engineering news
School of Engineering
WINTER 18
SANTA CLARA UNIVERSITY

DEAN'S MESSAGE

Happy eWeek! February 18-25 is National Engineers Week—a time to shine a light on our exciting and fulfilling profession, and a time to celebrate Santa Clara Engineering. In this issue of *Engineering News*, you will find just a few examples of the many great things going on in the School of Engineering.

Studying at the Jesuit University in Silicon Valley, our students have exceptional opportunities to stretch, and grow, and thrive in the epicenter of innovation. Opportunities abound to work with industry giants, travel the world with Engineers Without Borders, or become leaders in the field of humanitarian development working on projects in our Frugal Innovation Hub. Our mission to educate the whole person means our students enjoy a comprehensive liberal arts experience in addition to a rigorous engineering program, and our Jesuit foundation brings a unique ethical perspective to our work.

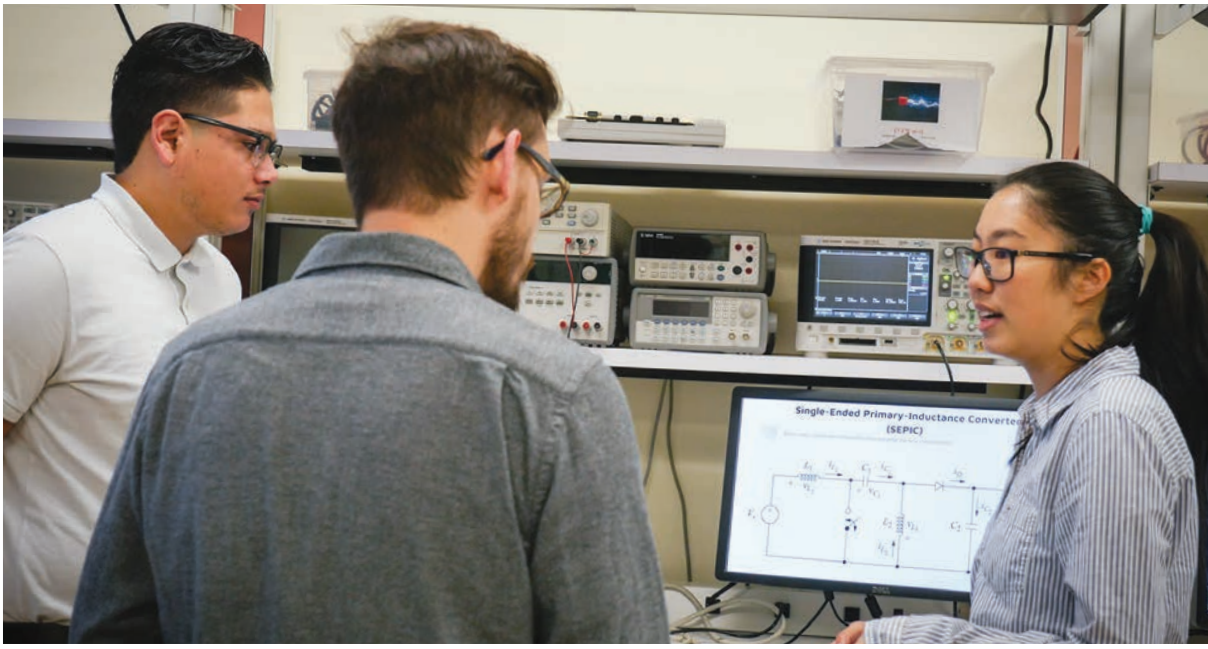
Looking at engineering from an ethical standpoint, in this edition Computer Engineering Associate Professor Ahmed Amer thoughtfully addresses what memories we keep and how we store them in a digital age, examining all the elements comprising a trustworthy process that protects the public's safety and privacy. And you will read about two of our alumni who are putting their ethics to work through community outreach and via a new startup aimed at feeding the world's 1.1 billion malnourished.

We are happy to bring you these stories and more. Enjoy!

Alfonso (Al) Ortega, Ph.D.
Dean
School of Engineering

Energetic Senior Wins IEEE Scholarship

Photo: Nicole Morales



Taylor Mau '18, right, in one of Santa Clara University's electrical engineering laboratories

Taylor Mau '18, double majoring in electrical engineering and computer engineering and minoring in design thinking and innovation, recently won a highly competitive IEEE Power and Energy Society Scholarship Plus Initiative award. A habitual overachiever, Mau was honored for her commitment to exploring the power and energy engineering field through both coursework and career experiences.

The busy senior has held internships at FileMaker and Apple, and work she performed with teammates last summer in the School of Engineering's Latimer Energy Lab led to a poster presentation, "NanoGrid: A path to energy efficiency and renewable energy," at the IEEE Conference on Technologies for Sustainability last November. She was also a member of SCU's 2016 Tiny House team, which took first place in California's inaugural competition.

For her senior design project, Mau is developing an air quality monitor. "Poor air quality contributes to a lot of deaths, so I'd like to bring awareness to this problem. I'm working on a prototype that harvests energy from the sun, vibration, or thermal energy to power the device. Data will be sent to the cloud and then to an iPhone to notify users of poor air quality," she said.

At SCU, Mau has shared her excitement for engineering as a School of Engineering tour guide, vice president of the student chapters of IEEE and Association of Computing Machinery, and president of the Maker Club. She is also an avid artist and enjoys drawing, painting, and various other arts and crafts. "I never took any art classes. I want to, but my schedule is kind of busy," she said, not even registering the understatement there. "After graduating, I want to get a job in prototyping or product design. Combining engineering and art in a career would be awesome."

We Have Contact

Glaucoma, the leading cause of irreversible blindness, afflicts 4 million Americans (and 70 million people worldwide), and those numbers are climbing. Often the disease—characterized by elevated intraocular pressure (IOP)—arrives without warning, but early detection can prevent vision loss. Bioengineering Assistant Professor Emre Araci and his team of student researchers believe they have just the right tool to help people detect changes in their eye pressure—a daily use soft contact lens with a highly sensitive built-in sensor.

Before joining the SCU faculty, Araci, whose background is in microfluidics and optics, was at Stanford University, where his team built an IOP detecting device for implantation into the eye during cataract surgery. It was quite a breakthrough; however, the nature of the procedure limited the potential to reach a wide population. He decided to build a soft contact lens version.

"This was a bigger problem than we had tackled previously," he said. "Measuring pressure from a sensor inside the eye is relatively easy; measuring it from the outside is challenging. While some devices do this now, they require a physician to take measurements, and they don't afford the comfort and convenience of soft contact lenses. My idea was to help the patients get measurements at home with the use of a contact lens that could interface with a smartphone." So, two years ago when he arrived at SCU, he recruited two graduate students and one undergraduate to help with his research. After six months building their lab, they began making microfluidic strain sensor microchips that would be embedded in the contact lens.

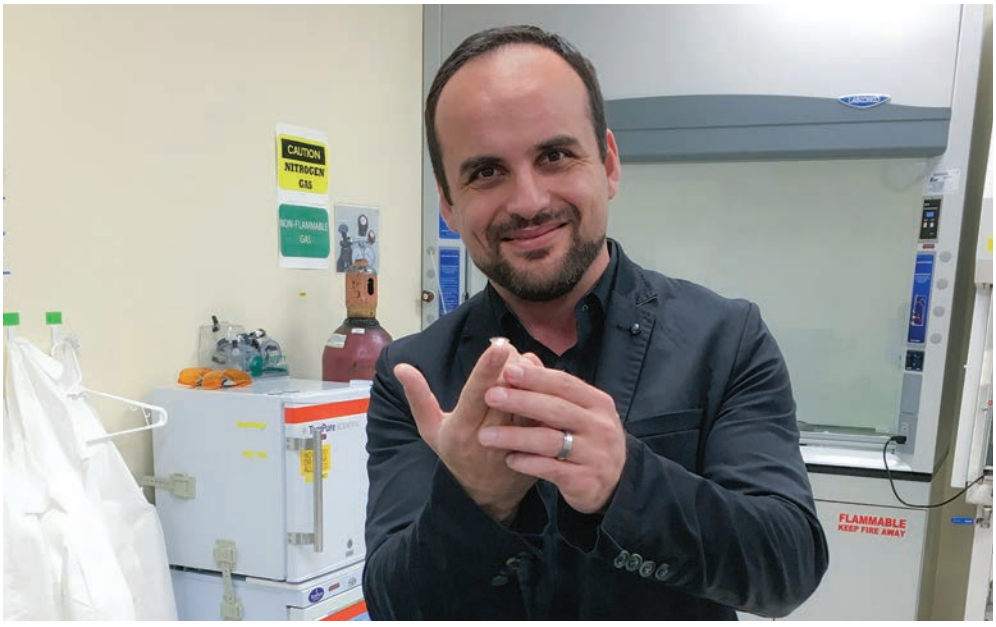
"Every step has been done here at SCU. In addition to my lab, we use SCU's Center for Nanostructures, and the students have been involved in every step along the way, from development of processes to design and prototyping," he explained.

One stumbling block was finding a material that would combine the comfort and safety of standard soft contact lenses—flexibility, air permeability—with the rigidity needed to maintain the integrity of the on-board sensor. "Things really started to get exciting when we began combining different technologies, microfluidics and metamaterials," Araci said. "Instead of getting thinner when they are pulled, metamaterials, or auxetics, get thicker; they don't distort, they grow. Auxetics have been used in athletic shoes and contacts, but they hadn't been applied to microfluidic technology in optics. For about a month, it was all I could talk about with my students. Eventually, we came up with a microfluidic metamaterial for our contact lens based intraocular pressure monitoring platform," he said.

With prototypes soon in hand, testing began. The team built mechanical eye models to test their pressure-detecting lens and gathered results using both a microscope and smartphone images. They did the same with porcine eyes obtained from a butcher shop, receiving excellent results in each case. Araci said, "We put the contact lens on the porcine eyes and pressurized them. We were able to detect a 4-micrometer change in the radius of the eye—not centimeters, micrometers! To validate our findings, we purchased a commercial tonometer, the same equipment used in ophthalmologists' offices, and ran the tests again, comparing those measurements to data gathered from our contact lens and smartphone. We verified that our sensor has a detection limit that matches the gold standard in ophthalmology."

Next steps? "We'll be collaborating with Stanford and UC San Francisco ophthalmology teams and glaucoma experts. We're also working on getting Institutional Review Board approval for testing on humans," said Araci. "This technology is very novel and the application is so interesting. There is great potential to solve a long-standing problem in glaucoma detection and treatment. People without the disease will be able to monitor their eye health and pressure changes that could lead to vision loss. Those with glaucoma would be afforded safe and comfortable long-term treatment management. Passively monitoring a patient's ocular response to drug regimens or lifestyle changes will help both doctor and patient make informed treatment choices and will also assist in the validation, discovery, and efficacy of novel drug candidates. It's very exciting!"

Photo: Heidi Williams



Bioengineering Assistant Professor Emre Araci with his groundbreaking contact lens

LAVISH ENTHUSIASM FOR FRUGAL INNOVATION

With a mission "to engage students and faculty in technological and humanitarian projects through partnerships and programs," Santa Clara University's Frugal Innovation Hub (FIH) has become a leader in the field of humanitarian technology development, research, and implementation. Its administrators are highly sought-after speakers on the global stage, and student project leaders routinely publish their work in journals and present at local and international conferences.

Often students are drawn to the Hub after hearing about a friend's project; others scan the website for interesting projects. Last year, computer engineering master's students Anjali Kumar, Grism Patel, and Barsa Nayak took both those pathways and teamed up to create a website for Collaborate for Africa (C4A), an organization connecting San Francisco Bay Area project innovators with one another. FIH Director Silvia Figueira explained, "The organization is set up to share who is doing what in Africa, but they didn't have a website. The grad students spent the summer building a site for C4A so their more than 300 members can share stories and learn from each other's experiences or offer help."

The team set to work, streamlining authentication processes to ease the moderator's work and making the site responsive for mobile devices. When they presented their ideas to about 30 of the NGO's members in San Francisco, they were moved by the response. "They treated us like we were doing a great favor for them. This inspired us to work harder and do more," said Barsa. Anjali agreed. "We entered the project to learn, but the clients were so overwhelmed and excited, it made us feel like part of something big and important." Aside from the warm feeling, the team walked away with great hands-on experience. "Professor Silvia chooses the latest technologies for us to use," said Grism. "She chose MEAN Stack because that's the hot new technology. Moving forward, we will have more opportunities since we've worked with that." The site officially launched in February during a C4A meeting at the Frugal Innovation Hub.

Other recent FIH projects include a mobile app for an organization in Kenya that educates people on how to avoid human trafficking, and another team's app will help a former San Quentin inmate improve the success of drug abuse recovery. Still another sorts cellphone data for an organization assisting refugees as they adjust to American life.

Photo: Heidi Williams

(Left to right) Grism Patel, Anjali Kumar, and Barsa Nayak take a break from their work in the Frugal Innovation Hub

Over the past five years, FIH has facilitated more than 125 projects in areas ranging from sustainable construction to thermal energy solutions, frugal materials, mobile for social benefit, and global health. With so much experience and knowledge culled from the work of scores of students, faculty, and partners, a core frugal task is to centralize that information so others can tap into it.

Figueira said: "We get a lot of interest in senior design projects focused on renewable energy for Africa, especially solar panels, and our engineering students have worked on a number of projects dispersed across the globe for similar types of communities with similar sets of needs. Our grad students are building a list of requirements and specifications for seniors working on this type of project so they can be ahead of the game when they start out—what to look for in materials, how to deploy, an instruction manual template. Having this set of tools at the outset, our seniors can focus on design and deployment based on the specific local needs, utilizing the knowledge acquired by previous SCU solar projects. We've done so many, a list of our best practices and case studies will be very helpful."

Recently the Hub has opened a new area of work in partnership with the School of Engineering's Robotics Systems Laboratory—technologies to prevent and mitigate natural disasters. Five of this year's senior design projects address such issues. "We're getting to a really interesting point in the Frugal Innovation Hub where external partners are coming to us for help, and a lot of students want to be a part of what's happening here," Figueira added. "We're growing like crazy. Our students want to work on these meaningful projects, and we want to generate world-class engineers to be leaders in developing solutions for humanity's challenges. It's a win-win situation!"

More: **scu.edu/engineering/frugal**

Alumnus Seeks to Feed the World

Photo: Courtesy of Gabriel Alcantar

Sam Bertram '16, M.S. '18

Imagine an indoor agricultural system that uses 98 percent less water and 95 percent fewer pesticides, yet yields 250 times more plants per square foot twice as quickly as traditional farming. Imagine location, climate, and soil fertility are no longer pervasive inhibitors. Now envision that system is fully automated and producing 5 million pounds of food per year in a footprint smaller than a football field. What you're seeing in your mind's eye is OnePointOne, the brainchild of mechanical engineering alumnus Sam Bertram '16, M.S. '18, and his brother John.

Born and raised in Australia, Sam came to Santa Clara University on a tennis scholarship. Despite not having taken any math, physics, or engineering courses, he transferred into the mechanical engineering program after deciding that engineering was cool. "The first quarter was absolute hell—I almost failed my first midterms—but I'm a hard worker and was able to grind through it," he remembered. Soon, he was working in the School of Engineering's Maker Lab, then as Research Assistant and Teaching Assistant in the Robotics Systems Laboratory (RSL) for three summers. "Almost all of the practical knowledge I have comes from the RSL—electronic components, coding, mechanical design—all of it weaves into what's required of engineers today. You need to be familiar with it all, and Professor Kitts [Christopher Kitts, mechanical engineering professor and director of the RSL] was always willing to sacrifice his own time to help his students learn," he asserted.

"Sam is bit of a poster child for the School of Engineering's KEEN program," said Kitts, referring to the School's comprehensive efforts to champion the entrepreneurial mindset in undergraduate students. "He's taken the Smart Products course, participated in contests and competitions, attended our speaker and mentoring events, and met many other budding and serial entrepreneurs. It's very exciting to see the impact the program is having on our students."

Technical skillsets and an entrepreneurial mindset were key components to launching a startup, but Sam and his brother (an electrical engineer) wanted to apply their knowledge toward something socially valuable. "We started looking into the world's largest sectors. Transportation and energy entice billions in venture funding, but agriculture, by comparison, is barren. Others are working to figure out how to optimize outdoor farming, but with exploding populations and an increased prevalence of environmental malaise, we believe indoor vertical farming has tremendous potential for good. There are 1.1 billion people in the world who are physiologically malnourished; many don't know where their next meal is coming from. The concept of pervasive malnourishment was galvanizing. We named our company OnePointOne to represent our mission to introduce food security to those 1.1 billion individuals," he explained.

Indoor vertical farming is not a new idea, but fully automating the brothers' aeroponics growing process using advanced robotics, computer vision, and artificial intelligence is novel. Sam took on the design and demonstration of the prototype as his graduate capstone project. "We sow our produce on metal growth structures that are 12 feet tall, 40 feet wide, and 1 foot deep. With aeroponics, the plants' roots hang in the air and you mist them with 20- to 50-micron droplets of water and nutrients. Growing plants indoors means you are outside the whims of rain, wind, sun, and pests; everything is controlled, so food can grow organically. The clear differentiator is our ability to automate the entire process," he said. "Our plan is to remove human beings from all operational processes inside the growth facility. Cultivation, harvesting, packaging, sanitation, and system maintenance will all be automated."

With his capstone work well underway, things really took off when Sam—then working part time as a tennis coach at The Bay Club in Los Gatos, California, ("where half the members are executive VPs or higher," he explained)—started giving lessons to Michael Steep, executive director of Stanford University's Digital Cities Program. After three or four lessons, Sam pitched OnePointOne, and Steep was intrigued. "He liked the idea and said it aligned well with what they were doing at Stanford. He

told me, 'If you're willing to work hard, I'm willing to help.' I'm always willing to work hard, so he gave me about two months' worth of homework to complete in two weeks, and with his guidance, I managed to get it all done. All in all, I think I've gotten about a half million dollars' worth of free consulting!" Sam said.

Free consulting, plus for the past year, Sam has been incubating the company in Santa Clara University's EDVenture Lab. "It's been fantastic having the support of SCU and the space to grow our idea. I can bring investors here to pitch, and the lab has injected money to build a prototype and fund undergraduates to help with the design work and financials. It's been super exciting to me, as a small fish, to have strong support from both SCU and Stanford," he said.

Through Steep's connections, Sam has pitched OnePointOne to Stanford's Farmers Investment Club, a mini angel investment group of the University's engineering faculty, past and present, and to a partner in Blackhorn Ventures, among others. "The first time I met with Blackhorn, I had TA duty in the RSL in the morning, then drove to Ames where the prototype is housed in the RSL's space in the NASA Ames Research Center. When I got there, the $3,000 prototype wasn't working; the pump had blown and all the plants were dead. These were the first serious guys I'd brought in, but I just had to laugh because the timing for a $70 pump to fail was so ridiculous."

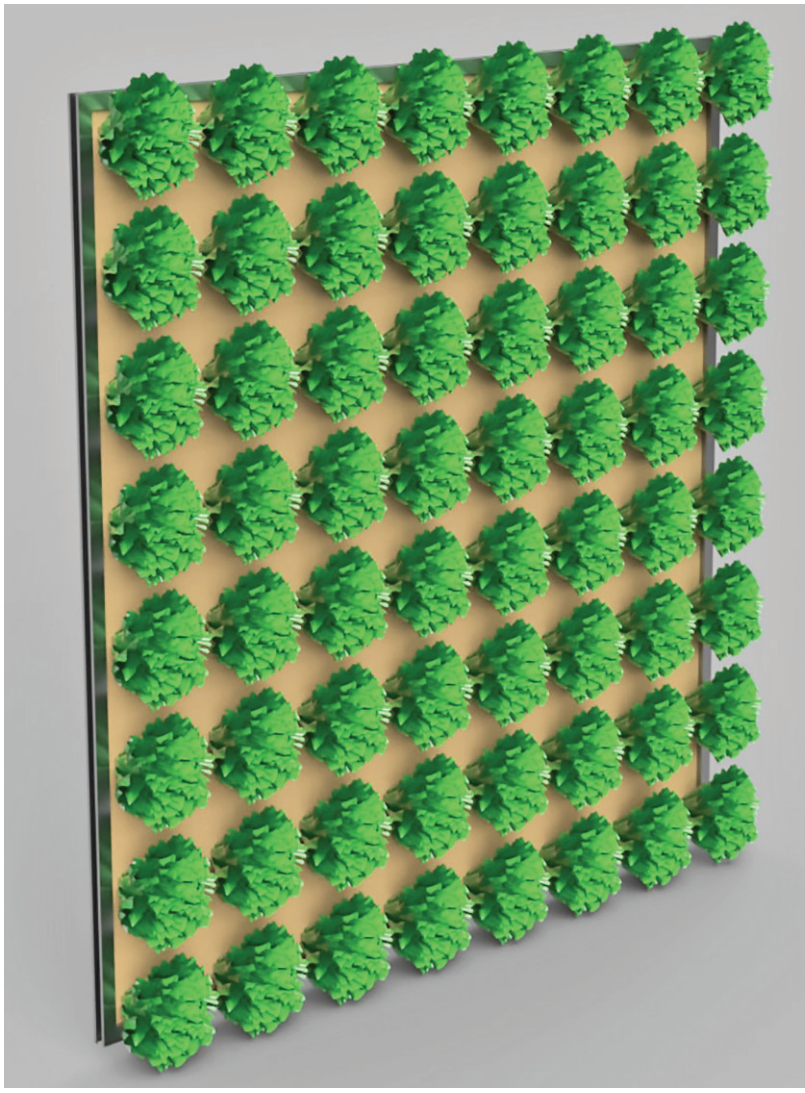
Turns out the "serious guys" could see the promise of OnePointOne and funded the fledgling company. To date, the startup has $330,000 invested and $1.3 million committed of its $1.7 million initial round of funding; they are in talks with Amazon and Google and have filed two provisional patents for their automated system. Also exciting: a growing list of employees who have all graduated from or are currently involved with SCU's Robotics Systems Lab. "Paul Mahacek is leaving his job at SpaceX, Aaron Schooley is leaving his at NASA, Robert McDonald, Scot Tomer, and SCU junior Zach Bellay '19 are all part of the team. They all have exceptional drive and believe in the vision wholeheartedly," Sam said.

"In five years we see OnePointOne scaling to compete with a thousand-acre outdoor farm," he continued. "It's hard work, and significant profitability is a requirement. We are a number of years away from addressing food deserts in cities like Oakland and New York, where people are more than five miles away from fresh food, though the goal remains. I want to deliver nutritious, delicious produce to people who do not currently have access to it. We need to prove that it is cheaper to grow food this way, and that we can do it. Ethics or morality is the driver of OnePointOne—we've woven it into the bylaws that when we achieve x-number of dollars of profit we will build in places where we won't be as profitable—but we must take one foot before the other.

"My goal in coming to the United States," he added, "was to contribute as much as I can to society and learn as much as I can in the shortest amount of time possible. Starting a business is a perfect way to do so. What an experience!"

More: **onepointone.us**

Photo: Courtesy of Sam Bertram



Artist rendering of the OnePointOne indoor vertical agricultural system

ON ETHICS AND TRUSTWORTHINESS IN THE DIGITAL AGE

For years, computer engineering Associate Professor Ahmed Amer has passionately focused his research on data storage, but these days new concerns are starting to take the forefront. To Amer, seemingly disparate questions of how to preserve our digital memories reliably, how to establish the trustworthiness and provenance of information found online, and how to deal with information gathered from burgeoning numbers of sources and sensors, such as images from police officers' body cameras, all relate to larger, overarching issues. How can data benefit people without disturbing their privacy?

Photo: Heidi Williams

Associate Professor Ahmed Amer

"We need to rethink how we store what we store, but while carefully considering and reconsidering for what purposes we are storing it," Amer said. "We need to look at the ethics of how we store data. It may seem like we know how to store and communicate our data reliably, but the sheer volume of data raises some fundamental questions about what we mean by 'reliably.' Our biggest concerns used to be preserving data if hardware failed. I now believe that's far from all there is to it. As a simple example, if the 1s and 0s survive but I can't trust that someone hasn't changed them, then there is a problem beyond their values surviving the failure of a drive. We need to look at all the elements going into trusting that data is stored well—computer security research and database research, certainly, but where I feel we really need to start looking more carefully is at the human element. The processes by which data is created, referenced, and verified need to be handled better. It's not a single problem; it encompasses many domains and takes on many forms," he added.

Putting his students to work on these issues, Amer leads both undergraduates and graduates in examining problems ranging from verifying the authenticity of online articles to verifying the provenance of articles and citation chains.

As for himself, Amer spends a lot of his time thinking about the ethics of protecting the public's safety and privacy, particularly in light of concerns over the use and misuse of body cameras on police and other security officers, the privacy of individuals' data as they travel or cross borders, and the increasing ubiquity of video and audio recording devices in our private and professional lives.

"What do you do with the information from a police body cam? How can you ensure the responsible and limited use of such data by the state? How can you have a trustworthy record if the recorder can turn the camera on and off at will, or is able to modify or delete the data after the recording has been made? Solutions to these problems are never purely technical. While restrictions on recording might seem to be the matter at hand, it's really more a question of what happens to the data and with whom (if anyone) it can be ethically shared. Personally, I find the idea of restricting people's ability to record, like attempts to ban photography and videography in public spaces, to often be a form of policing and restricting memories, and therefore deeply offensive. We often need to rethink how we are managing data in relation to the purpose for which it is being used," he said. "Beyond the 'how' of building massive data stores, we need to keep a sharper focus on the 'why.'"

As technology advances, issues of trustworthiness and ethics will only become more complex. "How we ethically manage the data we store is never going to be something we don't look at long and hard," said Amer.

The Foundation of It All: Young Engineers

As a well-respected civil engineer just seven years into his civil and geotechnical engineering career, Gabriel J. Alcantar '08 (B.S. civil engineering) has already helped build high-rises in San Jose and San Francisco and served as the lead field engineer overseeing the fast-track installation of more than 3,000 piles (in just 30 days!) supporting Levi's Stadium, home to the San Francisco 49ers. But it was caring for his community that won him special acclaim last year, the prestigious H. J. Brunnier Award for Outstanding Service to the San Francisco Section of ASCE (American Society of Civil Engineers). The award is named after Henry J. Brunnier, a young engineer who helped rebuild San Francisco following the devastating 1906 San Francisco earthquake and fire.

"I hope to leave my footprint or legacy with good work. In my case, it's in the foundation where no one can see it, but I know it's there."

For years, Alcantar has been an avid volunteer with a number of outreach programs. He regularly contributes his time at resume writing seminars and mock interview workshops for SCU civil engineering students. He has supported Silicon Valley Education Foundation STEM educational activities, and mentored high school students within the nationally recognized ACE Mentoring Program, helping youngsters identify aspirations while addressing stereotypical obstacles. "When I go out to Mt. Pleasant or Silver Creek High School, whose populations are generally underrepresented in STEM," he said, "I can show the students a path they may not have thought possible. I can relate to them because I'm no stranger to their community or environment; I grew up there."

Giving back has always been a passion of his. "My mother has worked in education for over 30 years. She is my role model, an educator who impacts and gives back daily; I only get to do it once a month, but it's important to me to do as much as I can. I'll take any opportunity to introduce young students to the possibilities a civil engineering career can offer," he said.

Recently, he seized upon an ideal opportunity by developing and chairing ASCE San Jose's Young Member Forum's *Dream Big* Outreach Student Program. Through his efforts, more than 700 children, aged 5 through 16, from the Girl Scouts of Northern California, San Francisco 49ers STEM Leadership Institute, and area schools, were treated to a showing of *Dream Big*, an IMAX film showcasing the wonders of engineering. "The San Francisco Section of ASCE was planning to host a red-carpet premiere of the movie at the Tech Museum of San Jose, but I thought we could do more. My vision was to bring as many kids as possible to *Dream Big* at zero cost to them. With the help of colleagues and members of ASCE San Jose's Young Member Forum, we applied for an ASCE national grant and received funding, but that wasn't the great part," he said with growing animation. "We created a whole program around the *Dream Big* premiere, which also coincidently kicked off National Engineers Week. We arranged sessions, coordinated show times, and recruited volunteers months in advance. We had at least one 'celebrity engineer' per 10-15 students who talked about engineering and IMAX technology before the show and then answered students' questions afterward about engineering and *Dream Big*. The whole experience was really inspiring—not only for the students, but for the volunteers, as well.

Photo: Courtesy of Gabriel Alcantar

"I love my profession," he continued. "As a civil engineer, you have the opportunity to create monuments, structures, or infrastructure for the next generations. In 30 years, I hope to walk around with my kids and point to buildings or structures and tell them, 'I helped design that; I helped build that.' I hope to leave a legacy for them. Something my father taught is very important. He says to me often, 'You're an Alcantar; you leave your name wherever you go.' My father being a man of few words, I understood this to mean 'know where you come from, leave a lasting impression in this world, and put your best into your work.' I hope to do just that. I hope to leave my footprint or legacy with good work. In my case, it's in the foundation where no one can see it, but I know it's there," he laughed.

An even less visible but perhaps more lasting foundation Alcantar is cementing is the one within the minds of countless young engineers to come. Alcantar hopes to continue his community outreach through his profession with competence, conscience, and compassion—values he admitted he truly learned at Santa Clara University.

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Photo: James Wang '19

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AN ARTFUL ENGINEERING EDUCATION

Photo: Heidi Williams

Hannah Sheldon '19 at work on one of her many art projects

Junior Hannah Sheldon '19 (electrical engineering) has always been crazy about the arts: singing, photography, drawing, painting, stippling ("I could stipple the night away!," she states). But she also loves the flexibility an electrical engineering education affords. "I can jump into a lot of things from EE, but I really wanted to bring the creative aspect into my engineering study." Product design is where she eventually sees herself, so she is pursuing a studio art minor in addition to her engineering coursework.

Breaking the stereotype of a single-minded engineer, Sheldon makes art that is thoughtful and provocative. One piece uses seven different maps to explore the state of decay or growth in Oakland, California, over a 200-year period. Another looks at states of mind through the lens of Tim Burton's *Alice in Wonderland* characters. "It's a study in the insanity we all feel but most of us have a handle on. The White Rabbit represents anxiety; the Cheshire Cat, depression or sadness; the Red Queen, anger, and the Mad Hatter depicts general insanity," she said.

"My whole life is addicted to the arts; I love the arts so much," she said. "But I also really like science and I really like making things. Engineering is a place where they can all come together."

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