

SPRING 2017

ENGINEERING SOLUTIONS



A PUBLICATION OF THE FRANCIS COLLEGE OF ENGINEERING

HANDS-ON EDUCATION:

Innovative Teaching
to Solve Real-World
Challenges



Dear Alumni, Colleagues and Friends,



At UMass Lowell, we take pride in the fact that our students receive a truly “hands-on” education, both inside and outside the classroom, such that when they graduate, they are ready to produce in the workplace. One testament to this fact is that our students spend a lot of time in the laboratory—roughly one-third of all sections taught in the Francis College of Engineering last semester were in labs.

In addition to lab work, there are numerous experiential learning opportunities for students to apply what they are learning in the classroom. Our professional cooperative, or co-op, education program was pioneered years ago by our Plastics Engineering Department. The program now spans all majors and allows for students to go off-campus and work for three or six months at one of our dozens of industry partners. And our full array of courses offered during summer sessions allows co-op students to stay on-track for graduation. More than just work experience, students learn practical and professional skills through a professional development seminar and work reflection course.

But co-op is not the only way students can gain critical experience. Each of our majors requires a senior capstone experience, with many projects provided by industry. The Electrical and Computer Engineering Department has partnered with various charitable groups over the years, developing practical solutions for those in need through its Assistive Technology Program. Furthermore, we launched our new Interdisciplinary Senior Design program last year with great success. This year, we are running 16 year-long projects for computer, electrical, mechanical and plastics engineering majors with sponsors that include Analog Devices, BAE Systems, Brooks Automation, Dell EMC, MACOM, MKS Instruments, Nypro, Raytheon, Skyworks, Symbotic and UTC Aerospace Systems.

Our student clubs offer numerous opportunities for hands-on engineering experience. Our students compete annually in a variety of regional and national engineering contests—concrete canoe, steel bridge, design-build-fly, SAE Formula One car racing, Collegiate Wind, etc.—allowing students the opportunity to get their hands dirty while acquiring practical skills such as project scheduling and teamwork. Similar skills are acquired by those who participate in our DifferenceMaker and Engineering Prototyping Competitions.

Our students share their expertise and gain experience by volunteering in the community, sometimes through a course with a Service-Learning component, or a student organization that partners with a local school or boys and girls club. The UTeach program, which provides an avenue for students to become certified teachers, is another way in which our students can build valuable skills and also give back to the community through practicum teaching.

This issue of Engineering Solutions looks at a number of these and other experiential learning opportunities for our students. I hope you’ll enjoy reading about our highly engaged and hardworking students.

As always, please feel free to contact me (Joseph_Hartman@uml.edu; 978-934-2576 or via LinkedIn) if you have a story to share or would like to partner with the college. I look forward to hearing from you.

Sincerely,

Joseph C. Hartman, Ph.D., P.E.
Dean, Francis College of Engineering
University of Massachusetts Lowell

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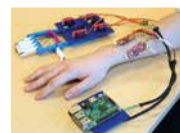
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ON THE COVER

Hands-on education is an integral part of the learning experience at the Francis College of Engineering. The cover shows a student and a 3D-printed prosthetic hand holding an Analog Discovery 2 learning kit— a complete, low-cost portable electronics test bench— which is at the heart of the “Laboratory Anywhere” teaching model and is used by electrical and computer engineering majors to put theory into practice (see page 2). The artificial hand was created by eNABLE Lowell, an all-volunteer university student chapter that designs and fabricates inexpensive prosthetic devices for children with physical disabilities. Photo by Jim Higgins.

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“Our undergraduates are motivating middle and high school students to pursue STEM fields, which is an important initiative in the state to meet the future needs of the Massachusetts economy.”

—Dean Anita Greenwood

Student Pursues Dual Career Path: Teaching and Engineering

It all began with his electric guitar. “I was curious how my guitar worked,” said Clint Perry, who asked his high school physics teacher for answers. “The next thing you know, I was building my own amplifiers. My teacher saw in me something I didn’t and then encouraged me to pursue a degree in electrical engineering.”

While the thrill of figuring out how things work led Perry to major in electrical engineering, he was also intrigued by the way his teacher took something that interested him—the guitar—and applied it to physics and engineering.

That curiosity led him to sign up for the university’s UTeach program, which allows science, technology, engineering and mathematics (STEM) majors to earn a minor in STEM teaching. UTeach is a national program that was developed at the University of Texas at Austin more than 15 years ago and launched at UMass Lowell in 2012.

When Perry graduates in May, he’ll have the best of both worlds when it comes to career choices—working in industry or teaching secondary school science. He is the first engineering student to graduate with the STEM teaching minor and an initial teaching license.

THE STUDENT-TEACHER

As a freshman, he took the first UTeach class, which wasted no time bringing him into a classroom so he could decide if teaching was for him.

“We learned how to develop a lesson plan, and then I taught a lab on magnetism to third graders,” says Perry. “It feels like I was always meant to

do this, but I had to discover that I wanted to do it. I’m grateful that UMass Lowell gave me this opportunity.”

Eager to let others know about the benefits of the UTeach program, he has presented at the UTeach Conference in Austin, Texas, as well as a STEM Summit in Worcester, Mass.

“Clint is enthusiastic about engineering and carries that enthusiasm into his teaching,” says Anita Greenwood, dean of the Graduate School of Education. “He is a perfect example of why the university became a UTeach site. Our undergraduates are motivating middle and high school students to pursue STEM fields, which is an important initiative in the state to meet the future needs of the Massachusetts economy.”

In the final semester of his senior year, Perry is student-teaching physics to 11th graders and engineering to 12th graders at Billerica High School.

“Teaching is like a puzzle,” he explains. “I need to guide the students to discover the answer without giving them the answer. It is challenging for me to find the best way to do this, and it’s very rewarding when I do.”

He uses some of the same teaching techniques that his electrical engineering professors employ, including applying engineering principles to subjects that interest students rather than teaching abstract concepts. The UTeach program taught him how to structure his lessons using the “5E model”—engage, explore, explain, elaborate and evaluate—which encourages students to use



John Wren (2)

inquiry and critical thinking as they learn.

“I’ve had very inspiring professors that have allowed me to work on real projects like creating a helix antenna for a cube satellite,” Perry says. “It is really interesting for me to understand how engineering is integrated into the real world.” Using what he learned in the UTeach project-based instruction course, which is sponsored by Kronos Inc. of Lowell, Perry and plastics engineering major and UTeach student Andrew Antonitis challenged the students to design and build a bridge made of fiber-reinforced composites. During a field trip to the Tsongas Industrial History Center, the high school students made fiber cloth for the bridge.

“The students were engaged, excited and interested, which was very fulfilling for me,” says Perry.

When Perry graduates, he’d like to work in industry before teaching so that he can integrate his experience into the classroom.

“I know I’ll end up teaching, no matter what I do next,” he says.

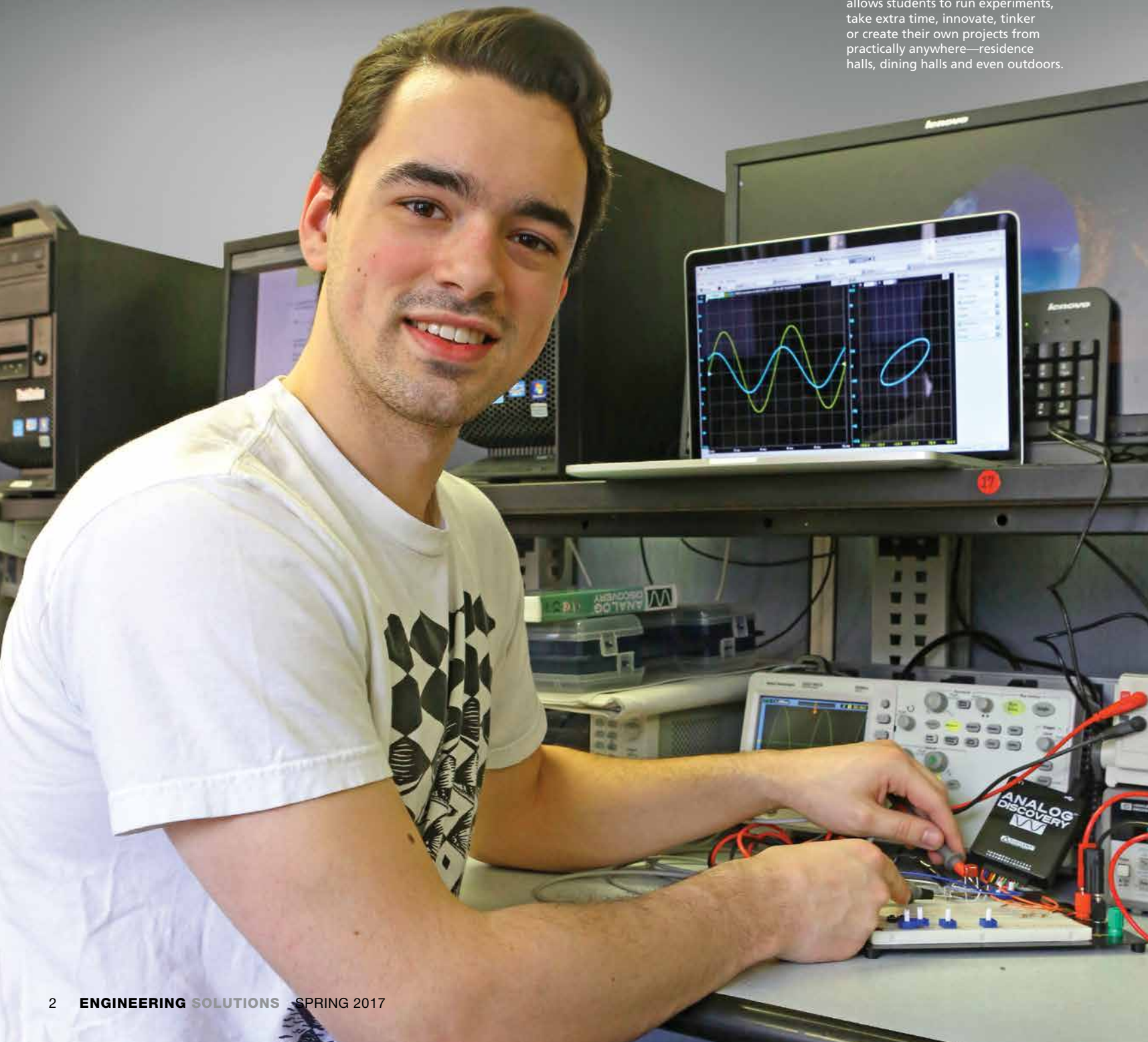
Top photo: UTeach students Clint Perry, left, and Matthew D’Angelo perform chemistry and physics experiments for incoming freshmen.

Above: Perry and fellow engineering student Andrew Antonitis teach high school students at the Tsongas Industrial History Center in Lowell.

Students Explore Electronics with 'Laboratory Anywhere'

Electrical, Computer Engineering Majors Put Theory into Practice

Electrical engineering sophomore Michael Nuzzo works on his lab project using an earlier version of the Analog Discovery learning kit. The kit is at the heart of the "Laboratory Anywhere" teaching model, which allows students to run experiments, take extra time, innovate, tinker or create their own projects from practically anywhere—residence halls, dining halls and even outdoors.



Students in the Electrical and Computer Engineering (ECE) program are getting the hands-on training they need to apply theory from their classes to real-world engineering. This is made possible by a new model for teaching ECE laboratories that's been developed by Prof. Jay Weitzen and Laboratory Manager Dohn Bowden. Called "Laboratory Anywhere," this innovative approach is based on the Analog Discovery module, which allows students to experiment on their own time and at their own pace from practically anywhere.

"We need to provide students not only with math, physics and engineering theory, but also significant hands-on laboratory and open-ended design experiences so they are ready for high-technology jobs of the 21st century," says Weitzen. "There is no substitute for hands-on experience—you cannot compensate for it with more theory and textbooks. It is very difficult for students to develop these hands-on skills with only limited lab time available each week."

The Analog Discovery module connects to the students' laptop or desktop computer via USB and, along with free software that they can download, converts their computer into a fully functioning oscilloscope, waveform generator, logic analyzer, voltmeter, spectrum analyzer and power supply.

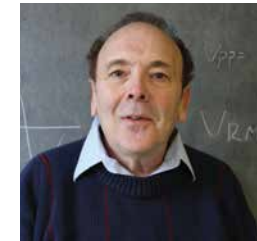
"This is not a virtual lab, with PC-based simulations of circuits and presumed results. It's a real, working electronics test bench that fits in your pocket," explains Weitzen. "With the Laboratory Anywhere-based curriculum, students get individualized hands-on experience that requires the learner to take responsibility for managing his or her learning curve and to become proficient in using basic and advanced test equipment."

For Weitzen and Bowden, Laboratory Anywhere is more about a philosophy of teaching rather than merely an electronic gadget.

"It is about taking the traditional laboratory model, in which students go to the lab once or twice a week and spend a few hours using the lab's test equipment, and bringing it to new level wherein students are given the freedom and flexibility to work on their projects practically anywhere, on or off campus. While the Analog Discovery module looks unimpressive, its capabilities and how it can transform engineering education is unlimited. It gives students the tools to innovate and create independently," says Weitzen.

"The Analog Discovery module replicates all the current lab bench test equipment, and as a bonus, it contains numerous other pieces of test equipment that are not currently available on the students' benches," says Bowden.

Michael Nuzzo, an electrical engineering sophomore, agrees. "Lab Anywhere is a neat little device that covers all of the basic functions of our lab's expensive and bulky test equipment," he says. "I've heard stories from alumni who used to have to come to the labs at night or on weekends so that they could finish their lab coursework, and the university had to provide staffing to the labs on weekends to accommodate this. By contrast, I have done my lab work in the library, in my dorm room and even outdoors using my laptop as a power source. It saves a lot of time and travel to be able to do these from the comfort of my home."



Prof. Jay Weitzen, above, developed the "Laboratory Anywhere" curriculum together with Laboratory Manager Dohn Bowden, both of the Department of Electrical and Computer Engineering.

FLIPPING THE LABORATORY MODEL

Under the Laboratory Anywhere-based curriculum, freshman ECE students learn the basic functions of the Analog Discovery kit and do projects to better understand electrical engineering fundamentals such as designing a microprocessor-based traffic light controller, a digital night light or a starting system for sailboat racing.

In their sophomore year, students continue to learn how to use both conventional test equipment and the Analog Discovery kit in the lab, perform experiments to complement their theory courses and develop skills for how to design, construct, test and troubleshoot circuits, collect analog and digital data and analyze the results.

Junior students are expected to come to the lab and work one week on a conventional test bench. The next week they work on their projects on their own using the Analog Discovery kit. If the students need help, they come to the lab and get assistance from Bowden or the teaching assistants. Weitzen and Bowden call this the "blended flipped laboratory" teaching model.

Last summer, Blackboard, a virtual learning environment and course-management system, was introduced as an aid to the traditional face-to-face lab setting. "We are also experimenting with providing remote access via some form of instant messaging or Skype so students can ask the lab teaching staff questions when they are off campus," says Weitzen. "This will provide additional support to our large, nonresidential student population."

COST-SAVING ADVANTAGES

Traditional engineering laboratories are expensive to equip, run and maintain. The basic Analog Discovery kit costs less than \$200 each, which is about the same as an engineering textbook. Students buy the kit while taking their freshman introductory ECE course and can use it throughout their undergraduate years. There are a few kits available for checkout for students who cannot afford them.

The flipped laboratory model has helped save the department money related to staffing and test equipment, Weitzen says: "Using the lab kits also helps address critical space issues since Laboratory Anywhere-based classes are run in general computer labs or open classroom areas instead of specialized, purpose-built electronics teaching labs."

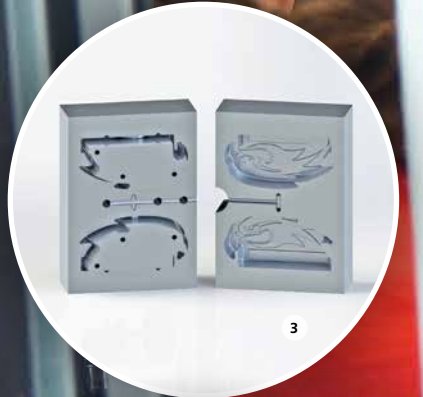
Department surveys have shown that Laboratory Anywhere has helped with student satisfaction. "Students clearly had fun and enjoyed coming to lab," says Weitzen. "The increased hands-on experience directly benefited the students in obtaining internships, co-ops and technical summer jobs."



The Analog Discovery 2 kit, manufactured by Digilent Inc. and developed in conjunction with Analog Devices, is a low-cost portable USB oscilloscope, logic analyzer and variable power supply that can replicate the functions of bulky and expensive desktop lab bench test equipment.

FROM ART TO PART:

Students Turn Mold Designs into Reality



Many student-designed academic projects never leave the drawing board. Students can spend weeks designing and evaluating their concepts, but they never have the opportunity to create the actual products to test their feasibility and functionality.

However, students enrolled in the Plastics Engineering Department's mold design engineering course, called PLAS.3730, have the advantage of carrying their ideas from concept to creation.

"During the semester, student teams will design a new plastic part, analyze its moldability, develop and produce the required tooling and finally use injection-molding machines to fabricate fully functional prototype parts," says Assoc. Prof. Stephen Johnston, who has been teaching the course since 2008. "The coursework includes an introduction to the fundamentals of plastics mold engineering, which imparts to students an overall appreciation of how the process affects part quality and what the job of a mold engineer is like."

Johnston says mold design courses like this are very unique. "There are a handful of other plastics engineering programs throughout the country that offer similar content and experiences, but to my knowledge none give the students the same level of design flexibility," he notes.

FILLING THE NEEDS OF A GROWING MARKET

The injection molding process involves forcing molten plastic material into a mold, where it solidifies and takes the shape of the mold. Injection-molded plastic parts are integral components of thousands of products across a range of industries, including automotive, medical devices, aerospace, consumer appliances, toys, electrical and electronics, plumbing, packaging and construction.

According to a recent industry report by Grand View Research, the global injection-molded plastics market was valued at nearly \$200 billion in 2014, and it is anticipated to "witness significant growth in the near future on account of increasing plastics component demand across various end-use industries."

"There is huge demand for our graduates because we are specialized," says Johnston. "When you consider the vast number of plastic products that we use as a society, most of them are not designed or manufactured by a trained plastics engineer. The industry relies heavily on on-the-job training, which is why our students are sought after by employers across the nation and globally."

FROM SIMPLE TO ELABORATE DESIGNS

Students are encouraged to be creative when designing their projects. Each team must design a new plastic part or improve an existing part design. Examples of early products include model toy cars, tops and planes, combs, drinking cups, utensils and measuring cups. Recent designs have become more elaborate, such as an earbud case, a ball maze and puzzle cubes, as well as Rowdy-themed cellphone holders, tea infusers, bottle toppers, bookmarks, golf tee holders, Christmas tree ornaments and the Rowdy piggy bank.

"The students' products are often given away during department open houses and alumni events, and some—like bottle openers, cookie cutters, light switch covers and rulers/bookmarks—are being marketed in the university's River Hawk Shop," says Johnston.

"The course is intended to be offered to juniors, but as long as the prerequisite and corequisite subjects are met, any student is permitted to take



it," says Michael Shone, a graduate assistant in the Department of Plastics Engineering who has assisted with the course for the past three years.

"The current class has 50 students in it, and we're looking forward to nine great projects this semester."

"I'm really enjoying the course," says Stephen Kender, a plastics engineering junior. "It really opens my eyes. For example, when I pick up a plastic water bottle, I know how it was designed and what different steps were involved in making it. I now have a better appreciation of how plastic products are put together."

Fellow plastics engineering junior Jonathan Cabot agrees: "The course offers an exciting hands-on experience. Mold design and manufacturing is a valuable skill to learn and will be very useful in my professional career."

The students typically spend 2½ hours in lecture and nearly 2 hours in lab work each week. They get introduced to SolidWorks (computer-aided

design and drafting software), Autodesk Moldflow Insight (finite-element analysis and simulation software) and Mastercam (computer-aided manufacturing software) to help them develop the necessary skills in designing and fabricating the project components. They also learn how to use computer numerical controlled (CNC) milling machines as well as manual equipment like grinders, lathes, presses and ovens to produce their molds and the corresponding parts.

"The students gain valuable knowledge and hands-on experience in injection molding, mold making and analysis," says Shone. "They become comfortable with the machines and terminology used in the industry, and it gives them the foundation to pursue mold engineering as a career or to work with mold engineers effectively. There is also an advanced mold design course, called PLAS.5760, which seniors and graduate students can take to further expand this foundation."

1. Assoc. Prof. Stephen Johnston teaches plastics engineering students enrolled in the mold design course how to operate a CNC milling machine.
2. From left: Plastics engineering juniors Molly Galvin, Hannah McKenzie, Anthony Cox, Violet Sullivan and Maggie Beadle of the Team Rowdy Bank present to the class the mold and actual product they had made during the mold design course in spring 2016.
3. CAD rendering of the mold used to make the bank.
4. CAD rendering of the finished Rowdy Bank.



a cake with colored frosting. Still other teams made devices that printed in Braille, pumped a piston to play a pennywhistle and rotated a solar panel to optimize its sun exposure.

In the process, the students learned as much about MatLab, a high-performance language for technical computing, as previous students have learned by their junior or senior year, Willis says: "We find the students are passionate about developing something that works. It changes their perspective on computer programming."

Willis, Prof. Sammy Shina and Asst. Prof. Christopher Hansen in mechanical engineering and Assoc. Prof. Stephen Johnston in plastics engineering developed the lab protocol in stages under the 2013 "Hands-on MADE 4 ME" grant. They started by buying off-the-shelf computer numerical control machines (CNCs) and hiring a graduate student to assemble them. Students learning MatLab would follow certain programming "recipes," then hook their laptops up to the CNC machines to see if their code worked.

Then the professors took it a step further. They designed a basic component—a 6-inch-square black plastic modular block with various holes and compartments—that could be assembled into machines using off-the-shelf hardware. In their first lab assignment,

students assemble three of them to make a device with a small motor that, when hooked up to a controller, moves one of the blocks along threaded rods strung between two more blocks.

Once students can control a single axis, they make CNC machines with two axes and a syringe that dispenses blue soap onto a flat grid. For the final project, they work in teams of three to five, making machines that move something in three dimensions and incorporate other components, such as sensors and actuators. Several teams entered their projects into the fall DifferenceMaker Engineering Prototyping Competition.

Elijah Gerrior, who's taking the class this spring, says he enjoys putting theory into practice in the lab: "You get that extra component of hands-on work right from the start."

Kristopher Tite, a senior who worked as a lab assistant last semester—and made 2,000 modular blocks over the summer for this year's freshman students to use—says the labs are much better than when he took the class. Instead of following standard programming recipes, this year's students are researching more advanced MatLab programming to realize their ideas, he says.

"That's pretty darn cool, to have their final project come to life."

Pilot Project in Mechanical Engineering Takes Off

First-Year Students Build Computer-Controlled Machines that Decorate Cakes, Print Braille, Play a Pennywhistle

Top photo, from left: Students Michael DelGenio, Aidan Burbridge and Piero Pocobene test and debug the computer code for their prototype "Automated Hotdog Condiment Dispenser" machine. Right photo: Jessica Brewer, Genevieve Deschenes, Brianna Anderson and Vittoria Santoro proudly display the "UML" cake icing printed by their "Frosting Laser" machine.

Nine sections of mechanical engineering freshmen built their own computer-controlled machines in the MakerSpace facility on North Campus last semester, creating whimsical devices that did everything from dispensing ketchup and mustard to "printing" pancakes.

It was the successful culmination of a three-year experiment to improve hands-on learning opportunities for first-year students in mechanical engineering. The labs for Introduction to Mechanical Engineering were developed by a faculty team under a \$200,000 National Science Foundation grant.

"I was impressed with the students' creativity," says Assoc. Prof. David Willis. One team printed pancakes using a machine resembling a 3-D printer that dispensed pancake batter, instead of plastic, onto a heated plate. "I was surprised at how perfectly the pancake was formed and cooked by their machine. A very tempting treat for any engineer!" Willis says.

Other liquid dispensers made for popular final projects, too. One team made a device that used a camera to scan a T-shirt for stains and then guide a syringe to dispense stain remover. Another used a laser pointer to decorate



DAVID WILLIS (3)



Brianna Goerke, Alex Jalili, Cullen Enwright, Justin Brangiforte and Jon Kenna tighten the fasteners on the CNC modular blocks used for their prototype "Pencasso" drawing robot.

Students Bring Great Ideas to Life in Prototyping Competition

Projects Range from Prosthetic Hand to Air Quality Monitor

Computer engineering junior Travis Kessler wanted to do something to help level the field for people with disabilities. He found inspiration in an unlikely source, an oceanic echinoderm believed to date back some 450 million years: the starfish. With the ability to regenerate limbs, the starfish offered a powerful example of resilience and renewal.

Using that as a model, Kessler teamed up with accounting junior Christopher Johnson, mechanical engineering junior Gregory Dorian, business administration junior Roma Aurora and electrical engineering senior Maxwell Roy. Working under the name Project Starfish, they created a prototype of a low-cost, 3D-printed prosthetic hand and entered it in the Francis College of Engineering Prototyping Competition, a contest that challenges students to bring their ideas to life.

The project won the first-prize purse of \$1,000, along with feedback from alumni judges and professors. The students are using both to help refine further development of the prosthetic. "This product has the potential to help hundreds of people," Kessler says. "And this proves that even though we weren't graded and there's no textbook or no syllabus, we could come up with a prize-winning idea and prototype."

Project Starfish was one of 22 teams to enter December's Prototyping Competition, which is affiliated with the campus DifferenceMaker program, but with a twist—students have to build an example of the product they are proposing. The College of Engineering supplies materials and the prize money.

"We're very hands-on," says Dean Joseph Hartman. December's competition was the third annual one since Hartman and the college decided to join the popular DifferenceMaker challenges with an evening of their own.

"We wanted to do something, but we wanted it to be different," says Hartman. "We asked ourselves: 'What can we do that best fits our mission?' It had to be something with the DifferenceMaker's socially conscious mission, and it had to involve building a prototype, because that's what we do—build things." They came up with a mantra for the competition: "Ideas are great, but we want you to build it!"

"This is how engineering is supposed to work," says Hartman. "It's not just the element of design, but also the making of the project."

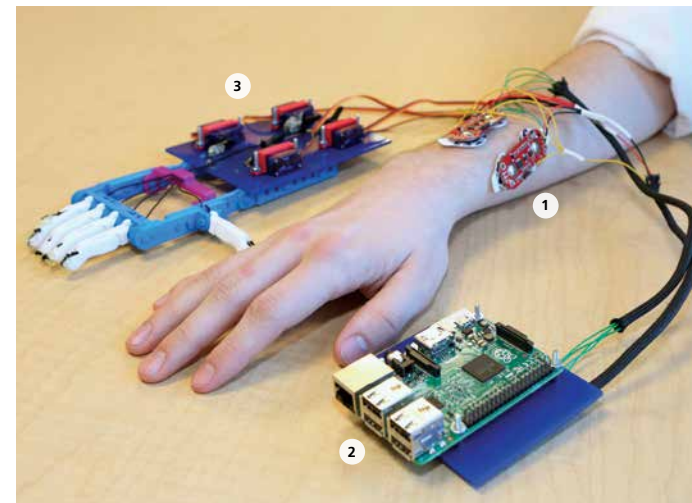
Opposite page: Members of the Project Starfish team include, from left, Travis Kessler, Maxwell Roy, Christopher Johnson, Roma Aurora and Gregory Dorian.

Since the prototyping contest began, more than 250 students have entered, although it is not an academic requirement. Two rounds of alumni judges with business experience decide the winners; the first panel of six queries the teams and chooses finalists to pitch to another panel of five judges in the final round. Projects from the teams competing in December's competition at the Mark and Elisia Saab Emerging Technologies and Innovation Center on North Campus included a real-time air quality monitoring system, an automatic stain remover for clothing, a device that allows a single syringe to be safely used for multiple drug injections and a hybrid musical instrument that can transform any object into a touch-sensitive device for making music.

Anna Faber came up with the idea for Breezy, the air quality monitor, after hearing a story on National Public Radio about \$200 monitors. She loved the idea of a low-cost monitor and wondered about the quality of the air she was breathing. But one thing bugged her about the radio story.

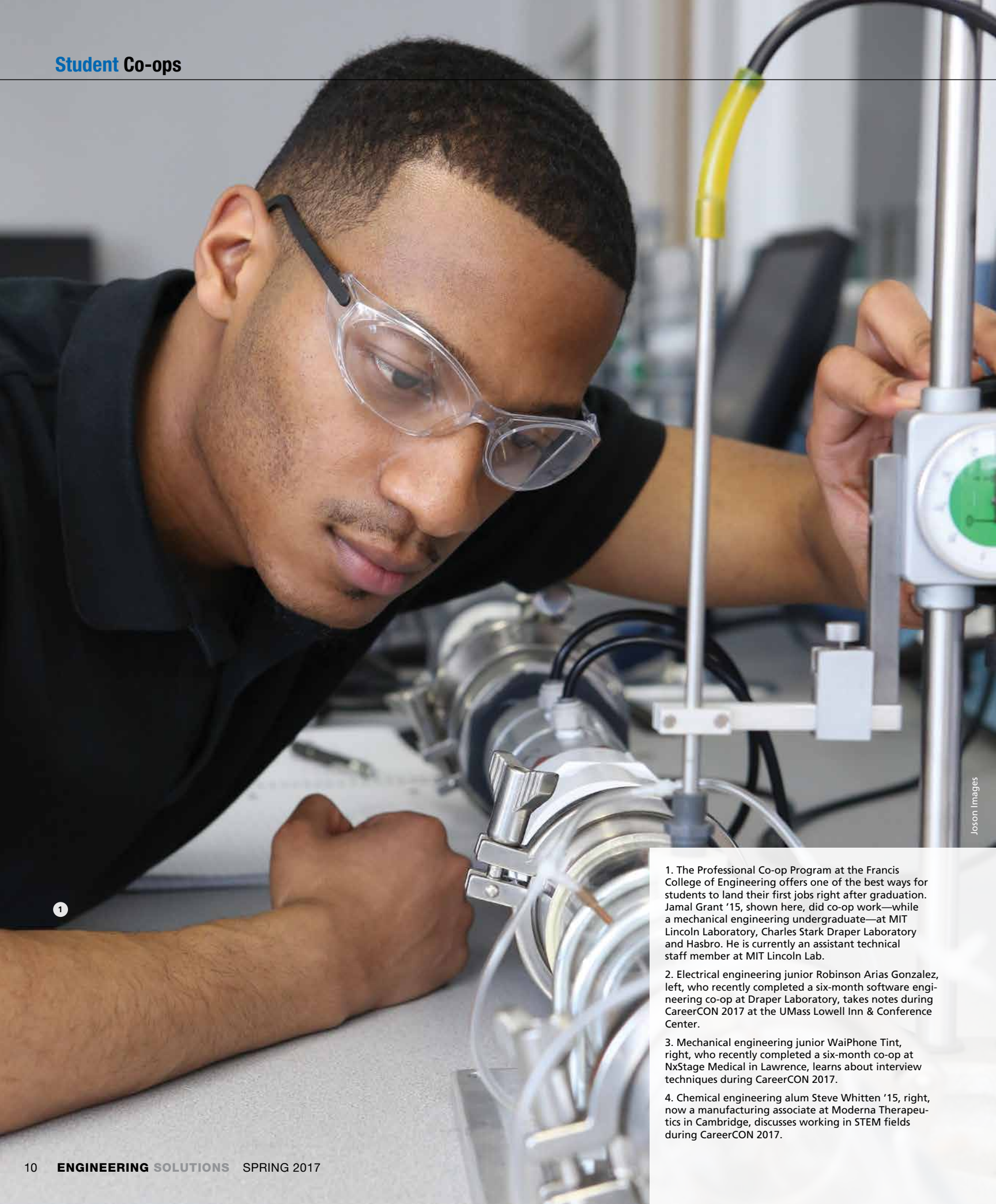
"That seems awfully expensive," says the mechanical engineering senior. So she designed a real-time monitoring system that can be checked through cellphones or online. Her prototype won second place and \$750.

As for Kessler and his teammates, they are committed to pushing ahead with development of the prosthetic hand. The group expects the work will continue over the summer. "I'm only a junior. But I want to see where this goes. Maybe it's my future," says Kessler.



The main electronic components of the Project Starfish prototype consist of: (1) sensors that attach to a person's forearm to detect muscle movement, (2) a Raspberry Pi miniature computer that interprets the data and (3) motors that translate the computer's output into mechanical movement of the fingers of the 3D-printed prosthetic hand.





1

1. The Professional Co-op Program at the Francis College of Engineering offers one of the best ways for students to land their first jobs right after graduation. Jamal Grant '15, shown here, did co-op work—while a mechanical engineering undergraduate—at MIT Lincoln Laboratory, Charles Stark Draper Laboratory and Hasbro. He is currently an assistant technical staff member at MIT Lincoln Lab.

2. Electrical engineering junior Robinson Arias Gonzalez, left, who recently completed a six-month software engineering co-op at Draper Laboratory, takes notes during CareerCON 2017 at the UMass Lowell Inn & Conference Center.

3. Mechanical engineering junior WaiPhone Tint, right, who recently completed a six-month co-op at NxStage Medical in Lawrence, learns about interview techniques during CareerCON 2017.

4. Chemical engineering alum Steve Whitten '15, right, now a manufacturing associate at Moderna Therapeutics in Cambridge, discusses working in STEM fields during CareerCON 2017.

Jason Images

WORKING WITH INDUSTRY

Professional Co-op Program Expands to Include All Engineering Majors

Initiative Matches Students with Employers to Get Hands-on, Professional Experience and Training

Mechanical engineering alum Franklyn Webb '14 has what he considers his dream job out of college: working with a team of engineers and physicists at the Charles Stark Draper Laboratory in Cambridge to develop and test cutting-edge instrument designs.

And he's thankful for UMass Lowell's Professional Co-op Program for helping make that dream a reality.

"I wouldn't be working at Draper without the co-op program. It's the main reason I was able to get my foot in the door," says Webb, whose original six-month paid co-op at the nonprofit research and development company turned into 18 months of co-op experience — and an eventual full-time position as an electro-atom/optic development engineer.

Since launching in the summer of 2010 with 29 plastics engineering students, the Professional Co-op Program has enjoyed tremendous growth, particularly for students in the Francis College of Engineering. With the addition of civil and biomedical engineering this year, the program now includes all engineering majors.

In the 2015–16 academic year, a record 222 engineering students were out on fall, spring or summer co-ops. That number will be eclipsed this year, as 195 students have already been hired for the fall and spring—and scores more will be out again this summer.

Many students have completed more than one professional placement, getting experience at different types of companies and organizations. All told, the program has provided 951 engineering co-op experiences to 665 students at 240 companies so far in its first eight years. More than 1,000 engineering students, meanwhile, have taken the Professional Development Seminar, which is required before students can begin their co-ops.

"We've been very intentional about how we've grown the program, actively doing the employee development while we bring more students into the program," says Rae Perry, director of cooperative education. "Now we're at the point where students are selling it to each other. It's definitely growing because of word of mouth."

Junior mechanical engineering major WaiPhone Tint just completed a six-month co-op at NxStage Medical in Lawrence. Working in sustaining energy research and development, Tint performed software verification and validation testing to ensure the company's home dialysis machine



meets FDA requirements. He also assisted in process improvements, software updates and component developments.

"It was an amazing experience. I learned a lot," says Tint, an international student from Myanmar. "I was able to work with several different departments and help them build up various testing on new things they are developing."

Robinson Arias Gonzalez, a junior electrical engineering major from Lynn, landed a coveted six-month software engineering co-op at Draper last fall—even though software engineering was a little outside of his academic wheelhouse.

"There was a big learning curve because my background is in electrical engineering, but I ran with it," says Gonzalez, who first connected with the company at a co-op expo on campus and believes he was hired because of his follow-through. "They told me I seemed determined to learn, and that's why they hired me."

Perry says the fact that UMass Lowell students are not required to do a co-op is a differentiator that works in their favor.

"I think employers find that our students are really eager for the opportunities," she says. "In many ways, they have to work harder for the opportunities because it's not like their curriculum has a distinct path. So the students want to be there and are ready to take advantage of the opportunity."

When Diane Hewitt, the university's former associate director of cooperative education, started the program, 80 percent of the co-ops were three-month positions. Today, nearly 75 percent of students are doing six-month co-ops.

"We know our employers prefer that, since it gives them more opportunity to teach a student and reap the rewards of having them there," Perry says.

Chemical engineering alum Steve Whitten '15 was among the program's first group of students to go out on a six-month co-op. In the spring of 2012, he worked as a semiconductor manufacturing co-op at Vicor Corp. in Andover.

"The program was a reset button for me," says Whitten, a native of Middleton who says his junior year hit him "like a wall" academically. "When I came back from that co-op experience, I learned what I wanted to do, which gave me that little bit of extra motivation."

Whitten went on to another six-month co-op, this one as an R&D engineer at Semprus BioSciences. After earning his degree, he worked as a research associate at BIND Therapeutics and is now a manufacturing associate at Moderna Therapeutics, a nanoparticle therapeutic startup in Cambridge.

"The co-op program was fantastic, especially if you're nervous for interviews or you need help with your résumé," says Whitten. He credits the professional preparation he received from Career Services, which works with students to fine-tune their LinkedIn profiles and résumés, practice interview skills and hone their elevator pitches.

Another way that engineering students are connecting with industry is through the college's Interdisciplinary Senior Design Projects, which has grown this year to include 64 students on 16 teams. Industry sponsors include Nypro, Dell-EMC, Brooks Automation, Symbotic, MKS, Analog Devices, Raytheon, United Technologies, BAE Systems, Skyworks Solutions and MACOM.

Working on multidisciplinary teams, students gain integrative design experience in engineering and apply their problem-solving skills on open-ended, real-world projects. Students presented their industrial capstone design work at a midyear project showcase in December at Moloney Hall. Final presentations are slated for May.

A Passion for Learning and Teaching

John Daniels' Hands-on Education at UMass Lowell Shapes His Teaching Career

John Daniels '98, '01 sits in his office at the University of North Carolina at Charlotte, where he serves as professor and chair of the Department of Civil and Environmental Engineering. The department has 25 faculty members, eight staff members and more than 500 students.



For John L. Daniels '98, '01, the education and training he received as a graduate student at UMass Lowell serves as a solid foundation for his current job as professor and chair of the Department of Civil and Environmental Engineering at the University of North Carolina at Charlotte.

UNC Charlotte, founded in 1946, is the fourth largest institution in the 17-campus UNC system. It is a nationally ranked public university with a 1,000-acre campus and a total enrollment of nearly 29,000 students. In the William States Lee College of Engineering, there are 419 and 37 students currently enrolled in the bachelor's degree and master's degree programs in civil engineering, respectively, as well as 56 in the interdisciplinary Ph.D. program in infrastructure and environmental systems.

Daniels, who earned a bachelor's degree in 1996 from Lehigh University and a master's degree in 1998 and a doctor of engineering degree in 2001 from UMass Lowell, all in civil engineering, joined the faculty at UNC Charlotte right after completing his studies in Lowell. He subsequently rose through the ranks of visiting, assistant and associate professor to his current position of full professor.

"I learned how to learn and was taught how to teach at UMass Lowell," says Daniels. "The doctor of engineering program included all the elements and rigors of a typical Ph.D. program while adding business course requirements, sort of like a mini-MBA. That has proven to be a powerful curricular recipe for developing deep technical expertise as well as solid business sense that's invaluable to any career."

What's more, his experience with hands-on, applied learning in the Francis College of Engineering has shaped his approach to teaching.

"When I teach my students about groundwater, we go out to the field and perform tests with actual groundwater wells. It also means not just learning appropriate software packages, but how they work. Engineers

need to understand the tools they deploy and have a visceral sense for accuracy and precision with the calculations they perform," he says.

Daniels says he never had any intention of pursuing a career in academia.

"And yet that's where I've been successful—not just in the field of higher learning, but also in interacting with private industry through industry-funded research and the federal government as a program director for the National Science Foundation. All of those experiences follow the careful training and mentorship I received at UMass Lowell," he says.

A LOT OF HELPING HANDS

Daniels credits several of his professors and fellow students for helping shape his career.

"I'm thankful to Ed Hajduk, a fellow UMass Lowell alumnus and current faculty member who welcomed me to Lowell in 1996 as a roommate at 161 University Avenue," he says. "I'm also thankful for all the teachers I had, including Profs. Burton Segall, who taught me water chemistry; Pradeep Kurup, who taught me soil mechanics and is a continuing mentor; Hilary Inyang, my primary dissertation adviser, who secured funding for me and led me to UNC Charlotte; John Ting, who has supported my career to the present day; and Chronis Stamatiadis, who hired me as his teaching assistant and mentored me on how to teach surveying and site design to undergraduates. Gary Howe was also an important teacher to me. His no-nonsense attitude helped me to grow and come prepared when asking for help."

As a professor, Daniels used his well-worn notes from Prof. Cliff Bruell's class on environmental remediation and chemodynamics to teach his students. "I really learned how to teach from taking his courses," he says. "That is why I apply hands-on education and training to virtually every lesson I teach at UNC Charlotte."

FOND MEMORIES OF LOWELL

"The City of Lowell was great to me," says Daniels. "I was active at St. George Antiochian Orthodox Church in Lowell, and I helped run their Middle Eastern food booth for two consecutive years. I don't have an Arabian bone in my body, but I sure learned to love the culture and the people, as well as how to make shawarma, fattoush and falafel."

Daniels, who is originally from Greensburg, Pa., now lives in Davidson, N.C., with his wife (and high school sweetheart), Julie, and their two children, Nicholas, 12, and Katherine, 9. "Free time is devoted to my family and the Nativity of the Holy Virgin Orthodox Church," he says.



Daniels works in the field with a drill rig that is used for geotechnical engineering teaching and research.



When not teaching civil and environmental engineering, Daniels focuses his research on the physical and chemical controls of soil and industrial byproducts, particularly coal fly ash from boilers.



Rob Sullivan '88, '93 specializes in robotics and automation. Here he poses with pallets of Symbotic's compact autonomous mobile Bots at the company's test facility in Wilmington, Mass. These green warehouse machines can whiz up and down aisles at speeds of up to 25 miles per hour, stacking and retrieving cases of merchandise.

Facing page: The robots are separating the merchandise into individual cases, rotating them if necessary to maximize storage density before they go into the company's multilevel storage system.

Alum's Company Is Reinventing the Warehouse

When corporate giants Target, Wal-Mart and Coca-Cola wanted to streamline operations at their U.S. distribution centers, they turned to Symbotic LLC, a private company based in Wilmington, Mass., that is a leading provider of robotic automation technology for warehousing solutions.

According to a recent Wall Street Journal article, these companies are investing in autonomous robots to help increase warehouse efficiency, control rising labor costs and avoid the expense of building new warehouses.

A recent study by the Robotics Industries Association showed that 2016 was a record-breaking year for robotics orders and shipments in North America. A key driver of that growth was demand from consumer goods and food industries, where orders for robots increased 32 percent last year. Robots in those industries are used for performing repetitive primary packaging tasks such as bin picking, tray loading and bottle handling, as well as assisting with secondary packaging tasks such as case storage/retrieval, case packing, bundling, bagging and palletizing.

Unlike many existing warehouse robots, which are limited in what they can perform because they are either bolted in place or run on fixed routes or tracks, Symbotic's network of compact autonomous mobile Bots can whiz up and down aisles at speeds of up to 25 miles per hour, stacking and retrieving cases of merchandise in a huge, multilevel metal enclosure called "The Structure."

"Symbotic's automation systems are deployed across major grocery, beverage and general merchandise warehouses in North America," says Rob Sullivan, co-founder and chief development officer at Symbotic. "Our robots are considered the gentlest handlers in the industry."

Sullivan, who obtained a bachelor's degree in mechanical engineering in 1988 and a master's degree in engineering management in 1993 from the Francis College of Engineering, is responsible for Symbotic's research and new product development initiatives.

"Manufacturers, retailers and distributors build and operate large and expensive warehouses as part of their supply chain to sort, store and distribute products with very tight margins for profitability. Operating these warehouses and distribution centers is both capital- and labor-intensive," he explains. "Symbotic allows our clients to build more flexible, modular and scalable systems to existing warehouses, thereby reducing costs, simplifying operations, increasing capacity and improving product flow from the distribution center to the store shelf."

FROM STARTUP TO A MAJOR INDUSTRY PLAYER

Sullivan has 28 years of experience as a senior operational and technical leader with expertise in engineering, research, manufacturing and program management. He holds more than 30 patents, over 20 of them in robotics.

Prior to joining Symbotic as executive vice president and chief operating officer in mid-2008, Sullivan spent more than seven years at Raytheon in Waltham as a hardware design and development lead engineer. He then moved to Brooks Automation, Inc. in Chelmsford, where he spent the next 12 years in



various engineering positions, most notably as vice president of engineering for the company's critical components division.

At Symbotic, Sullivan believes his most challenging and rewarding accomplishment was bringing the company from a small startup to eventually winning major projects for some of the largest companies in North America. "An equally fulfilling achievement was establishing Symbotic's intellectual property—including its proprietary integrated automation system—that will solidify our company's future," he says.

Last September, Symbotic won the Innovative Technology of the Year Award for Robotics from the Mass Technology Leadership Council (MassTLC) for its contributions to the state's economy and technological leadership.

A ROCK-SOLID ENGINEERING FOUNDATION

"We currently have 32 UMass Lowell alumni working at Symbotic," notes Sullivan. "I am consistently impressed with the academic and pragmatic strength of our alums. Working in an emerging technology takes a level of innovation and commitment that I regularly see in our engineers."

He says UMass Lowell had provided him with a great education that truly propelled his career: "I am an advocate for the strength of the university's engineering program, because it offered me a rock-solid foundation that allowed me to succeed."

As an undergraduate student at UMass Lowell, Sullivan had the opportunity to work on projects that trained him in the mindset of an engineer while preparing him for the practical expectations of the workplace.

"The engineering curriculum provided real-world experiences that went beyond theoretical study," he recalls. "For example, I worked on a project in my senior year to enhance the suspension system of a Ford Mustang. We were able to model the suspension system, upgrade the vehicle and see positive acceleration results in a 0-to-60-miles-per-hour test run near where LeLachur Park is located today. I believe the practical application of theory is one of UMass Lowell's strengths. Upon graduation, students are able to step into the workplace ready to apply their critical thinking skills and academic knowledge."

Sullivan lives in his hometown of Wilmington with his wife, Kathleen, and their children, Kelsey and Meghan. "When I'm not working, I enjoy golf, tennis and hiking," he says.

SYMBOTIC (2)

Faculty Successes



■ **Joyita Dutta**, assistant professor of electrical and computer engineering, has been named this year's Bruce Hasegawa Young Investigator Medical Imaging Science Award winner. The award was presented at the IEEE NSS/MIC conference in Strasbourg, France. (Photo 1)

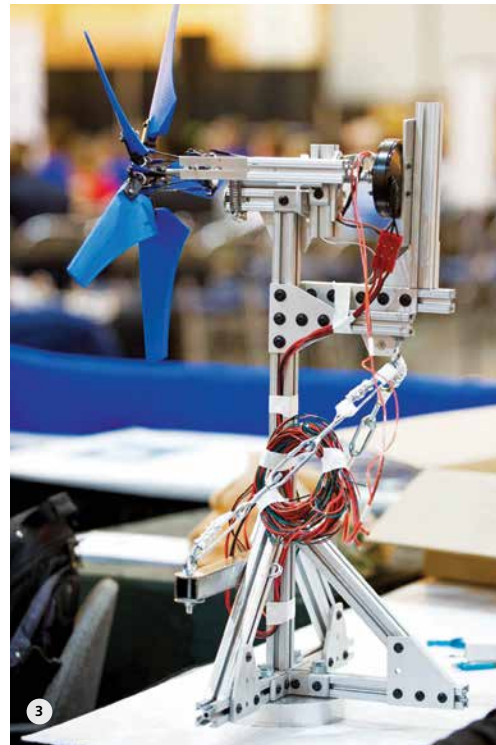
■ **Robert Parkin**, professor of mechanical engineering, published his textbook "Building-Integrated Solar Energy Systems" through CRC Press.

■ A committee that includes **John Christian**, professor of civil engineering, has published the three-year effort, "State of the Art and Practice in Earthquake Induced Soil Liquefaction Assessment," for the National Academy of Engineering.

Student Successes



■ Nonspec, a nonprofit company composed of biomedical engineering Ph.D. student **Jonathan Perez de Alderete** '13, plastics engineering Ph.D. student **Erin Keaney** '14 and **Brendan Donoghue** '15 (mechanical engineering), won a Silver Medal at the Collegiate Inventors Competition. The team has won numerous awards for its prosthetic designs. (Photo 2)



■ **Patrick Anderson** and **William Hallissey** (electrical and computer engineering), **Christian Bain** (business) and **Dana Pierce** and **Linda Pratto** (mechanical engineering) garnered first place for their project, "WindHawk Solutions," during the 2016 Advanced Textiles Student Design Challenge presented by the Advanced Textile Products and the Narrow Fabrics Institute. Asst. Prof. **Christopher Hansen** and Assoc. Prof. **David Willis** served as faculty advisors. (Photo 3)

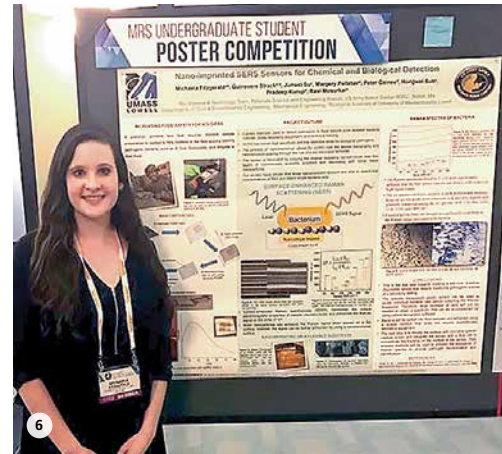


■ **Omkar Bhandakkar** (energy engineering), along with three teammates from MIT, won first place and the \$3,000 cash prize at the MIT Energy Hackathon in November at the MIT campus in Cambridge. (Photo 4)

■ Plastics engineering undergraduate **Heather Beebe** won the John P. Davis, Jr. Memorial Scholarship from the New England Rubber and Plastics Group.



■ Mechanical engineering major **Jonathan Aguilar** was named one of two student presentation contest winners at the ASME Internal Combustion Engine Division 2016 Fall Technical Conference held in Greenville, S.C., for his work on filter-sensing technologies. (Photo 5)

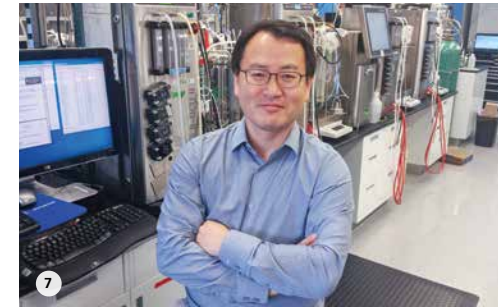


■ Civil engineering major **Michaela Fitzgerald** won first place in the undergraduate poster competition at the 2016 Materials Research Society Conference in Boston last November. She is advised by Assoc. Prof. **Hongwei Sun** and Prof. **Pradeep Kurup**. (Photo 6)

■ Graduate student **Azadeh Farahanchi**, working with Asst. Prof. **Margaret Sobkowicz-Kline** in plastics engineering, won the Graduate Student Travel Award from the American Chemical Society's Polymers Division to present her talk, "Understanding the Effect of Ultra-High Speed Twin Screw Extrusion on the Thermo-Mechanical Properties of Polymers."

■ Chemical engineering doctoral student **Evan Wernicki**, working with Assoc. Prof. **Zhiyong Gu**, won a travel award to participate in the IEEE Georgia Tech FUTURECAR 2016 Workshop and to present his paper, "Nanoparticle-Enhanced Lead-Free Solder Pastes for Electronics Assembly and Packaging."

New Research Awards



■ The National Institute of Standards and Technology named the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) as the 11th institute in the Manufacturing USA network. NIIMBL will help advance the biopharmaceutical industry, foster economic development, improve medical treatments and ensure a qualified workforce by collaborating with educational institutions to develop new training programs matched to specific biopharmaceutical skill needs. The University of Delaware is the overall lead, with the state of Massachusetts a major partner, led by UMass and MIT. UMass is headed by UMass Lowell and the UMass Medical School's MassBiologics. Assoc. Prof. **Seongkyu Yoon** will lead the effort for UMass Lowell, with help from Assoc. Prof. **Carl Lawton**, both of the Massachusetts Biomanufacturing Center. (Photo 7)

■ The U.S. Department of Energy (DOE) announced its funding of the REMADE (Reducing Embodied-energy and Decreasing Emissions) Institute as part of the Manufacturing USA initiative. The Rochester Institute of Technology is the academic lead with UMass Lowell, behind the efforts of **Sobkowicz-Kline**, serving as the university's member in the initiative. The REMADE Institute will focus on driving down the cost of technologies needed to reuse, recycle and remanufacture materials such as metals, fibers, polymers and electronic waste; it aims to achieve a 50 percent improvement in overall energy efficiency by 2027.

■ The National Science Foundation (NSF) has awarded an Industry/University Cooperative Research Center (I/UCRC), named the Center for Science of Heterogeneous Additive Printing of 3D Materials, or SHAP3D, to UMass Lowell, with the University of Connecticut and the Georgia Institute of Technology as partners. Prof. **Joey Mead** is leading the effort for UMass Lowell, along with Assoc. Prof. **Nese Orbey**, Prof. **Carol Barry**, Prof. **David Kazmer** and **Hansen**.

■ NextFlex, America's Flexible Hybrid Electronics Manufacturing Institute, has awarded the UMass Lowell Nanomanufacturing Center (in partnership with Raytheon and Dassault Systèmes SIMULIA Corp.) a \$1.9 million grant for the proposal "Multi-Functional Substrates and Printing Integration for RF Devices." The team is led by Profs. **Mead**, **Alkim Akyurtlu** and **Barry** as well as **Mary Herndon** of Raytheon.

■ **Dean Wang**, associate professor of nuclear engineering, was awarded a grant by the DOE for his study: "RELAP-7 Application and Enhancement for FLEX Strategies and ATF Behavior under Extended Loss of AC Power Conditions." The DOE award was made through the Nuclear Engineering University Program, which is in collaboration with Texas A&M University, Idaho National Laboratory and Oak Ridge National Laboratory.

■ **Gu** in chemical engineering and **Sammy Shina**, professor of mechanical engineering, were awarded an NSF grant for their study: "Novel Nanocomposite Solders for High Reliability Electronics Applications."

■ **Mead** and **Barry** in plastics engineering were awarded a grant by the Office of Naval Research (ONR) for their study: "Corrosion, Biofouling and Hydrodynamic Behavior as a Function of Topography and Composition of Superhydrophobic Coatings."

■ **Alireza Amirkhizi**, assistant professor of mechanical engineering, and **Joel Therrien**, associate professor of electrical and computer engineering, were awarded a grant by the ONR for their study: "Coupled Atomic Force and Apertured IR Scanning Near-field Optical Microscopy (SNOM) for Simultaneous Nano-scale Thermo-mechanical and Chemical Characterization."

■ **Amirkhizi** was also awarded an Air Force Research Lab grant for his study: "Dynamic Recovery Characterization of Anisotropic Composites Under Axial and Internal Loading for Deformation and Damage Mechanisms."

■ **Dutta** was also awarded a grant by the National Institutes of Health for her study: "Tau Quantitation in AD with High Resolution MRI and PET." (Photo 1)



University and College Notes

■ The Francis College of Engineering climbed to No. 104 in this year's U.S. News & World Report rankings, up from No. 118 last year, and No. 140 in 2013. The college is ranked 66th among public institutions. Six programs received national ranking this year: chemical, civil, computer, electrical, mechanical and nuclear.

■ The Francis College of Engineering is embarking on a \$50 million renovation of Perry Hall (known as Engineering Hall when it opened in 1952). The result will be new research labs for clean energy, biomedical engineering, biomanufacturing, environmental engineering and chemical engineering, as well as new teaching labs.

■ UMass Lowell's M2D2 (Massachusetts Medical Device Development Center) has been named the seventh location for a "JLab" by Johnson & Johnson Innovation, joining other sites in Cambridge, Houston, San Diego, San Francisco and Toronto. J Labs are life sciences incubators that provide entrepreneurs and startups shared lab space, offices and access to scientific, industry and capital funding experts. (Photo 8)

■ UMass Lowell is opening another location in Haverhill, Mass., to host classes and a business incubator.

For the Record
The sale of UMass Lowell-developed technology, through the acquisition of Anterios by Allergan, brought in \$3.8 million to the university, not \$11.8 million (fall 2016 issue, page 13).

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The event is **free** and open to the public. High school students and their families, teachers, guidance counselors, college students and faculty members, industry partners, alumni and friends—anyone who wants to be inspired by the innovation taking place at UMass Lowell!

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