



# Penn Engineering







# evolute

Instead of having to walk to a bike-sharing kiosk to pick up or return your ride, autonomous bike “evolute” will come to you! For their Mechanical Engineering and Applied Mechanics (MEAM) Senior Design project, Amilcar Cipriano, Jesus Gallegos and Eloisa Baez Jones (pictured from left) installed electric motors to drive the wheels and to steer, sensors to determine the position and motion of the bike, and an Arduino MEGA 2560 microcontroller that dictates ride speed, turning radius, and simple paths for the bike to navigate.

*Team evolute is comprised of MEAM seniors Amilcar Cipriano, Jesus Gallegos, Alberto Jimenez, Eloisa Baez Jones and Ketsy Resendez, and is advised by MEAM Senior Lecturer Bruce Kothmann.*

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Penn Engineering / Spring 2017  
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“PENN ENGINEERING IS POSITIONING ITSELF TO UNLEASH THE NEXT GENERATION OF HIGH-TECH ENTREPRENEURS. IT’S A NATURAL PLACE FOR BOLD IDEAS TO COME TRUE.”

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## Advancing the Penn Compact

When President Amy Gutmann introduced *Penn Compact 2020*, she offered both a visionary and pragmatic plan. Three values—*inclusion, innovation and impact*—would define Penn’s mission and direct the future of the University. I am proud to say that the aspirational vision of the Compact has been made real and tangible across the Penn Engineering campus.

On this issue’s cover and inside are photos from Access Engineering, an initiative developed, organized and implemented by Penn Engineering undergraduates. These students saw an unmet need: many high school students don’t know what engineering is or have access to sophisticated laboratories. Now, on Saturday mornings in classrooms and hands-on labs in Penn Engineering’s campus, students from local Philadelphia high schools broaden their understanding and experience firsthand what it means to be an engineer.

Penn Engineering alums Matt Lisle and Adrian Lievano, previous winners of the Penn President’s Engagement Prize, launched startup Everwaters,

which fabricates a simple, cheap and sustainable water filter to address one of the world’s most pressing needs: clean water. The entrepreneurs spent a year in Kenya creating a device to remove waterborne diseases and other contaminants from the local water, and the startup continues to flourish, shipping thousands of the filters to Kenya.

And for sheer innovation and fun, I invite you to meet Piccolissimo, the world’s smallest self-powered controllable flying vehicle, weighing in at less than 2.5 grams and spanning about the width of a quarter. Despite its diminutive stature, it is big enough to carry a camera or sensor, and when deployed in the hundreds or thousands, can quickly gather data over a large geographic area.

I am privileged to lead a School that, at its core, exemplifies the vision and mission of Penn. This issue of *Penn Engineering* shows not only the breadth, depth and reach of our technology, but also our humanity as engineers. I hope that you are as honored as I am to be a part of this inclusive, innovative and impactful community. 🇺🇸



# Incubating Innovation

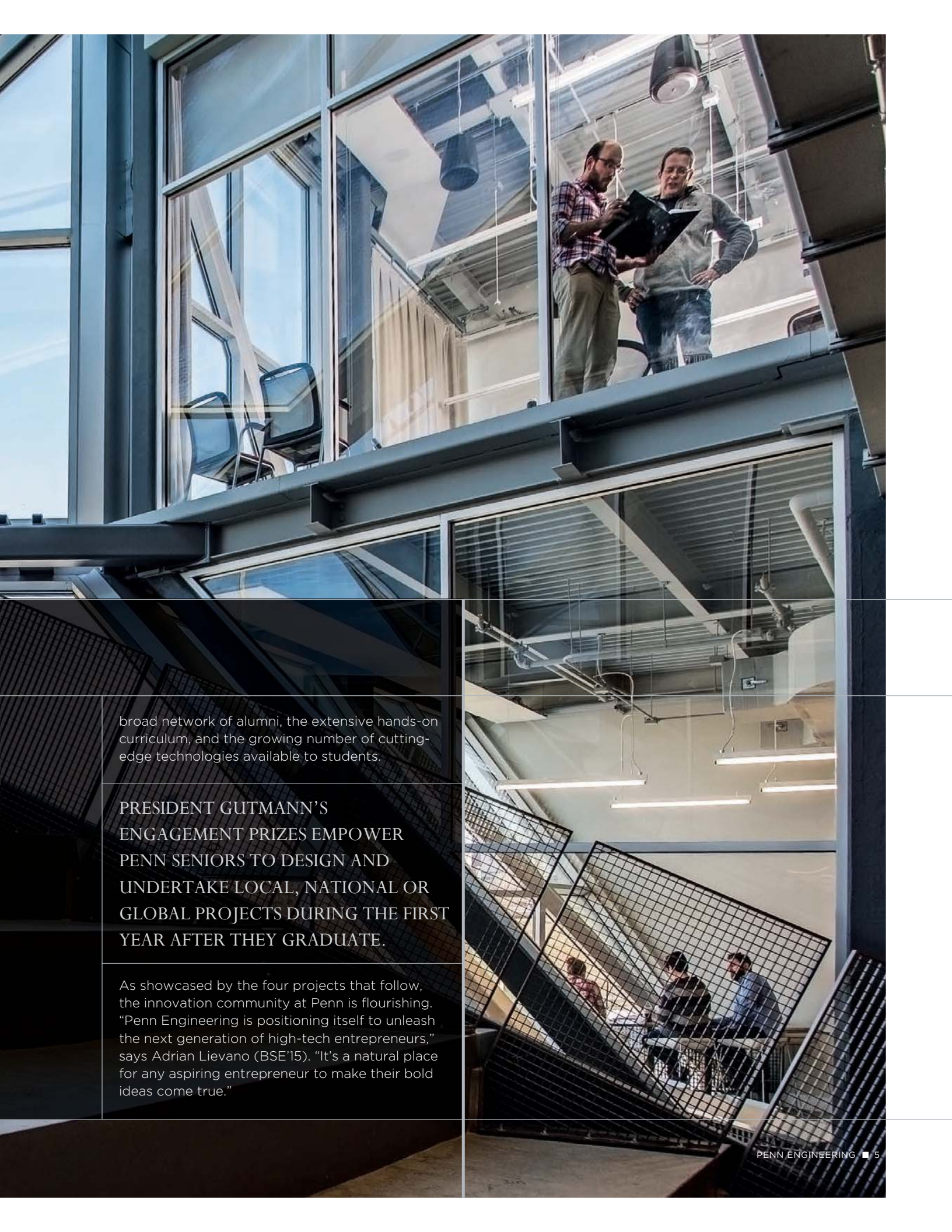
When Matt Lisle (BSE'15) started his freshman year at Penn, most of the upperclassmen he knew were looking into banking or consulting jobs, and none were starting companies. "By my senior year, that ratio had almost completely flipped," he says. What brought about the change? According to Lisle, it was the product of Penn's initiatives designed to inspire budding entrepreneurs. As a result, startups among alumni are finding both great support and success.

Penn President Amy Gutmann has named innovation as one of the three main thrusts of her *Penn Compact 2020*. In 2014, she introduced the President's Engagement Prizes, which empower Penn seniors to design and undertake local, national or global projects during the first year after they graduate. One year later, Gutmann announced the launch of the President's Innovation Prize, which provides social-minded graduating seniors with financial support and mentorship during the first year out of college,

in addition to dedicated space at the recently opened Pennovation Center.

One notable example of Penn's commitment to entrepreneurship is the Y-Prize, which was launched in 2012 by Vijay Kumar, Nemirovsky Family Dean of Penn Engineering, and Mark Yim, professor in Mechanical Engineering and Applied Mechanics (MEAM) and director of the Integrated Product Design master's degree program. This award provides \$10,000 to members of the Penn community who propose the best application for an emerging technology.

Penn Engineering students can also take advantage of opportunities such as the PennApps and Pennvention competitions, the Engineering Entrepreneurship Program, and the I-Corps Site summer startup accelerator program, among others. That's not to mention strong collaborations across Engineering, Wharton and Medicine at Penn, access to outstanding mentors and a



broad network of alumni, the extensive hands-on curriculum, and the growing number of cutting-edge technologies available to students.

PRESIDENT GUTMANN'S  
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As showcased by the four projects that follow, the innovation community at Penn is flourishing. "Penn Engineering is positioning itself to unleash the next generation of high-tech entrepreneurs," says Adrian Lievano (BSE'15). "It's a natural place for any aspiring entrepreneur to make their bold ideas come true."



*Startup Everwaters produces a water filter made of coconut carbon and natural ceramic, which work together to reduce lead, bacteria and rotavirus, the most common cause of severe diarrheal disease in infants and young children worldwide.*

## MEETING THE WORLD'S WATER NEEDS

With the help of a 2015 President's Engagement Prize, Lisle and Lievano (pictured top row, middle) are tackling one of the biggest challenges of the 21<sup>st</sup> century: meeting the world's growing water needs in the face of a changing climate. The award allowed the duo to spend the 2015-16 academic year designing and implementing a simple, sustainable and inexpensive water filtration system in Kimana, Kenya, where access to clean drinking water is a daily struggle.

Upon graduation, Lisle and Lievano launched the startup Everwaters to develop their system. The result of their efforts was a water filter made of coconut carbon and natural ceramic, which work together to reduce lead, bacteria and rotavirus, the most common cause of severe diarrheal disease in infants and young children worldwide.

The product removes more than 15 times the number of contaminants as a Brita filter, and was the focus of a Kickstarter campaign initiated in November 2016. Thousands of filters are now en route to Kenya, and Everwaters also plans to expand in East Africa and other developing and emerging markets.

Lisle and Lievano are also developing a filter that leverages the natural water purification capabilities of the moringa seed, which contains a coagulant protein that binds heavy metals and microorganisms, effectively removing them from the water. In the end, the filters could save countless lives from waterborne diseases and metal poisoning. "We think we can start and grow a sustainable, socially responsible business," Lisle says. "Looking back, becoming an entrepreneur was the most fulfilling direction to take, and I'm grateful that both the people and my experience at Penn showed me the way."





*Like a 3D printer, BioBots extrudes a solution of biomaterials, sculpting cell cultures into miniature organs. The 3D constructs can serve as model organs for drug testing and other types of biomedical experiments.*

## MADE-TO-ORDER ORGANS

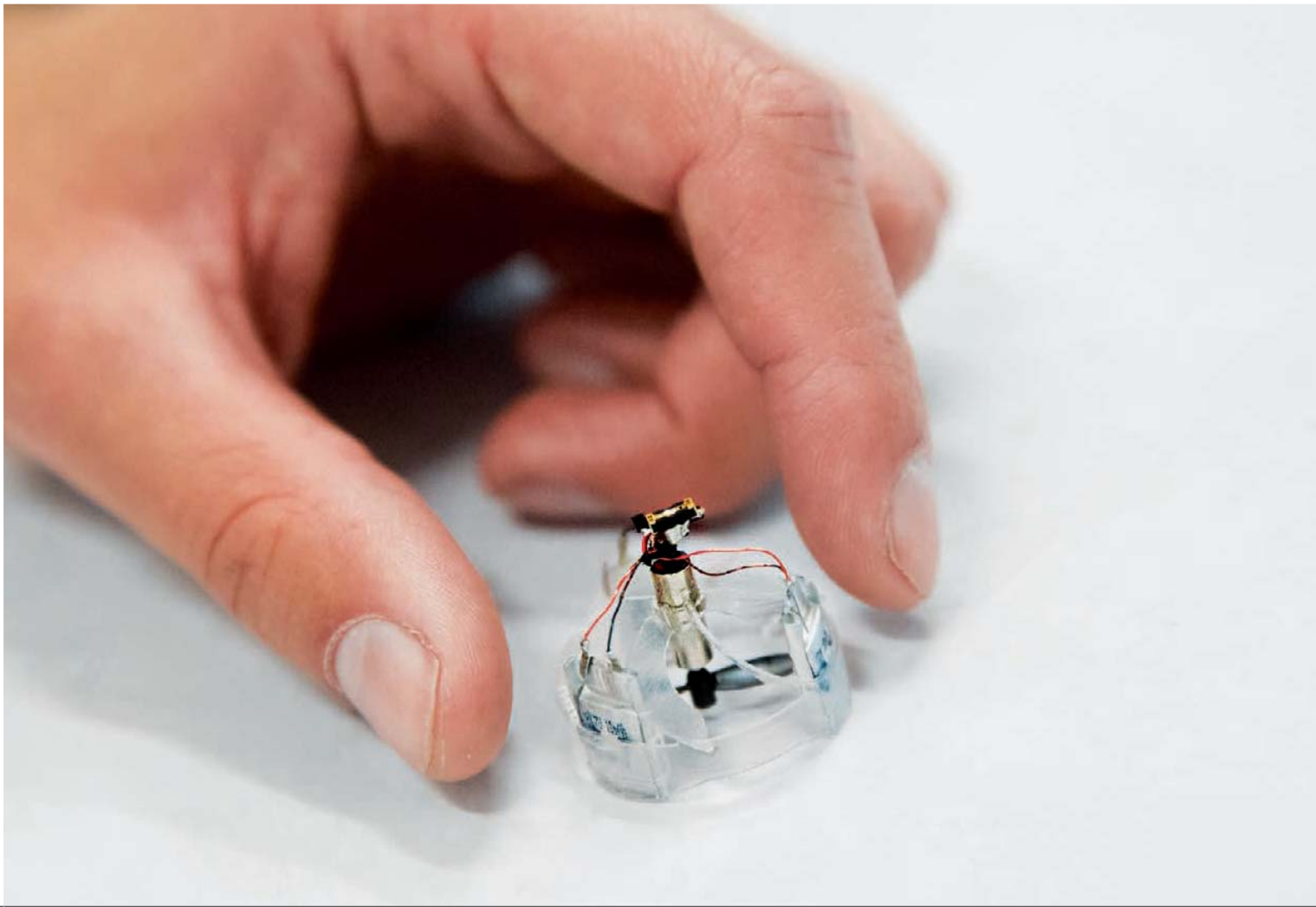
Danny Cabrera (BSE'14) did not spend his weekends like a typical college student. Instead, he and Ricardo Solorzano (BSE'13) holed up in an apartment located above a noisy college bar, and toiled on a Frankenstein-like device that extruded a 3D matrix of living tissue. Once they were satisfied with their creation, Solorzano suggested that they enter it into the 2014 Pennvention investor's competition.

The idea paid off. The duo's team, BioBots, won the \$5,000 grand prize for a 3D printer that can sculpt cell cultures into miniature organs. Like an inkjet printer, 3D printers have a moving nozzle that translates a digital pattern from a computer into a physical object. But instead of using ink, the BioBots printer uses a solution of biomaterials.

Containing living, growing cells and vasculature to feed them, the 3D constructs can serve as

model organs for drug testing and other types of biomedical experiments, offering a humane alternative to animal-based research. In the future, the technology may advance to a stage where fully functional artificial organs could be made to order from a patient's own cells. This breakthrough would hold promise for eliminating the organ waiting list and reducing the risk of harmful immune responses that cause transplant rejection.

At their startup company BioBots, Cabrera (pictured above) and Solorzano are already working on a second-generation version of their printer, and hundreds of scientists in more than 20 different countries are currently using their products. "I am constantly inspired by our partners' research projects, goals and progress," Cabrera says. "They remind me that we are accelerating the pace not only of regenerative medicine, but of human evolution."



*Italian for “tiniest,” Piccolissimo is the world’s smallest self-powered controllable flying vehicle. About the width of a quarter, it is big enough to carry a camera or sensor, and when deployed in the hundreds or thousands, can quickly gather data over a large area.*

## ROBOTS TO THE RESCUE

Imagine hundreds of small flying robots swarming over the site of an airplane crash, searching across thousands of square miles for human remains amidst the debris- and tree-filled landscape. Or a team of robotic weather balloons that can hover low in the atmosphere to monitor man-made and natural disasters, such as gas leaks, fires or nuclear meltdowns. These scenarios may have come a step closer to reality with the introduction of Piccolissimo, the world’s smallest self-powered controllable flying vehicle.

Italian for “tiniest,” Piccolissimo is the brainchild of Matt Piccoli, a doctoral student in Mark Yim’s Modular Robotics Lab (ModLab). The smaller version of the robot weighs less than 2.5 grams and is about the width of a quarter. Yet it is big enough to carry a camera or sensor, and when

deployed in the hundreds or thousands, can quickly gather data over a large area for applications such as search and rescue, disaster relief and agriculture.

The idea for this project only came to fruition because of the unique, cutting-edge equipment and facilities of ModLab, part of the General Robotics, Automation, Sensing and Perception (GRASP) Laboratory, in addition to MEAM’s AddLab, Precision Machining Lab, and the Rapid Prototyping Lab, Piccoli says.

“I also benefited from Penn’s wide range of expertise by taking classes in Mechanical and Electrical Engineering and Computer Science, and in Integrated Product Design as an upperclassman and a graduate student,” he says. “These courses not only helped me perform my research, but also taught me how to make a well-rounded product.”



*A solution to decreasing the amount of time spent on metal fabrication led to the development of WAZER: the first small-scale, low-cost waterjet. It uses an ultra-high pressure stream of water containing abrasive particles capable of eroding through the toughest materials.*

## WELDING WATER IN WORKSHOPS

For Nisan Lerea (BSE'12), a major part of the Penn experience was racing. Along with other members of the Formula SAE team, he designed, fabricated and competed against other schools with small formula-style race cars. He did almost all of the custom metal fabrication in-house, spending hundreds of hours cutting and shaping sheet metal with hand tools.

A solution to decreasing the amount of time spent on metal fabrication arose through his MEAM Senior Design project. With the help of several classmates, Lerea developed WAZER: the first small-scale, low-cost waterjet for Penn Engineering. A few years after graduating, Lerea (above right) and fellow racer Matt Nowicki (BSE'10, above left) quit their jobs to turn the project into a business.

WAZER uses an ultra-high pressure stream of water containing abrasive particles capable of eroding through the toughest materials. The consumer-friendly tabletop tool can cut virtually any material with digital precision, enabling individuals to convert their ideas into finished goods themselves. Applications range from developing drone prototypes, manufacturing signs, and even crafting glass artwork, ceramic pottery and stone sculptures.

“Once we get the initial machines out into the world, we’ll be able to learn from our users what’s most important to them,” Lerea says. “We’ve created a unique tool that enables creativity and independence, and we can’t wait to see what people make with it!” ▾

*By Janelle Weaver*

# Hidden Meanings

## CAN COMPUTERS IDENTIFY GREAT WRITING?

Today, documents on nearly any topic on the web are accessible with a quick search. Type in a few keywords, and a staggeringly complex algorithm combs through data all over the globe in seconds. As far-reaching as these tools seem, they have a few major limitations. While they are great at finding content relevant to a given keyword or phrase, they can't create an accurate summary of a piece's content, explain its tone or intent, or find other subtle meanings that humans can extract at a glance.

"The general problem of search on the web is already solved," states Ani Nenkova, associate professor in Computer and Information Science. "You can find articles on a given topic, but can you find only articles that are inspiring around a topic? Can you find articles that are well written and fun to read?" An ideal search method, she says, would pay attention not only to keywords, but also to deeper layers within a piece of writing. "You'd put in your usual query and then say, 'I'm looking for general information on the topic,' or, 'I'm looking for detailed information on the topic,' or even, 'I'm looking for something that's entertaining,' and through this refine your result," she adds.

From a computer science perspective, this turns out to be incredibly tricky. Narrowing a search by aesthetic preferences means creating software that can "read between the lines" to tease out what words really convey: emotional tone, narrative voice and the overall "quality" of a piece.

That last benchmark may be the most difficult to pin down. Aesthetics and quality are uniquely human ideas and remain so slippery to define that entire branches of philosophy exist to debate them. For a computer program to pick out "great" works,

it would have to take into account the seemingly unknowable essence that makes Nabokov a master storyteller or Carl Sagan a legendary communicator of science—and put that into mathematical terms.

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Nenkova thinks she's coming closer to solving the challenge. Language is, after all, a sort of code and in every code there are distinct and predictable patterns. By looking at enough written material of a specific genre, she says, statistical relationships begin to emerge in word choice and sentence structure, making it possible to sort works by subjective criteria.

### THE RULES OF GREAT WRITING

To test this idea, Nenkova and her former graduate student, Annie Louis, looked at works that are generally considered to be solid, clear and engaging, in the hopes of teasing out the informal "rules" good communicators follow when writing. "Annie and I started by looking at writing and journalism textbooks," Nenkova recalls. "They all say things like, 'make your writing visual,' so we developed a rubric for scoring how visual a given word or topic was." With these textbooks as a guide, she identified a number of rules that are often followed, then used them to analyze more than a decade's worth of science articles in *The New York Times*.





Nenkova compared each of the pieces in the *Times* to a known source of quality work: an annually published anthology called *The Best American Science Writing*. Because pieces are selected for that publication by fellow science journalists, Nenkova reasoned that their judgment would serve as a proxy for “quality” writing in the field. For the purposes of her study, if a piece appeared in the anthology, it was automatically deemed an example of “great” communication. Pieces by the same authors appearing in the *Times* were tagged as “very good,” and all other pieces in the newspaper were graded as “typical” writing. With articles lumped into these three quality “buckets,” Nenkova and Louis began looking for patterns that appeared in the works themselves: the frequency and complexity of words authors used, whether they used folksy colloquialisms, or if they relied on dense academic language, among other factors.

After analyzing hundreds of articles, the findings that emerged surprised her. Authors in each “quality bucket” used visual language—vivid, descriptive words—in predictable patterns. “Typical” writing used the most visual words overall, but “great” writing used those words more judiciously, sticking to specific categories or themes like “landscape” (trees, hills, mountains, lakes), or “shapes” (square, triangle, sphere, and so on). “In writing that stands out, there are fewer visual words but they exhibit a stronger pattern of organization,” Nenkova says. “They appear mostly at the beginning or end of the article rather than uniformly throughout, and stay within one coherent visual topic.” Unusual word combinations like “plasticky woman,” or “anti-spam operations” also appeared often in quality writing, she adds.

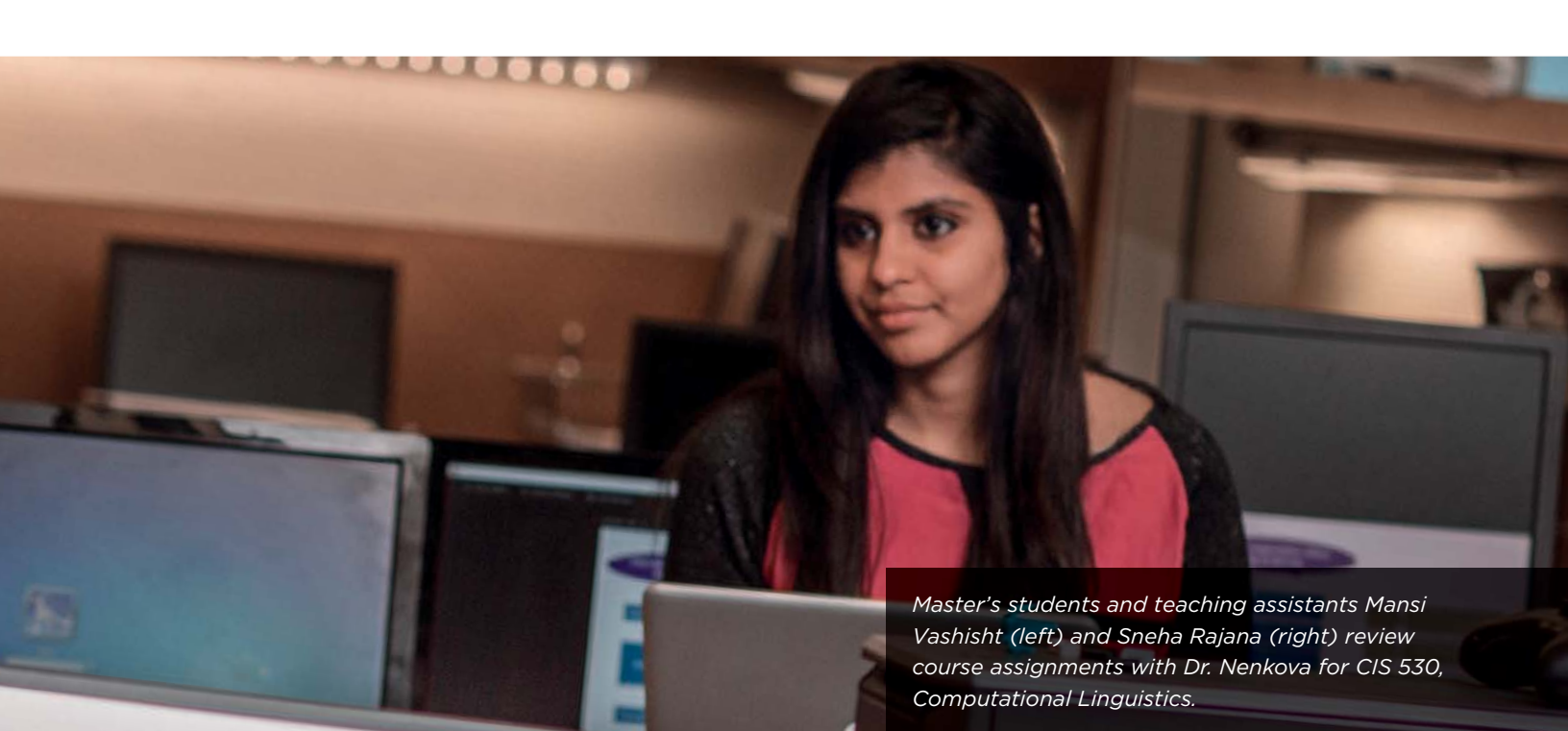
The biggest surprise, however, was that notable writing is lighter on detail than more pedestrian works, and is able to convey complex information without going into the weeds of a particular scientific finding. “It’s a lot easier to get excited about a topic when you’re not buried in the details,” Nenkova says.

Patterns like these are already helping Nenkova, who isn’t simply looking to grade journalistic works. She has her sights set on a bigger goal: uncovering the hidden linguistic “rules” that expert communicators use when writing. Knowing those rules, she notes, could have a far bigger impact than improving a search algorithm. It may actually improve people’s lives.

## A LOSS FOR WORDS

For those with Autism Spectrum Disorder (ASD), communicating with others can be a daily struggle. They may have trouble telling appropriate jokes, understanding sarcasm, or choosing the right tone of voice to use with a boss or a close friend. Ultimately, these communication issues can lead to awkward and even disastrous social interactions, making it difficult to maintain a job or develop a romantic relationship.

Knowing when to use the right level of specificity, and whether to hold back on detail in some instances or add it in others, can be a factor in these exchanges, says Julia Parrish-Morris, research assistant professor of Psychology in Psychiatry at the Perelman School of Medicine and scientist at the Center for Autism Research at CHOP, who is currently collaborating with Nenkova.



*Master's students and teaching assistants Mansi Vashisht (left) and Sneha Rajana (right) review course assignments with Dr. Nenkova for CIS 530, Computational Linguistics.*

"The idea of language specificity is what really intrigued me about Ani's work," she says. "If, for example, you're talking to someone who knows a lot about the educational system, it makes sense to be very specific. But the decision about how specific to be calls on you to understand someone's history and perspective, and to calibrate your level of interaction for that person." That ability, she says, can be elusive for her ASD patients.

## NENKOVA HAS HER SIGHTS SET ON A BIGGER GOAL: TO UNCOVER THE HIDDEN LINGUISTIC "RULES" THAT EXPERT COMMUNICATORS USE.


Teaching computers to identify clear communication might lead to software that helps people with ASD on a daily basis, such as a tool that offers subtle reminders of the right tone or specificity to use with a given audience, steering users through delicate social situations.

## INFORMATION WITHOUT BORDERS

Difficulties in creating good communication aren't limited to people with autism. Most of us at one point or another have struggled to be understood by our peers, even Nenkova herself. "I always liked reading books, but I was a terrible writer," she admits. "I really wanted to know how great writers were able to move me."

As a computer science professor, she's starting to pick apart that question logically, and is helping students do the same. In the past, some of her undergraduates have adapted her tools to look at their own work, creating software that could gauge the clarity of their writing in real time. Others, like doctoral student Jessy Li, who will graduate in May, have applied Nenkova's techniques to other languages, and are attempting to characterize good writing in Chinese as well as English.

Since every language and every culture has a different definition of how "quality" text should be organized, Nenkova and her students have their work cut out for them. "A Chinese person will have totally different interests when it comes to writing," states Nenkova. "What does it mean to say what's representative for that culture? We need more emphasis on understanding subpopulations to really tell." The internet has no real borders, she notes, and a single search can turn up countless webpages in other languages, so being able to identify hidden traits that resonate with a given culture may help ease the spread of ideas worldwide. Although recognizing quality writing in other cultures is a tall order, she's confident that the idea is gaining momentum.

"We're making real progress with predicting text quality and style," Nenkova says. "When I first started studying it several years ago, there was hardly anyone else working on the problem, and now it's getting a lot more active. It's amazing." 

*By David Levin*

*Access Engineering instructor Jared Cepollina demonstrates the use of an Arduino microcontroller to drive servo motors.*





# Access Engineering

## Expanding Interests, Inspiring Leaders

In order for the U.S. to remain globally competitive in technology and innovation, widening the pipeline of incoming engineers is critical. Despite booming numbers of education initiatives in STEM (science, technology, engineering and math), many students across the country continue to graduate from high school without a real grasp of the field of engineering or its career opportunities. This gap is particularly wide in rural and urban areas where STEM's more costly educational resources can be harder to provide.

A number of Penn Engineering students identified this area of need and formed Access Engineering, allowing high school students throughout Philadelphia to experience firsthand what it means to major in engineering. Initiated in 2014 with a pilot program of 20 high school students, today the program boasts nearly 80 participants each semester and has provided more than 300 total students with the opportunity to explore the applied sciences, participate in specialized courses, and be exposed to Penn's revolutionary laboratories and equipment.

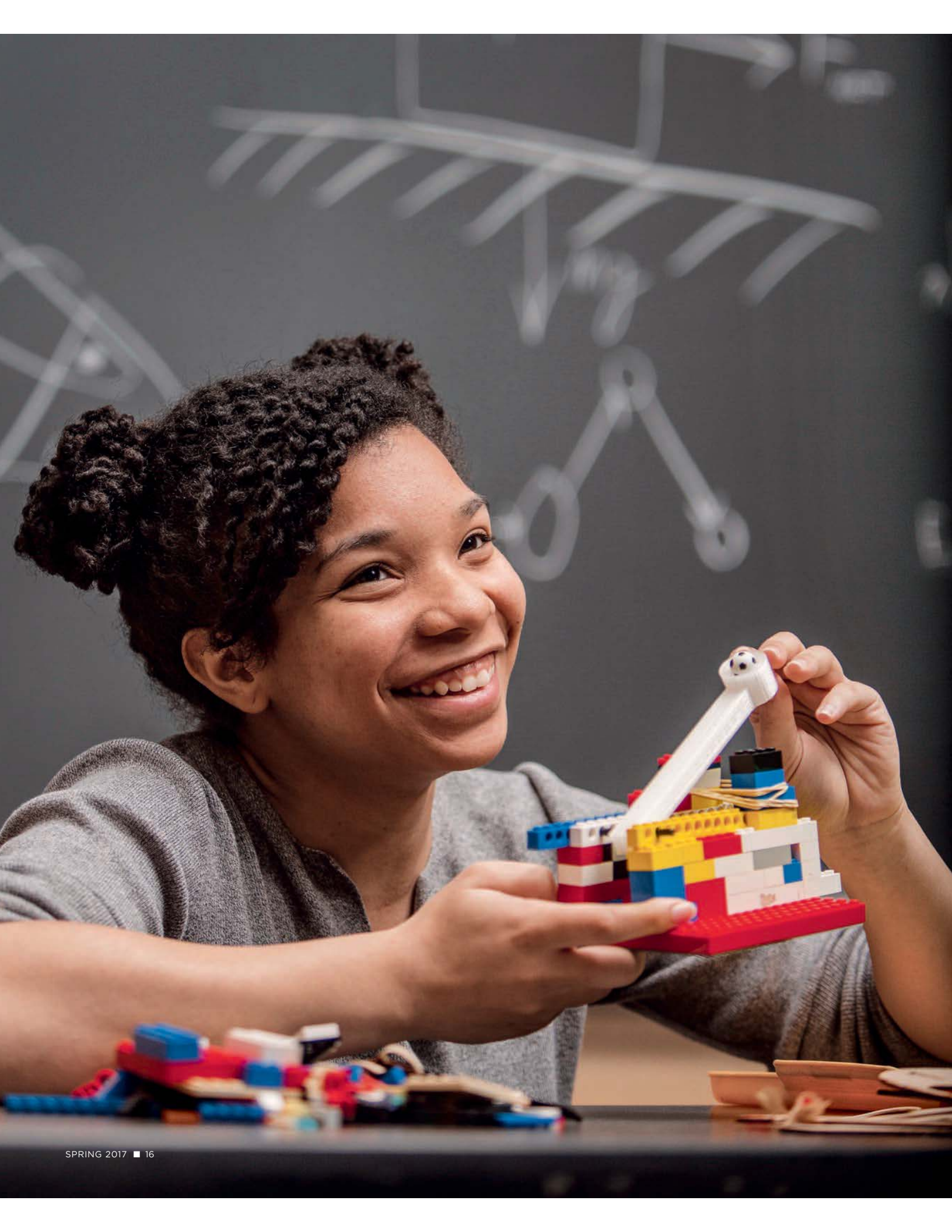
"We have a very strong commitment to serving the Philadelphia area," states Kyle DeLuca, current president of Access Engineering and junior in Chemical and Biomolecular Engineering. "We want to target schools that might not be able to expose students to the full breadth of engineering and to what being an engineer really involves. We feel that it's very important for these students to know that becoming an engineer is an option that is truly open to them."

### COMMUNITY ACTION

Since its inception, Access Engineering has worked closely with schools including Northeast High School, Central High School, Julia R. Masterman School, and George Washington Carver High School of Engineering and Science (HSES) to recruit students interested in careers in STEM fields. As of the current academic year, Access Engineering has grown to offer eight-week sessions during both the fall and spring semesters, where participating students gather in the Penn Engineering complex for three hours each Saturday. Upon completion of their first session, many students opt to attend a second semester in order to receive more advanced instruction.

IT'S VERY IMPORTANT FOR STUDENTS TO KNOW THAT BECOMING AN ENGINEER IS AN OPTION THAT IS TRULY OPEN TO THEM.

"I think hands-on labs with real-time equipment and the opportunity to experience a university campus encourage people to go to college," says past president Kaylin Raby, a junior in Systems Science and Engineering. "That is the main value of our program, to give a glimpse at what it would be like to be an engineering major and just how much fun it really is."



*Building on previous lessons that explored mechanical engineering concepts and CAD software, this Access Engineering participant is constructing and testing her combined LEGO and 3D-printed catapult.*

Begun by William Mannherz (BSE'16) and Rahul Gupta (BSE'16), Access Engineering is now the largest community service club at Penn Engineering. Thanks in large part to DeLuca and Raby, the organization has grown to more than 30 active Penn student volunteers, and was honored with the 2016 Engineering Student Activities Council (ESAC) Club of the Year distinction.

## ENGINEERING ILLUMINATED

Currently, each eight-week session encompasses exercises from across a number of Penn Engineering's undergraduate majors, teaching methods that can be applied to fields such as bioengineering and nanoscience. The student teachers brainstorm lessons from their own classroom experiences and create assignments for each of the workshops.

ACCESS ENGINEERING EXISTS TO INSPIRE AND ENERGIZE HIGH SCHOOL STUDENTS, EXPOSING THEM TO THE FULL BREADTH OF ENGINEERING AND WHAT BEING AN ENGINEER REALLY INVOLVES.

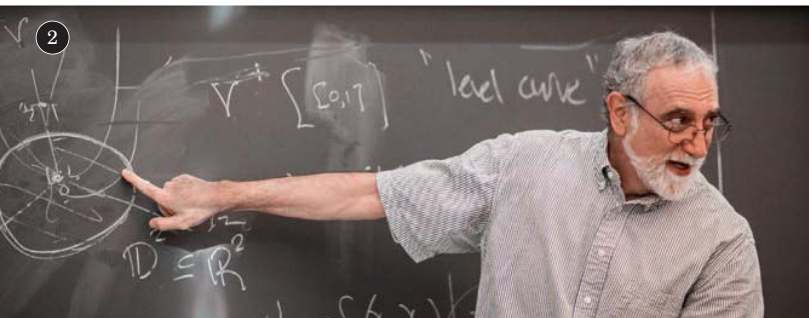
One of DeLuca's favorite assignments for the students involves mechanical engineering concepts and using a computer program called SOLIDWORKS to design a 3D-printed catapult. Once the arm of the catapult is printed, students

attach it to a base they design using LEGO bricks, and they compete against their peers to see who created the best arm and catapult, and who can fling the object farthest. As he explains, "It shows the students that they can understand and implement engineering ideas and that they can be successful."

A senior at Northeast Magnet High School, Gina Lepore's favorite part of the program was learning to use design software. After completing the Access Engineering program, Lepore decided to apply to Penn, was accepted and will begin as a freshman in the fall. She plans to major in Biology with a pre-med track in the College of Arts & Sciences and would like to take a class or two in coding. "My decision to go to Penn was strongly influenced by the program," Lepore recalls. "I saw how diverse the campus is and how well the students work together."

Access Engineering exists to inspire and energize high school students like Lepore. Because it is a relatively recent endeavor, the effects of these motivated Penn Engineers and the students they are able to connect to engineering can be difficult to quantify in a chart or spreadsheet. But whether they are a Penn student passing the torch or a high school student thinking about a future in technology, they are each playing a part in making the future one where engineering is accessible to anyone who possesses the curiosity, drive and desire to make the world a better place. ♥

*By Liz Connolly Bauman*



# On Our Camera Roll



**1.** Steady concentration and focus direct this study session. **2.** Professor Daniel Koditschek clarifies a point in ESE 512, *Dynamical Systems*. **3.** Mechanical Engineering undergraduate Ilana Teicher prepares to mill a part for her Senior Design project in the Precision Machining Lab (PML). **4.** Comfortable benches in the Towne Building make for impromptu study spaces. **5.** Captured from the mezzanine view of Levine Hall, a cyclist is seen arriving for a day in the lab.



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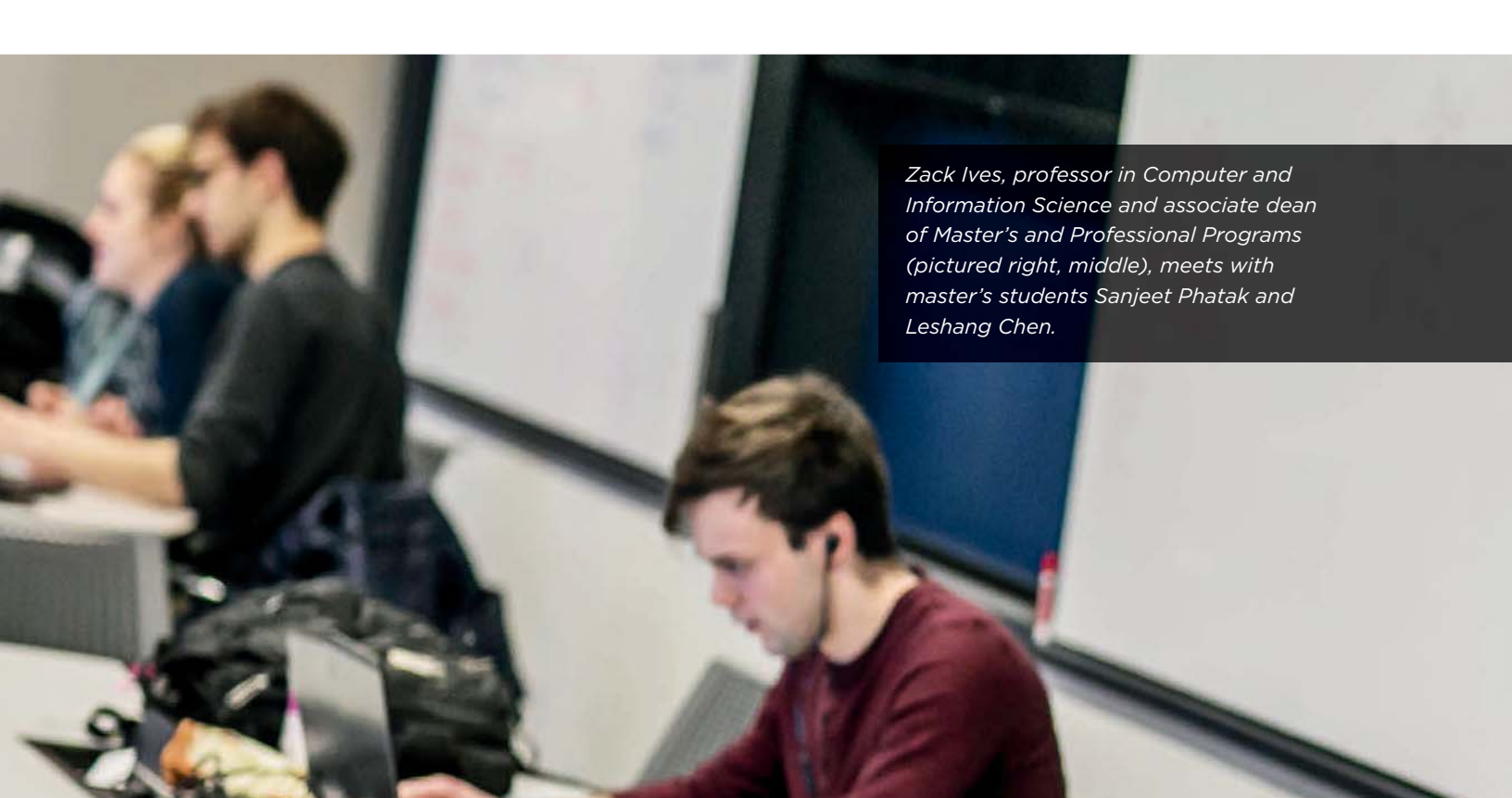


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**6.** The Cyber Café offers snacks, drinks and a chance to connect with friends. **7.** Researchers fabricate biosensors in the Singh Center for Nanotechnology. **8.** Turner Topping, doctoral student in the Kod\*lab at PERCH, attaches legs to the Minitaur robot. **9.** Graduate student Emily Tess performs cell culture in the Huh lab. **10.** Senior Lecturer Bruce Kothmann confers with students on a simulation model of a smart highway system in the Forman Active Learning Classroom.



*Zack Ives, professor in Computer and Information Science and associate dean of Master's and Professional Programs (pictured right, middle), meets with master's students Sanjeet Phatak and Leshang Chen.*

# Building Community

## The Master's Program at Penn Engineering

Understanding data and how to analyze it uniquely qualifies Zachary G. Ives, professor in Computer and Information Science, for his new role as Penn Engineering's associate dean of Master's and Professional Programs. By applying a methodical, analytic approach to understanding the student pathway from the application process to career placement to the alumni experience, he intends to implement curriculum improvements and enhance professional development for students in the program's 15 master's degrees. His goal is to maximize their experiences while they are enrolled at Penn and after they graduate.

Key to his data collection is one simple question: Why Penn? "I want to understand the various prospective, enrolled and alumni constituencies in order to tell a story, and to understand and creatively consider the enormous resources available across the University and how those resources can enhance our program," says Ives.

Ives' approach is already beginning to bring about change. For matriculated students, Ives has initiated networking opportunities with alumni. This interaction lends a new and invigorating coherence to

both the individual degrees and the entire cohort of enrolled master's students. In working to establish this "broader Penn network," Ives is confident this process will create opportunities for mentorship and connections that enhance each student's experience.

"In addition to support centered in the degree offerings, strengthening the cultural experience for enrolled students, especially those from outside the country, is also an important focus of what we want to do," Ives states. "Students often need to be coaxed out of their comfort zones. It can be easy for them to interact primarily with members of their own culture or they can get into the habit of being isolated, concentrating only on their coursework. We need to make opportunities for students to come together and build a community because ultimately this is how they will find the working world."

As a leader in network and data science research and an award-winning teacher, Ives also understands the importance of considering market demand. In addition to exploring opportunities to improve the program's existing degrees and




enhancing the student experience, Ives is working with fellow faculty member Susan B. Davidson, Weiss Professor in Computer and Information Science, and others to develop a new master's degree offering in Data Science. The development of the new degree has brought together colleagues from Wharton's Statistics program, from Mathematics and from each of the Penn Engineering disciplines.

**WE NEED TO MAKE OPPORTUNITIES FOR STUDENTS TO COME TOGETHER AND BUILD A COMMUNITY BECAUSE ULTIMATELY THIS IS HOW THEY WILL FIND THE WORKING WORLD.**

The Data Science degree will feature an umbrella of core coursework in information science, but the degree's distinction will lie in customizable sub-specializations of enormous utility in fields where a deeper understanding of big data is critical, such as medicine, the social sciences

or linguistics. Ives expects the program will cross existing boundaries of various disciplines at Penn, and eventually in the hundreds of global industries already well represented by Penn master's program alumni, who work at major companies in fields as diverse as the 15 individual degrees.

Several years ago, during a sabbatical at Google in New York City, Ives was pleasantly surprised to encounter several Penn alums throughout the company. "I was impressed by how these graduates identified with Penn Engineering," he recalls. "Some had graduated from Penn years ago, but they remembered me, remembered their coursework and the community very fondly. I knew we could build on that."

Zachary Ives aims wide, but he leaves little to chance. Penn Engineering master's and professional students will find themselves well served by his mix of enthusiasm, vision and creativity which is thoroughly grounded in a dynamic, objective understanding of the program and how to guide it to even greater levels of excellence. 

*By Mark West*



# Engineers as Artists

If Penn students were asked in a random campus survey to describe their individual skillsets and learning styles as either “left brain” (analytical, qualitative) or “right brain” (artistic, intuitive), the majority would most likely answer by naming one cerebral hemisphere or the other. An exceptional and talented few would be able to reply, “both.”

Penn Engineers Sarah Organ, Ryan Solomon, Arjun Shankar and Emily Peters (pictured from left) are members of this unique cohort. Their range of talents and how they express them should not be surprising. Together, they show that engineers are fundamentally creators, whether they are developing the next biomedical or nanotech devices, or using their voices to sing or bodies to dance.





## INVITATION OF A LIFETIME

**Arjun Shankar**, senior in Bioengineering and a tenor with the Penn Glee Club, describes the energies he dedicates to both his studies and to his practices and productions with the 155-year-old club as “feeding all parts of his brain.” In past years, as student music director and a board member of the club, Shankar’s time commitment was close to ten hours a week. He currently spends at least seven hours a week practicing. And then there’s the traveling.

Shankar counts singing The Lion King’s “Circle of Life” at the top of Mount Kilimanjaro during the club’s 2014 Spring Tour as his favorite Glee Club memory, but performing at 1600 Pennsylvania Avenue in Washington, D.C. that same year easily ranks a close second. Having greeted 700 or so guests with a song at the annual White House Holiday Party, the club members received the surprise invitation of a lifetime: Would they meet with and perform privately for the President and First Lady? With a unanimous “Yes!” Shankar and the others soon found themselves in the Diplomatic Reception Room, shaking hands with President and Mrs. Obama and singing a short set of songs for their entertainment.

In his recent application for a Fulbright Scholarship, Shankar proposed a research concentration that would even more strongly connect his work in bioengineering with his love of singing. He intends to investigate the physiology of vocal production in both Indian pop and the Hindustani and Carnatic classical music traditions of India.

## ALL ABOUT THE BLEND

**Emily Peters**, music director for the Quaker Notes, the University's all-female a cappella group, is another engineering student who finds creative expression through song. At tryouts early in the fall of her freshman year, Peters, still somewhat unfamiliar with the Quaker Notes' culture, had reservations about joining. The possibility of the environment proving to be overly competitive or at worst harshly critical and a distraction from her studies concerned her. But throughout the requisite three rounds of auditions, which she successfully completed, Peters was relieved to discover that quite the opposite was true.

Group singing without instrumental accompaniment is all about "the blend," and blending requires active listening and self-correcting. And while these concepts refer musically to voice parts, they can also be applied to the personalities of the members. Peters, an alto, found the 13 other singers to be collaborative, supportive and dedicated to the group's sound.

A junior majoring in Chemical and Biomolecular Engineering, Peters works with the Quaker Notes for three hours, two days a week, but points out that practice can take place anywhere. Should one observe, for instance, any young woman emitting vocal percussive and rhythmic sounds as she makes her way across campus, she is most likely a "QNote."

Throughout the past few years, Peters has learned and performed more than 60 songs with the Quaker Notes and now creates her own arrangements using an online program called "Noteflight." She has gained experience as a leader within the group, and finds that singing and performing keeps her stress levels down. She is also strongly connected socially to the group, meeting up for dinners and evenings out, often along with singers from the Pennchants, the Quaker Notes' "brother" group.





## DEDICATION AND DISCIPLINE

**Sarah Organ**, Sparks Dance Company (SDC) artistic director, is a Computer Science major who chose to submatriculate into the Systems Engineering master's program. SDC, founded at Penn in 1989 to incorporate dance performance with community service, is another close-knit performing arts group on campus.

The 12-member SDC performs in a range of dance styles, including ballet, modern, jazz and hip-hop. Members choreograph their own dances and produce on-campus shows in the spring and the fall. SDC can also be seen performing throughout Philadelphia, sharing their art with audiences at the Ronald McDonald House and Salvation Army.

Trained as a dancer since the age of 3, Organ has long been familiar with the dedication and discipline intrinsic to success as a performance artist. Each week, she attends a one-hour technique class, taught by professional jazz and ballet instructors, and an additional nine hours of rehearsals. (She also puts in 24 hours a month with Philadelphia's Medical Emergency Response Team (MERT), but that's for another story!)

Along with the edifying artistic interaction with her peers, Organ feels that she benefits mentally from her SDC activities. Her ability to think critically, she asserts, has been enhanced by the memorization, pattern recognition and attention to detail required in dance performance. The design of a dance presents a series of puzzles with a multitude of possible answers for the dancer, and Organ has found that her problem-solving skills have been honed through her art. Her ability to bring self-expression to an audience has given Organ a self-confidence that ultimately informs her academic and extracurricular pursuits.

## CREATIVITY AS CORNERSTONE

**Ryan Solomon**, a member of the University's venerable Mask and Wig Club, was 8 years old and at summer camp when he made a life-shaping decision he remembers with great clarity. Presently a candidate for a Master of Science in Engineering in Mechanical Engineering and Applied Mechanics, Solomon was presented with the choice between two camp activities: playing soccer or putting on a play. While most of his friends gravitated to the soccer pitch, Solomon stepped into the unknown, making the choice he now recognizes as seminal: the stage.

Solomon, who understandably finds it a point of pride to have never "pulled an all-nighter," dedicates 15 to 25 hours per week to Mask and Wig, and this significant commitment has afforded him the opportunity to direct, write and perform. As director of the Freshman Fall Free Show for the past two years, Solomon and the 19-member club sang, tapped and played to a packed house at the Annenberg Center's Zellerbach Theater. In the spring, they take their Annual Show on the road, using a script developed by club writers which is professionally directed and choreographed.

Solomon sees creativity as the "cornerstone of engineering" and notes a strong correlation between his Mechanical Engineering concentration in product design and his theatrical background in script writing. "Both require ideation and iteration through the creative process," he explains, "with the intent of developing a deep emotional bond to the audience." 🍷

*By Patricia Hutchings*



# Rajeev Misra

Invest. Accelerate. Disrupt. Repeat.

Few people possess Rajeev Misra's power to profitably disrupt the global economy.

As leader of the new \$100 billion SoftBank Vision Fund, Misra is rapidly making unparalleled investments in technology and telecommunications companies, accelerating breakthroughs in artificial intelligence, robotics, miniaturization, machine learning and the connectivity of everyday objects.

"We aspire, along with Google, Apple, Facebook, Amazon and Alibaba, to push the boundaries of the technological revolution," says Misra (ME'85, GEN'86). He's tasked with fully investing the fund, launched in 2016, within five years. "Most large venture capital firms, such as Sequoia Capital, take a year or two to invest a billion dollars. By comparison, our fund's average investment has to be a couple of billion dollars each year. There is no one like us who can write that kind of investment today."

**YOU CAN'T STOP INNOVATION. YOU HAVE TO CONTINUALLY EDUCATE YOURSELF, OTHERWISE YOU WILL BECOME REDUNDANT AND OBSOLETE.**

"As the world becomes more highly connected with faster processing power, greater telecommunications capacity and artificial intelligence, a lot of white collar jobs that require human intelligence will soon be done by computers," says Misra. "This is all happening over the next 5 to 10 years and will be disruptive for society. By comparison, the first Industrial Revolution, which began in the 1760s,

lasted 60 to 80 years. People had time to adapt." He expects the current era of career displacement to begin with driverless, autonomous cars and to very soon affect jobs in fields like medicine, law and accounting.

## CAUTIONARY PERSPECTIVE

A member of Penn Engineering's Board of Overseers, Misra offers a cautionary perspective on how these changes may likewise transform engineering education and careers. He sees strategic opportunities for Penn Engineering to refine its curriculum to strengthen core skills for long-term career agility, serve alumni needs for continuing education and address a likely social backlash against technology.

"You can't stop innovation," he cautions. "You have to continually educate yourself, otherwise you will become redundant and obsolete. Penn Engineering gave me a great running start. It's an amazing engineering school where you can round out your academic experience at Wharton and in the liberal arts; that's important because the world of tomorrow is about connecting the dots."

Misra reads voraciously as he travels the globe from his home in London to evaluate investments, meet with investors and recruit employees. He plans to double the fund's 100-person staff within 18 months. Many will be engineers. "I'm biased. This is a technology and telecommunications fund so by definition you need to know the domain," says Misra. "When I hire, what I really look for is the hunger: where they come from, where they are today and how passionate they are about where they want to go."



*"We aspire, along with Google, Apple, Facebook, Amazon and Alibaba, to push the boundaries of the technological revolution," says Rajeev Misra, leader of the new \$100 billion SoftBank Vision Fund.*

His own trajectory began when he left his New Delhi home for undergraduate and graduate engineering studies at Penn, followed by an MBA at MIT's Sloan School of Management. He then held successive leadership positions at Merrill Lynch, Deutsche Bank and UBS, and joined the publicly-held SoftBank Corp of Japan in 2014, where he reports to Masayoshi Son, founder and CEO.

**WE'RE INVESTING IN TECHNOLOGY AND TELECOMMUNICATIONS TO LEVERAGE THE NEXT 10 YEARS OF THE TECHNOLOGICAL REVOLUTION.**

Today, Misra spends his precious free time with his wife, Shalini, an architect, interior designer and real estate developer, who also grew up in New Delhi. "I don't have many hobbies," he quips, noting they enjoy time with friends and going to movies.

## LEVERAGING THE REVOLUTION

It takes sophisticated research, analysis, foresight and more than a little courage to challenge market assumptions. These days Misra carefully scrutinizes emerging technologies and changing market dynamics to find ways to successfully achieve the Vision Fund's target of an annualized internal rate of return of 25 to 30 percent. "We're investing in technology and telecommunications to leverage the next 10 years of the technological revolution. We're also looking at ways SoftBank can help these companies grow through our global reach as we share and leverage technology, expertise and presence in global markets," he says.

As for the fund's possible global economic impact, Misra notes, "Our first responsibility is to provide returns for our investors. The rest will fall into place." 🍷

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*By Jessica Stein Diamond*



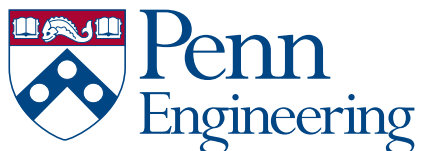
# Partners for the Future

The Penn Engineering we know today was shaped, in part, by past generations of alumni, parents and friends who envisioned themselves as partners in the School's exciting future. Today, we offer you the opportunity to join this philanthropic tradition through a planned gift.

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**NEW FACULTY**

**Vincent Liu**, *Assistant Professor, Computer and Information Science*  
Ph.D. in Computer Science, University of Washington

Dr. Liu's research is in the general area of networked systems and bridges all layers of the networking stack, from hardware concerns to application and user demands. Within computer networking, he has published in a variety of fields including data center networks, fault-tolerant distributed systems, energy-efficient wireless communication, and systems to preserve security and privacy.



**HONORS & AWARDS**

**Brian Chow**, *Assistant Professor in Bioengineering*, was a recipient of an NSF CAREER Award for his proposal, "Establishing Novel Signaling Transmission Modes of LOV Photoreceptors." This award is the NSF's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research.

**Nadia Heninger**, *Magerman Term Assistant Professor in Computer and Information Science*, was a recipient of an NSF CAREER Award for her proposal, "Cryptographic Security at Internet Scale." This award is the NSF's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research.

**Sanjeev Khanna**, *Henry Salvatori Professor in Computer and Information Science*, was a recipient of a Lindback Award for Distinguished Teaching. The Lindback Awards were established in 1961 with the help of the Christian R. and Mary F. Lindback Foundation. They are the most prestigious teaching awards given by the University of Pennsylvania.

**Daniel Koditschek**, *Alfred Fitler Moore Professor in Electrical and Systems Engineering*, was the recipient of the 2016-17 George H. Heilmeier Faculty Award for Excellence in Research for his "pioneering contributions in robot motion planning and legged locomotion." The Heilmeier Award honors a Penn Engineering faculty member whose work is scientifically meritorious and has high technological impact and visibility.



Brian Chow



Nadia Heninger



Sanjeev Khanna



Daniel Koditschek





**Cynthia Sung**, *Gabel Family Term Assistant Professor, Mechanical Engineering and Applied Mechanics*  
Ph.D. in Electrical Engineering and Computer Science,  
Massachusetts Institute of Technology

Dr. Sung's interests focus on computational methods for design automation of robotic systems, with research at the intersection of computational geometry, data-driven methods, and rapid fabrication techniques such as 3D printing and origami-inspired assembly. She aims to provide intuitive computer-aided design tools for creating customized robots and behaviors by developing techniques for representing, modeling, simulating, and fabricating these designs.



Amish Patel



George Pappas

**George Pappas**, *Joseph Moore Professor and Chair of Electrical and Systems Engineering*, was a recipient of the Provost's Distinguished Ph.D. Teaching and Mentoring Award. This award is presented by the University of Pennsylvania to standing faculty members for their distinguished teaching and mentoring of doctoral students.

**Amish Patel**, *Reliance Industries Term Assistant Professor in Chemical and Biomolecular Engineering*, was a recipient of a 2017 Sloan Foundation Fellowship. Since 1955, the Alfred P. Sloan Foundation has granted yearly fellowships to early-career scientists and scholars whose achievements and potential identify them as the next generation of scientific leaders. Dr. Patel was also a recipient of an NSF CAREER Award for his proposal, "Computational Characterization of Protein Hydration and Interactions."



Alejandro Ribeiro



Victor Preciado

**Victor Preciado**, *Raj and Neera Singh Term Assistant Professor in Electrical and Systems Engineering*, was a recipient of an NSF CAREER Award for his proposal, "Scalable Algorithms for Spectral Analysis of Massive Networked Systems." This award is the NSF's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research.

**Alejandro Ribeiro**, *Rosenbluth Associate Professor in Electrical and Systems Engineering*, was a recipient of a Lindback Award for Distinguished Teaching. The Lindback Awards were established in 1961 with the help of the Christian R. and Mary F. Lindback Foundation. They are the most prestigious teaching awards given by the University of Pennsylvania.

# Andy Rachleff

Hardwired to Give Back



Ask Andy Rachleff (W'80, MBA Stanford) how he manages his time so well and he'll tell you it simply comes down to doing what you love. For Rachleff, that means sharing innovative ideas and aligning himself with good people to make those ideas work, whether it's in venture investing or in supporting Penn and Penn Engineering.

"I feel fortunate to be able to contribute in many meaningful ways," he says. "I wouldn't have the amazing life I have if it weren't for my education at Penn. To be part of a group that is passionately devoted to making Penn Engineering an international center for innovation and excellence is beyond exciting." This spring, Rachleff will step down from his role as chairman of the Penn Engineering Board of Overseers after a 10-year term.

***What were some of the highlights of your term as chairman?***

I feel fortunate and honored to have been able to work closely with two deans: Eduardo Glandt and now Vijay Kumar. Eduardo focused on strategy, enabling us to enhance our faculty and build three amazing buildings. Vijay is now building on that foundation, growing the faculty and driving innovation.

***Was your involvement with the University a natural step?***

It was, but I was highly encouraged by former Trustee Dave Pottruck. He sat me down one day and said, "You owe it to your university to give back!" Now I give that speech to others. After my term is complete, I'll remain a member of the Board of Overseers, a Trustee of the University and will take on the chairmanship of Penn's Endowment Investment Committee.

*Overseer chair Andy Rachleff at the Board of Overseers meeting at the Pennovation Center on March 16, 2017*

***What is your new venture, Wealthfront?***

Wealthfront makes it possible for everyone to access investment services that were traditionally only available to the very wealthy. Our service is targeted at people under 40 who prefer to manage everything in their life digitally and cost effectively. Interestingly, the idea for Wealthfront was actually inspired by my involvement with the Penn Endowment Investment Committee.

***What is a theme for you in business and leadership?***

I'm a big believer in the Golden Rule: Treat others the way you want to be treated. I believe in applying it in every aspect of my life. It's what helped me start Benchmark and Wealthfront and it drives everything I do.

***Any words of advice for your successor?***

I'd encourage Rob Stavis to continue to be as supportive as possible of the dean and focus on recruiting great Overseers. The success we have had is attributable to a Board that is passionate about Penn Engineering. I know Rob is going to do a great job. 🍷

*By Amy Biemiller*

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## INSPIRING ENGINEERS

Penn Engineering manages 200 FIRST LEGO robotics teams and the competitions in the Southeast Pennsylvania region each year. Here, members of team "Robotic Waffles," comprised of students from Hillendale and Pocopson Elementary Schools in Chester County, visit Penn Vet's Swine Teaching and Research Center to gather information for this year's challenge: Animal Allies. After their trip, the young roboticists decided to improve upon the pigs' living quarters by pushing mats into flooring slats (where hooves sometimes become caught) and developing a robot to clean the pens.



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