Societal Engineering Fund
2017–2018

A report to our investors

Moving society forward
Confidence
Impact

design
innovative mindset
proof of concept
Impact

Interdisciplinary
quality of life
Public health

Practicality
prototype
real-world problems
FROM THE DEAN

Boston University Creating the Societal Engineer®

Thanks to your generous support, several extraordinary student programs were partially or completely funded this year through the Societal Engineering Fund. They are: the Societal Impact Awards, including the PhD Thesis Awards; the Senior Design Project Awards; the Technology Innovation Scholars Program; the Technology Innovation Concentration; the Imagineering Competition Awards; and Engineers in the Real World.

It is only with your help that BU’s College of Engineering is able to educate Societal Engineers—citizens who will use their powerful quantitative and creative problem-solving skills to succeed at any career path they choose in order to address society’s challenges and improve the quality of people’s lives. Among our Societal Engineers’ many attributes are a facility for systems-level thinking and working in cross-functional teams, a global awareness, an appreciation of diverse cultures, and a deep understanding of how an innovation ecosystem works.

Together, these skills and qualities prepare our engineers to embrace lifelong learning and foster a passion for continued impact.

The award-winning projects and societally focused programs in these pages attest to the power of the college’s dual commitment. Thank you again for helping to make these student successes possible.

Sincerely,

Kenneth Lutchen
Dean

Cover:
Dean Kenneth Lutchen (far left) and Solomon R. Eisenberg, senior associate dean for academic programs (right), celebrate with award-winning College of Engineering students.
OVERVIEW: SOCIETAL IMPACT AND SENIOR DESIGN PROJECT AWARDS

“While working on the senior design project, I learned so much about the design process, from initial concept to testing. The experience reaffirmed that I want to use my engineering skills in the medical field to help people who are born with a disease or who have some type of health issue. My aim is to have a direct impact on people’s lives.”

Eric Gerard Rapp (ENG’18), co-recipient of the first-place Societal Impact Award for “Development of an Efficient Method for Integrating Bioprosthetic Valves and Stents,” a simple, rapid method to facilitate custom valve assembly in the operating room for pediatric heart patients.

“Going through the full product development cycle for our senior project was invaluable. We had to figure out what technologies to use and how to build our solution from the ground up—the hardware, the mechanicals, the back-end server, and the front-end maps. These were all black boxes to us in the beginning.”

Reetpragya Chowdhary (ENG’18), co-recipient of the ECE Senior Design Project Award for “COMPOS,” a system that keeps patients with dementia safe by enabling a facility’s caregivers to track them effectively.

Those are just two of the comments from the winners of this year’s Societal Impact and Senior Design Project Awards on how their capstone engineering projects influenced their focus, their direction, and their lives.

The other four winning projects were:

“Water Efficiency Recirculator,” a recycling system that reduces freshwater usage in brewing beer with a filtration system that removes excess biogases from wastewater produced in the brewing process and a temperature control system that maintains the appropriate temperature of the recirculating water (second-place Societal Impact Award).

“Healthy Hands Handwashing Monitoring System,” a device that advances the capabilities of Tippy Taps—simple handwashing stations that don’t require running water—by automatically tracking the number of handwashing events with soap to improve the handwashing rate among students in Ghana (third-place Societal Impact Award).

“Contributions of Geometry and Tissue Properties to Whole-Bone Strength,” an investigation, using mouse cortical bone, to optimize a mathematical method used to determine bone stiffness by considering the true geometry of the bone along its length, with the aim of allowing future researchers to determine if different genotypes and drug treatments affect bone strength (Outstanding Senior Design Project in Biomedical Engineering).

“Rocket Engine Piston Pump Prototype,” a novel type of piston pump that can increase launch vehicle efficiency and reduce the cost of getting to space, complete with a numerical simulation toolbox and a study of the technology’s use in the launch market (Outstanding Senior Design Project in Mechanical Engineering).

The projects shared the exemplary traits of taking an innovative approach to a real-world problem, integrating parts that operated seamlessly as a whole, and making an impact both in their given fields and on their users’ quality of life.
Societal Impact Awards

Third Place: Healthy Hands Handwashing Monitoring System

A large container of water attached to a pole, a bar of soap looped on a string, and a foot pedal to set the system in motion. Can such a simple device, called a Tippy Tap, help improve public health in developing countries where running water is scarce?

Yes, it can, particularly with the advances integrated into the technology by the ENG team that created the “Healthy Hands Handwashing Monitor System.”

For their client, the Emerson Engagement Lab, which works closely with UNICEF Ghana, the BU students set out to automate the tracking of a Tippy Tap’s use: Which people used soap and how much? Which people used just water? In both cases, how much water was dispensed per session?

Why does all of this matter? Using soap and adequate water are critical for reducing bacterial transmission.

“The problem was that UNICEF researchers had to be physically present to record this data,” says team member Anthony Pasquariello (ENG’18). “They would watch thousands of hours of videos of kids washing their hands and then manually mark down whether they used soap or just water. The process was inefficient and very expensive.”

“This was the first time that I built something that directly helped people.”

Anthony Pasquariello (ENG’18)

Healthy Hands, installed on the handwashing stations, provided an efficient and accurate solution. Its data-capturing system comprises sensors that detect water flow and soap use as well as a camera eight feet above the station to capture video data as a backup. It processes these interactions, recording the number of people who wash their hands in a given time and whether they use soap. The data, which is easily accessible as a comma-separated values (CSV) file, also includes the amount of water and soap dispensed per session and the length of each session.

Proof of concept came when the team brought the system to three Boston-area schools.

“I was really passionate about this project because of its societal impact,” says Pasquariello. “It was the first time that I built something that directly helped people. So much in school and work can be abstract. This was the real thing.”
PhD Dissertation Awards
The awards recognize PhD dissertations whose projects are both technically sound and aimed at solving important societal challenges.

First Place: “Enhanced Mass Transport in Graphene Nanofluidic Channels,” by Quan Xie (ENG’18’18), Department of Mechanical Engineering

Improving mass transport without increasing energy consumption is highly desired for a variety of technologies that address global challenges such as clean water and health issues. This thesis describes, for the first time, the creation of graphene nanochannel (GNC) devices with significant mass transport enhancement and systematically investigates fundamental mechanisms of that transport in single graphene nanochannels. These findings can be used to guide the development of new GNC-based nanoporous membranes, such as graphene oxide membranes, which can exhibit water permeability that is orders of magnitude higher than current reverse-osmosis membranes for water desalination, solving the global challenge of clean water. They may also lead to the development of new lab-on-a-chip devices with improved mass transport characteristics, which can dramatically accelerate sample delivery, separation, preconcentration and sensing processes for rapid disease diagnosis.

Second Place: “Machine Learning in the Real World with Multiple Objectives,” by Tolga Bolukbasi (ENG’18’18), Department of Electrical & Computer Engineering

Existing machine-learning (ML) systems are based on optimizing a single quality metric such as prediction accuracy. These metrics typically do not fully align with real-world design constraints such as computation, latency, fairness, and acquisition costs. This dissertation shows the development of ML methods for optimizing prediction accuracy while accounting for such real-world constraints. It introduces multi-objective learning in two setups: resource-efficient prediction and algorithmic fairness in language models. It demonstrates that a naive application of ML methods runs the risk of amplifying social biases present in data, and that this danger is particularly acute for methods based on word embeddings. It also reports the development of an algorithm that significantly reduces gender bias in embeddings while preserving their useful properties, such as the ability to cluster related concepts.

Senior Design Project Awards

Electrical & Computer Engineering Award: COMPOS

Concerns about safety meet those about respect when it comes to caring for people with dementia. Reetpragya Chowdhary (ENG’18) and his teammates learned about this firsthand when they began researching technologies to help people with Alzheimer’s disease for their senior project.

“We talked to the head nurse at a local Alzheimer’s caregiving facility, and she said that one of the problems they face is ‘elopement,’ where patients will actually leave the building without notifying anyone,” says Chowdhary.

But how to keep track of patients’ whereabouts in a dignified way? Some facilities the team visited used

COMPOS includes a device that looks like a digital watch (and does tell time) that communicates a patient’s whereabouts through sensors.
radio frequency identification (RFID) tags on people’s wrists as part of a so-called “wander guard” system, says Chowdhary, “but we found that very clinical.”

That’s when the idea for COMPOS (think “compass”) was born. The system includes a device that looks like a digital watch (and does tell the time), which each patient wears, and “beacons”: square units outfitted with Bluetooth and a Wi-Fi module mounted on walls throughout the facility. The sensors in the wearables—including an accelerometer and a gyroscope—communicate with the beacons, which then send data about the patient’s location to servers. On the front end, a webpage displays a list of the patients; when a caregiver clicks on a name, the person’s location shows up on a map that updates in real time.

“We had no idea going in how we were going to do any of this,” says Chowdhary. “We were thrown into the deep end, effectively, then had to swim up and find things we could leverage that were already out there to build our products. That was incredibly valuable; those are skills that I’m going to be employing in my current job as a full-stack developer at Rocket Software, in Waltham.”

Professor Alan Pisano, who advised the team and runs the ECE Design Program, praises the team’s ability to meet those challenges. “The students designed and built a complete patient-locator system in the form of a low-cost ‘watch’ to be worn by the patients that would track their location within a care facility,” he says. “These wearables were based on team-designed miniaturized printed circuit boards (PCBs). They built several complete ‘watches’ and tested the system successfully. The team’s attention to detail, their use of the engineering design process, comprehensive testing, and an important societal focus all contributed to their selection as the Best Project in ECE this year.”

Technology Innovation Scholars Program

“All of the kids get super-excited because they don’t realize the potential they have. When they have the ability to do something creative, to make their own code or make their own design, they see ‘I can do this.’ That’s the best thing we can provide for them—the confidence.”

Alyssa Liem (ENG’16,’21,’21)

“I am still amazed by how smart and motivated the high school students we work with are. Being a FIRST® robotics ambassador allowed me to be a part of a bright young group of future engineers. And, honestly, they even taught me a few things!”

Kevin Mannix (ENG’15)

So say ENG undergraduates who have participated in the Technology Innovation Scholars Program (TISP). Their words capture the significance of TISP for them as well as for the young people they serve.

TISP recruits and trains some of BU’s most talented engineering majors and sends them to middle and high schools around the country to show how engineering can transform our lives. Called Inspiration Ambassadors, the ENG students give interactive, fun presentations that frame engineering as essential to our quality of life—from the cleanliness of the water we drink to the distribution of the energy we use to power our homes. Students in grades K–12 explore the design process and see themselves as problem solvers and future leaders of technological innovation. Some TISP Ambassadors concentrate on mentoring FIRST® robotics teams at these high schools, visiting their designated teams weekly and attending at least one of their competitions.

“The TISP program is special because it empowers undergraduate students to improve their communication and leadership skills, while positively impacting middle and high school students around the country,” says Stacey Freeman, ENG’s assistant dean for outreach and diversity. “Through hands-on presentations and activities, our TISP Ambassadors get school-age children excited about engineering.”
TISP has grown by leaps and bounds since its founding in 2011. Trained Inspiration Ambassadors have increased in number by 150 percent, to more than 60 a year. They have reached nearly 21,000 K–12 students in 27 states and 9 countries and mentored 35 high school FIRST® robotics teams. Fifty percent of the K–12 students reached are female, and 25 percent are members of underrepresented minorities.

The Societal Engineering Fund provides stipends, training, and materials that allow the program to reach these diverse students.

A TISP Inspiration Ambassador guides students at Boston’s Josiah Quincy Upper School. Hands-on activities range from learning to code to developing prototypes for everything from wind turbines to fuel cells.
Imagineering Competition Awards

Students flock to the Binoy K. Singh Imagineering Laboratory or, as they call it, the “Tinker Lab.”

Why? Because it gives students the resources—the tools, machinery, and faculty guidance—to take flight. There they can experiment with new ways of addressing society’s challenges with no limits on topic or time frame.

The seventh annual Imagineering Competition, made possible by the generous support of John Maccarone (ENG’66), brought together nine innovative projects. They ranged from an automated T-maze to a no-slosh water bottle to a bicycle-powered air pump for Zambian aquaculture farmers.

Prizes for the competition are:

- **First prize:** $3,000, plus assistance with patent submission, a marketing analysis consultation, and an invitation to serve on the Competition Committee the next year
- **Second prize:** $1,500, plus assistance with patent submission and a marketing analysis consultation
- **Best-in-class prizes:** $500, awarded to the best project from each undergraduate class; mixed teams are categorized by the team leader’s class year

What makes a winning entry? Innovation, strong technical attributes, and practicality. “It’s great if you can build a better mousetrap, but that doesn’t really have much effect on society,” says Richard Lally, associate dean of finance administration, who oversees the Imagineering Lab. “It has to have value to people, work well as a system, and be reliably produced and affordable.”

**First Place: The Vertical Axis Wind Turbine**

Sometimes the most mundane activities spark the most creative ideas. Consider the inspiration behind the Vertical Axis Wind Turbine (VAWT): cars whizzing by on I-90.

“My teammates and I always joke about how there’s a wind tunnel by the engineering building at BU, and how strong it is,” says team captain Brendon Bourgea (ENG’18). “And we started thinking about where it came from, and then we looked at I-90 behind the building. What we observed was all this extra energy coming from passing cars that wasn’t due to wind from the weather, but actually man-made wind.”

The VAWT capitalizes on that. It uses wind from high-speed traffic to produce renewable energy. Compact enough to be built into highway medians, it would sit...
between opposing streams of traffic on the highway, effectively doubling the torque. In addition, heat from the dark tarmac helps the air rise, giving an extra boost to power generation.

“The reliable, clean energy produced from the turbines can supply highway lighting sources or route directly to the grid to help offset traditional fossil fuel-burning power plants,” says Bourgea.

Vertical axis wind turbines are not new, but they are typically large and bulky to capture the optimal amount of weather-induced wind. “The advantage of capturing the wind on a highway is that it’s predictable,” says Bourgea. “We know a lot about traffic patterns, when there will be a lot of traffic and when there will be a medium amount—which makes it very different from a traditional turbine.”

The students used computational modeling to show how opposing air flows would create strong, circular wind flows, or vortices, when captured in the VAWT’s small space, providing the torque that would spin the turbine and generate electricity. Then, using a 3-D printer and other resources in the Engineering Product Innovation Center, they made a small-scale prototype.

A major benefit of the project, says Bourgea, was the opportunity to apply what he learned in the classroom to a real-world problem. “What really solidifies an education is taking ownership of the skills that you’ve learned in class,” he says. “In my fluid dynamics course at BU, for example, we had a lab where we used computational fluid dynamics. I used that lab to ask additional questions: ‘How do I use this computer software to help develop this specific turbine?’”

Engineers in the Real World

Thanks to the generosity of Joseph P. Healey (ENG’88), the Engineers in the Real World program brings highly accomplished professionals from a variety of fields into the classroom to speak to sophomore engineering students. The speakers, many of them ENG alumni, use their own experiences to illustrate how their engineering degree shaped their careers, emphasizing the role of their quantitative and creative problem-solving skills in contributing to their success. While some speakers are practicing engineers, others have leveraged their training to forge careers in medicine, law, business, finance, and other areas, showing students both the diversity of careers an engineering degree can lead to and the impact the degree can have on all facets of society.

This year, Engineers in the Real World was honored to host the following guests:

Sanjay Prasad (ENG’86,’87), principal of Prasad IP, which provides innovative enterprises with experienced counsel at the intersection of technology and intellectual property

Bill (William) Neifert (ENG’90,’92), senior director of market development at ARM, which designs and develops the integral platforms, sensors, and subsystems that drive IoT performance

Benjamin Sullivan (ENG’97), CSO and founder of TearLab Corp., which manufactures equipment that uses human tears to diagnose dry-eye disease

Bob (Robert) Clarke (ENG’90), CEO of Pulmatrix, whose proprietary iSPERSE technology supports its development of innovative inhaled therapies for serious pulmonary disease

Jacqueline Gallo (ENG’03), operations manager at the Whitcraft Group, which makes precision-formed, -machined, and -fabricated flight-critical aerospace components

Jill Albertelli (ENG’91), vice president of quality at Pratt & Whitney, which designs, manufactures, and services aircraft and helicopter engines and auxiliary power units

Brendon Bourgea (ENG’18)
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