially. My mentor, Ally, reassured me that what I was thinking was the right thing to do. It's great to have that “big sister” when you have a tough question, and you don't want to ask your parents or your professors.

In the future, I think it would great to be that person—you have all this knowledge about Georgia Tech, and you can do something with it.

When I look back at that experience, it seems really hard. But because of that program, I fell in love with Georgia Tech.



Jamie Clark

Junior majoring in civil engineering

Hometown: Corvallis, Oregon

Involved in: Women in Engineering

Visits K-12 schools as a student ambassador for engineering

After a year and a half at Tech, I felt like I wasn't doing anything to help my community. Women in Engineering has provided a great outlet—it reminds me why I love engineering so much. It took me back to what got me interested in engineering in the first place.

As an ambassador, I've been to elementary schools, middle schools and high schools. The sooner you catch kids, the more they think about engineering as they grow older. The kids I met are so incredibly smart. I learn new things every time I go.

We make our presentations interactive—we use Prezi and do fun activities instead of just talking to the students. For example, we had kids make a rocket out of cups, straws, index cards, rubber bands, and other materials. They had to find a way to keep the two astronauts, which were

actually marshmallows, inside the rocket, which was a small paper cup. That taught them about impact and other engineering principles.

In another activity, we gave the students a set number of uncooked spaghetti noodles and marshmallows and told them to build a structure that can hold weight. They had to make it as strong as possible. We tested the strength with card stock. Some did such a good job that their structures could actually hold magazines!

My plan after Tech is to go to graduate school, then get a Ph.D. I want to focus on sustainable building in developing countries, where they have limited resources. I feel there's a huge need for that in the world. I want to figure out a way to use natural resources in those countries rather than bringing in materials that are not sustainable.



Ivan Tibavinsky

Junior majoring in
mechanical engineering

Hometown: Bogotá, Colombia

Involved in: Engineering Education
Outreach

Mentored high school juniors and
seniors at Tech's Summer Engineering
Institute

For three weeks, I was in charge of a group of four high school kids, helping them with their ideas. I lived with them in the dorm. I was like a mentor to them.

They worked on a surveillance system. Kind of like Google Maps has satellites taking pictures—they were supposed to come up with a way to attach cameras to a balloon to photograph some different-colored figures on the ground. They did some programming to differentiate the colors, which was like simulating the Google Maps system.

In another project, the students learned how solar panels work, and they tried to find the most efficient way to attach a solar panel to a refrigerator. Then they had to justify their design. It was a competition. In the end, they had to present what they came up with, and in a professional way. That decided the winner.

You look at the many problems we face today in the world—the energy crisis, for example—and we really need engineers to address these challenges.

I became close with a lot of these kids. By the end of the three weeks, they found a lot in common with me. We had similar ethnic backgrounds. They saw opportunities that I'd had as being more accessible to them, too. A few of them actually came to Georgia Tech, and I run into them once in a while. It's rewarding to see them working in their classes.

Most Tech students come with the mentality of making an impact on the world. And most people look ahead to that. But it's worth looking back to

when you were younger—where you were. You can look back on people coming behind you with dreams and aspirations. Reaching out to those people is another way of creating an impact.

You look at the many problems we face today in the world—the energy crisis, for example—and we really need engineers to address these challenges. That was my motivation to become a mechanical engineer. ■

PERSPECTIVE

In Fall 2013, students born in 1995 will enter the College of Engineering as freshmen.

1995

The Kessler Campanile is under construction as Georgia Tech prepares for the 1996 Summer Olympics.



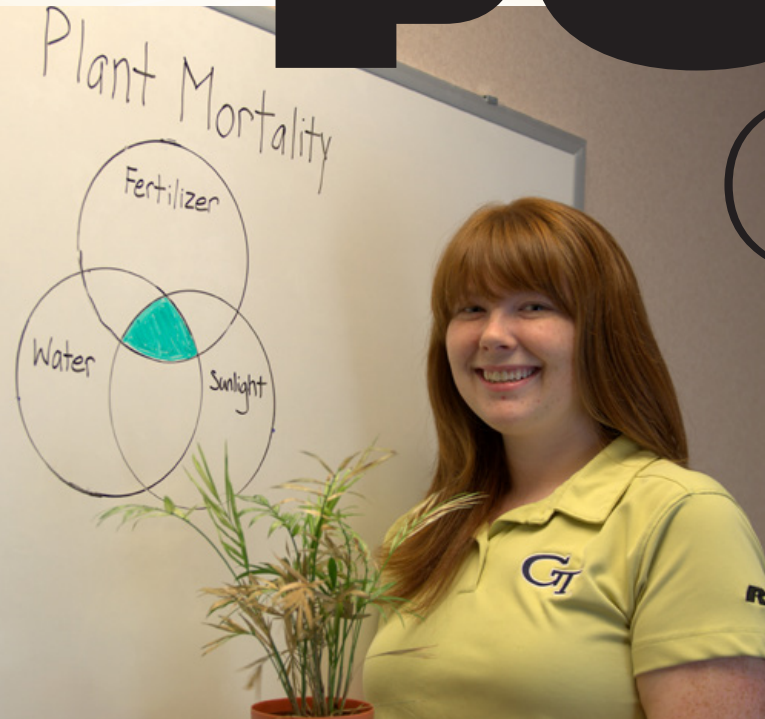
2013

The Campanile, now surrounded by extra greenery, is one of the Institute's most recognized symbols.

LEFT PHOTO: STANLEY LEARY; RIGHT PHOTO: LYNDSEY LEWIS

POP

QUIZ



JAY GALLMAN

with BRITTANY WOOD

Major: Industrial and Systems Engineering**Year:** 4**Hometown:** Gainesville, Georgia

College of Engineering students are famously industrious, but what are they like outside of class?

Why did you decide to major in industrial and systems engineering?

I started at Georgia Tech as a biochemistry major. Honestly, I took general chemistry and that was not for me. So I looked around at what majors I wanted and decided that industrial engineering was a good combination of all the things that I'm interested in, like statistics and computer science. So I chose industrial engineering.

What's your favorite ice cream flavor?

It's hard to choose. I'm pretty much non-discriminatory with ice cream, but Moose Tracks is my favorite.

What's your favorite Georgia Tech memory?

My favorite memory is probably being in marching band my freshman year. We went to the ACC championship and we won, so we went to the Orange Bowl. It was a great experience to go and do that as part of the band.

What's the best thing you've ever bought?

I guess my car! It's pretty useful and I love it.

Do you have plans yet for life after graduation?

Right now, I'm a year away from graduating. My main

concern is getting a job — a good job that I like. I'm looking around at companies that I'm interested in but definitely have some in mind.

Are you guilty of having ever accidentally killed a houseplant?

I don't really go with plants because I know that I would probably kill them.

What's the toughest thing about majoring in industrial engineering?

Industrial engineering is interesting because it seems like, for me, the hardest classes are right up front. Probability and statistics classes are a little bit difficult just because it's a new way of thinking, but once you get it, it's really fun and interesting. All the things you can model with probability and statistics is pretty cool.

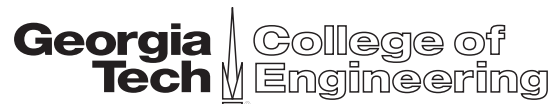
What's your favorite Atlanta hangout?

I don't know how much hanging out I do. [laughs] Georgia Tech? Georgia Tech, of course.

What's the best snack for studying?

The best studying food is something that is not messy, like chips!

- INTERVIEWED by LYNDSEY LEWIS



The College of Engineering at Georgia Tech is the largest of its kind in the country, with more than 12,000 undergraduate and graduate students enrolled. The college ranks among the top five programs in undergraduate and graduate engineering as determined by U.S. News and World Report.

THE FACE OF ENGINEERING ChBE Assistant Professor Ryan Lively uses the hollow fiber membranes shown here to efficiently separate gases, a process that typically consumes a lot of energy. With the membranes, Lively is developing a more efficient way to recover carbon dioxide from sources like coal-powered power stations, and his system will reduce costs and leave a smaller environmental footprint.

