AMERICAN SOCIETY FOR ENGINEERING EDUCATION

PRISM

WINTER 2024

ENGINEERING STORYTELLING

COW ROBOTICS

LIGHTING THE PATH

A national curriculum is helping to illuminate engineering for high school students, and enable entry for all.

THE
JONSSON SCHOOL

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To solve society's most pressing problems, enterprising faculty deserve the support and structure to work across disciplines. Housed at The University of Texas at Dallas, one of the fastest-growing universities in the United States, the Jonsson School has departments that are focused on five research thrusts of national significance. With a joint bioengineering building opened recently at UT Southwestern Medical Center and a newly established Innovation Quarter launched with the City of Richardson to support entrepreneurship, tenure-system faculty will have the opportunity to excel together in the laboratory, the classroom and the marketplace. We are now hiring for leadership positions including associate dean for undergraduate education, associate dean for research and head of the Department of Systems Engineering, as well as for multiple other faculty positions.

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ERIK JONSSON SCHOOL OF ENGINEERING AND COMPUTER SCIENCE

engineering.utdallas.edu/careers

FEATURES

DEPARTMENTS

SEE IT TO BE IT

Engaging students from diverse backgrounds in engineering requires helping them see themselves as engineers. One effort, with roots within ASEE, has been doing just that for going on a decade. Engineering for US All (e4usa), originally a pilot program for high school students funded by the National Science Foundation, has now evolved into an independent nonprofit with proven success in its goal to "help remove the mystery and democratize the learning and practice of engineering."

The key: making it easier for truly all students, and teachers, to participate. The program eschewed higher-level math prerequisites and promised that any teacher—even those with backgrounds in history or music—could lead courses. The road wasn't always smooth, however. The original reaction of engineering deans to high school classes they feared could supplant their institutions' introductory ones: "'H' no!," according to one cofounder. In our cover feature, chief correspondent Thomas Grose shares the origin story of e4usa, its achievements thus far, and what's next.

A nontraditional approach to helping students develop an engineering identity has developed out of a partnership between Boise State University engineering faculty and nonprofit storytelling organization Story Collider. The effort, helmed by ASEE's 2023 Outstanding Teaching Award winner Krishna Pakala, may hold promise for retaining engineering students from underrepresented groups. "The stories we tell ourselves shape how we see ourselves," says the associate professor of mechanical engineering. In addition, the effort is helping to break public stereotypes about engineers. Frequent *Prism* contributor Rina Diane Caballar tells the tale in our second feature.

Young girls' interest in STEM is growing, according to a new study. But the good news has been tempered by their dropping confidence in math and science. How can we reverse that trend? Databytes offers info and suggestions.

And at Portland State University, engineering dean Joseph Bull is serving as a role model for Indigenous students. An enrolled member of the Delaware Tribe of Indians and the first and only Native engineering dean in the country, Bull is showing students what's possible while at the same time working to make his school a premier destination for Indigenous students in STEM. With programming and architectural design, Bull is creating a sense of belonging for them. In our Heritage Month Q+A, the dean discusses his efforts, as well as how Native perspectives can benefit us all.

As I write this, we're heading into the holiday season. I wish all of you peaceful times with loved ones, and a feeling of belonging as you celebrate.

EVA MILLER
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THE
JONSSON SCHOOL

COMING **SOON**

The
journey
continues...

THE UNIVERSITY OF TEXAS AT DALLAS
ERIK JONSSON SCHOOL OF ENGINEERING AND COMPUTER SCIENCE

See previous editions at: **https://utd.link/2mm**

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NEW INTRO COURSE

Some engineering students enter college knowing the field of engineering they want to study. Others are undecided and delay choosing an engineering major. But if they wait too long, they may have to stay in school longer to complete the intensive study required by their preferred engineering discipline.

To help students choose their field more quickly, some colleges have introduced a multidisciplinary introduction to engineering class. The first part of the course highlights multidisciplinary problems while the second discusses the various engineering disciplines involved in solving those problems. What's missing, however, is a transition specifying precisely how a multidisciplinary problem is divided into individual problems for different engineering disciplines. As a solution, I propose introducing systems engineering, a long-used method in defense and aerospace that is now also being employed in the automotive, transportation, health care, and software industries.

Systems engineering excels at breaking complex, multidisciplinary problems down into discipline-specific ones that, once solved, can be put back together to address the original problem. (There might be cases where some subsystem problems still require multidisciplinary effort.)

In this proposed course, faculty would work through the steps of the systems engineering process with students. The second part of the course would focus on how each engineering discipline addresses the discipline-specific subsystem problems.

At the conclusion of the course, faculty and students should discuss how each of these solutions is integrated back into the multidisciplinary solution. Since most real-world challenges are multidisciplinary, this underscores the importance of each engineering discipline. To interest non-engineers in the course, the class could also discuss changes in procedures, organizations, training, personnel, and facilities that might be needed to successfully implement the solution.

I believe such a course, in addition to helping engineering students choose a major, could increase the number of students interested in engineering. Instead of thinking about how one person can make a difference, students can focus on choosing their role on teams that make a difference.

I am interested in partnering with other ASEE members in developing such a course, possibly supported by outside grants. I welcome your feedback at *rbordley@umich.edu*.

ROBERT F. BORDLEY
Professor and Program Director in Systems Engineering and Design
University of Michigan, Ann Arbor

MEDICAL INNOVATIONS

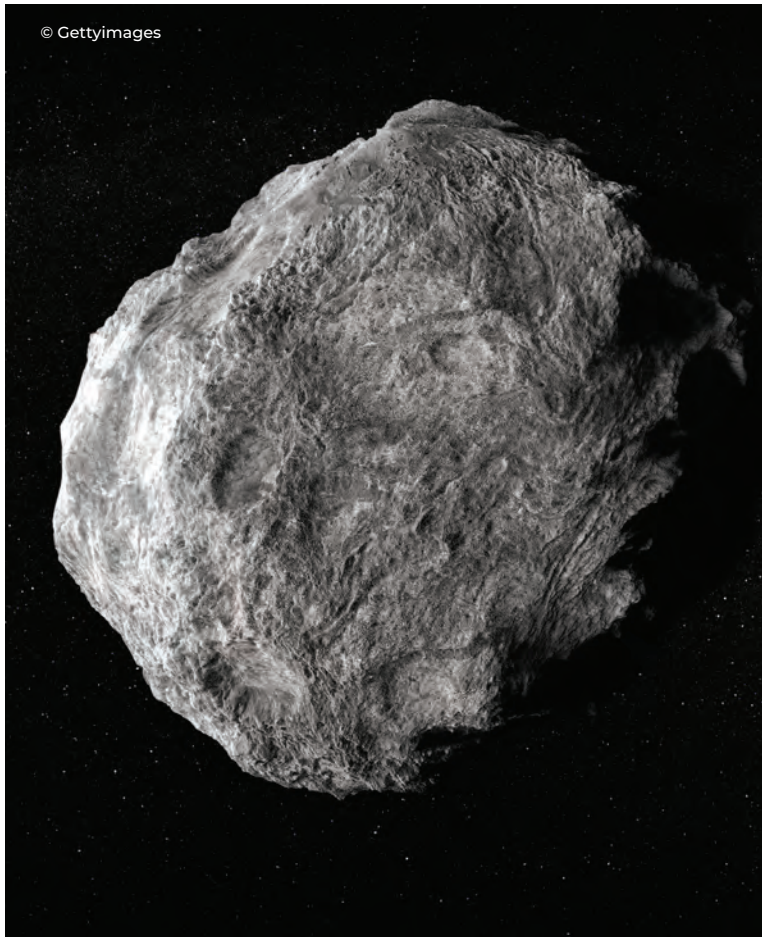
STAR STUDDED

Some skin diseases are caused by infection, inflammation, or other pathologies deep within the skin. Topical medications aimed at treating such skin conditions may not be able to penetrate the epidermis, or outer skin layer, because the medications' molecules are too big. Microneedle patches, using an array of microsized needles that contain the medication, have served as a workaround in such cases. The needles painlessly penetrate the epidermis to deliver the drug where it's needed, into the interstitial fluid between cells deeper within the skin. But these patches are not a perfect solution. They're too small to treat a malady that covers a large skin area and can't be applied to parts of the body that aren't smooth and open. Now, materials engineers at the Swiss Federal Laboratories for Materials Science and Technology, working with Boston-based drug company Aldena Therapeutics, have another solution: nanoceramic stars. Each three-armed star is 0.8 millimeters in diameter, made from alumina—an aluminum oxide ceramic. The stars are mixed into a gel that's also been infused with a medication. When rubbed onto the skin, the starry gel creates microwounds in the epidermis, through which the drug can seep more deeply before the wounds heal. Because the punctures aren't deep enough to hit nerve endings, the treatment is pain-free. According to the researchers, nanostars could go beyond treating skin ailments to potentially replace painful—or to some people, just scary—hypodermic needles used to deliver drugs for preventing and treating other diseases and conditions. Now that's star power.

SPACE TECHNOLOGY

PAYLOAD DIRT

The fuel load a spacecraft can carry is limited by the high cost of launching propellant-heavy vehicles from Earth. If we hope to explore distant planets, future spaceships will need to refuel en route. So aerospace engineers at the UK firm Magdrive have devised, and university researchers are testing, rocket technology to allow spacecraft to fuel up far from our world. Called Super Magdrive, the futuristic thruster can burn any metal—iron, aluminum, or copper, for instance—as fuel. Minkwan Kim, an associate professor of astronautics at University of Southampton, is leading a study funded by the UK government to measure the new propulsion system's thrust. If it meets the test, Kim says, moons, comets, and asteroids could all be mined as potential refueling stations. First, a spacecraft would land on one of the mineral-rich bodies in our solar system; then, a human crew or robotic miners could harvest available metals to refuel the craft's propulsion. "The system could help us explore new planets, seek out new life, and go where no human has gone before," Kim enthuses, echoing *Star Trek*. The pioneering thruster uses solar power to charge capacitors that ionize any metal, producing a high-density, high-temperature spray of plasma "bullets." Fired from the rear of a spacecraft, these projectiles would generate magnetic fields to spur the ship on its journey. While a conventional solid- or chemical-propellant rocket could still be needed to launch a craft from Earth, once aloft, Super Magdrive could in theory keep the vehicle hopping from moons to comets to asteroids for fill-ups on voyages into deep space.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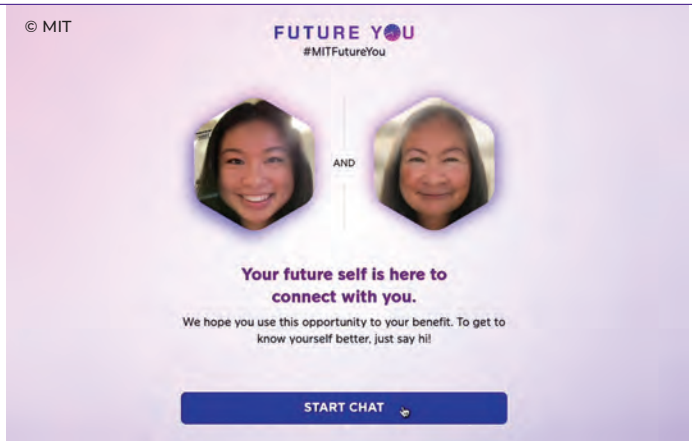
DRONE ENGINEERING

RAY OF HOPE

NASA. Boeing with DARPA funding. Google. Facebook. These organizations have spent millions of dollars trying, but failing, to build a solar-powered drone for effectively perpetual flight. Their failures weren't caused by solar cells, batteries, or electric motors: They were doomed by aeroelasticity—the critical balance between the size and flexibility of the high-flying aircraft, Robert Miller, CEO of Oklahoma aerospace company Skydweller Aero, tells *Forbes* magazine. All previous solar drone iterations have disintegrated in flight because of a "death zone" of atmospheric turbulence and other stresses between 5,000 and 30,000 feet. To navigate at these altitudes, a drone needs flexible wings; yet, as Miller notes, "aerodynamics scale, but aeroelastics don't." With funding from the US Navy, Miller's company has devised and is testing its Skydweller solar drone, made of ultralight carbon fiber with a wingspan of 236 feet, weighing just 5,620 pounds. The drone has clocked its longest test flight at an impressive 22.5 hours, but ultimately the Navy needs a drone that can stay airborne for weeks, powered by sunlight in daytime and batteries at night. Skydweller will scale up its test flights to last seven to fifteen days, carrying a full payload of Navy sensors and communications gear. The Navy's current fuel-powered long-range drone can fly 30 hours but costs $35,000 per hour to fly; solar-powered Skydweller will be far cheaper to operate. While the military will be among the earliest adopters of lightweight solar drones, Miller predicts commercial demand will ultimately soar.

Have a technological breakthrough, new invention, or emerging trend First Look should report? Submit your ideas to prism@asee.org.



ARTIFICIAL INTELLIGENCE

BACK TO THE (AI) FUTURE

Development of a time machine has taken a virtual step, thanks to a multi-university research team led by technologists at MIT's Media Lab. Their online, text-based system uses generative artificial intelligence (AI) to enable users to talk with their future selves. Indeed, the system is called Future You. Psychologists say that people with a good grasp of their future self-continuity—an understanding that their future self will be much like their current self—tend to be more secure, better at making long-term decisions, and less stressed, because their expectations of the future are realistic. The researchers saw the potential to use generative AI to offer people realistic simulations of conversations with their older selves. Users first answered a series of questions about their lives, goals, and values; from that information, the AI model generated a backstory, from which it created "future self memories." The AI also produced age-enhanced images of users, making it easier for them to visualize themselves at age 60. A study of 344 participants found that after engaging with the platform for 30 minutes, users felt less anxious and had a stronger sense of connection to their future selves. While a simulation can also result in negative outcomes, the researchers explain to users that each simulation is only one possible version of their future, and that answering the questionnaire differently will yield an alternative result. Each outcome is not a prophecy, one researcher says, but a possibility.

MATERIALS SCIENCE

PAINT WITH A PEEL

Suppose you're a renter who hates the color of your bedroom walls but can't repaint because if you do, you'll lose your security deposit. Thanks to an accidental innovation by a Colombian materials science startup, now you may have an option: peelable paint. The new custom coating, called Unpaint, adheres to any interior surface and can be peeled away by hand, reports *Fast Company*. No chemicals or tools are needed for removal, and once Unpaint is peeled off, the surface below remains unblemished. Glasst Innovation, an ecologically sustainable products company, claims their paint is biodegradable and its manufacturing process carbon-negative. The firm's scientists were working on creating biodegradable single-use plastics when they discovered the plant-based, liquid polymer with "truly unique physical properties" that made it peelable. Uses could include repainting rooms to match seasonal or holiday themes or letting realtors change colors for different stagings of a house for sale. Unpaint is for indoor use only, but an exterior version is in the works.

TECHNOLOGY AND SOCIETY

THE EYE OF THE BEHOLDER

Martine Gosselink, director of the Mauritshuis museum in The Hague, Netherlands, has long felt that people respond more powerfully when they come face-to-canvas with genuine works of art than with reproductions. A recent study using high-tech devices has proven her right, according to the *Guardian*. Eye-tracking technology and MRI scans recorded the brain activity of 20 volunteers, ages 21 to 65, as they first gazed at five of the museum's original paintings—including its star attraction, Johannes Vermeer's *Girl with a Pearl Earring*—and then viewed poster reproductions. Their brain responses were 10 times stronger when looking at the originals. According to *The Art Newspaper*, researchers found actual artworks activate the precuneus, the part of the brain that deals with consciousness, self-reflection, and episodic memories. The study, conducted by the University of Amsterdam and neuromarketing agency Neurensics, found Vermeer's masterpiece elicited the greatest response of all the originals viewed. The painting's layout and use of light, the study determined, cause viewers to first focus on the girl's left eye, then her mouth, then the pearl earring, and finally back to her eye, in a "pearly triangle" that creates a "sustained attention loop."

Crisis of Confidence

Efforts to grow the numbers of girls pursuing STEM are making strides, but hurdles remain. According to a recent large study, the overall percentage of girls who reported an interest in STEM careers increased from 45 percent in 2017 to 55 percent in 2023. Surveying girls in fifth through twelfth grades both years, the study found the biggest gains among fifth-grade girls. Their interest rose a whopping 78 percent (or 25 percentage points). The less positive news: girls' belief in their STEM abilities decreased over that time, dropping from 73 to 59 percent overall reporting they were good at math and science. The decline was most stark among seventh- and eighth-grade girls, whose belief in their abilities dropped from 78 to 58 percent.

Girl-focused nonprofit Ruling Our eXperiences (ROX) surveyed more than 10,000 girls in each of the two years. The *2024 Girls Index: Girls and STEM Impact Report* highlights a "concerning trend in girls' confidence levels…particularly during the critical middle school years."

According to the report, the interest versus confidence gap isn't tied to race, socioeconomics, or academic ability, but is instead due to social and emotional factors—such as pressure to fit into roles and stereotypes. From 2017 to 2023, girls' self-confidence in their STEM abilities decreased across every grade surveyed.

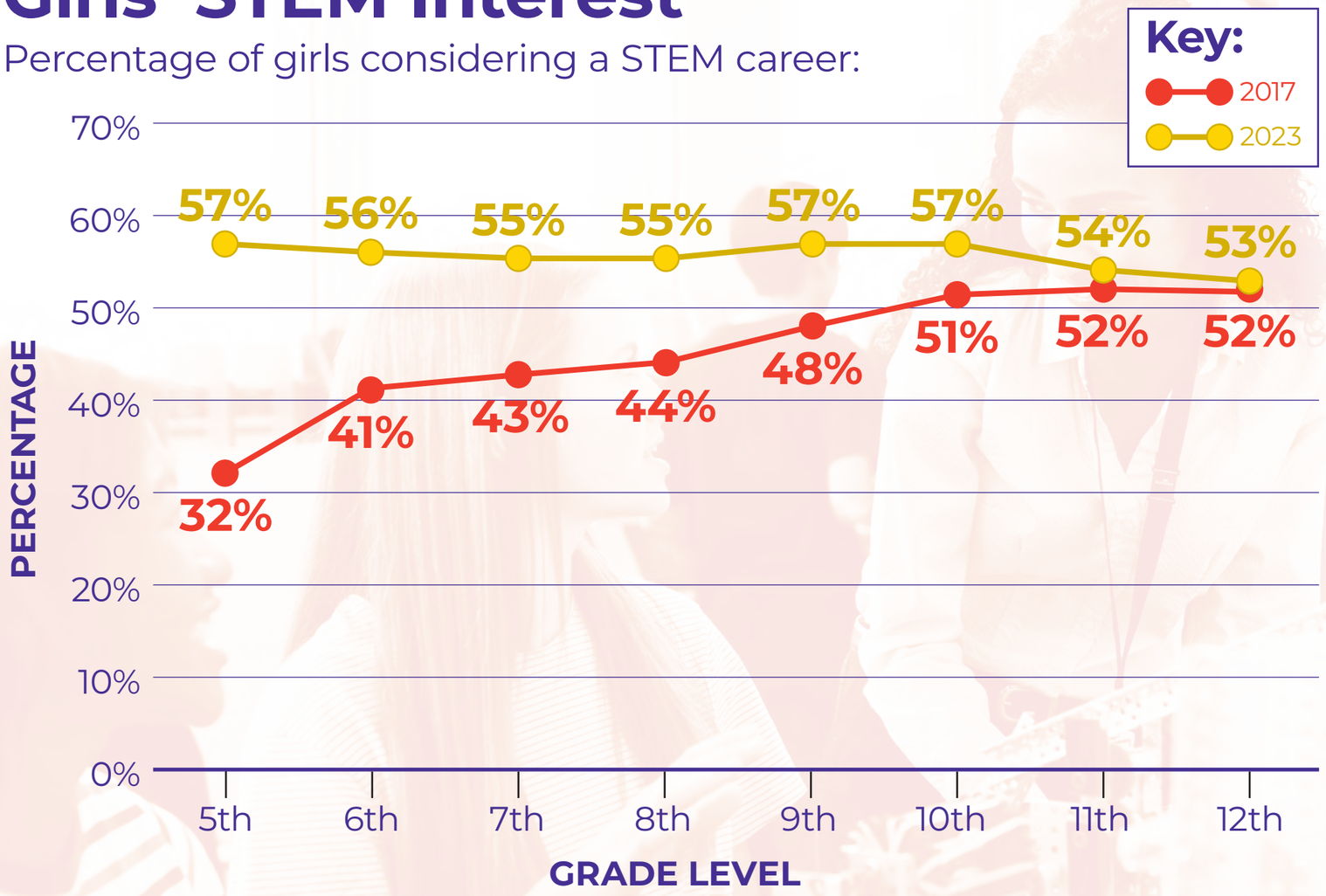
Among the report's recommendations: nurture confidence and competence together. This requires "a multi-faceted approach that goes beyond academic instruction," developing an "ecosystem of support that nurtures girls' overall confidence and self-efficacy while simultaneously cultivating their STEM interest and identity."

Source: The Girls' Index: Girls and STEM Impact Report 2024, *by Ruling Our eXperiences Inc. (ROX).*

Access the report at www.rulingourexperiences.com/stem.

Girls' STEM Interest

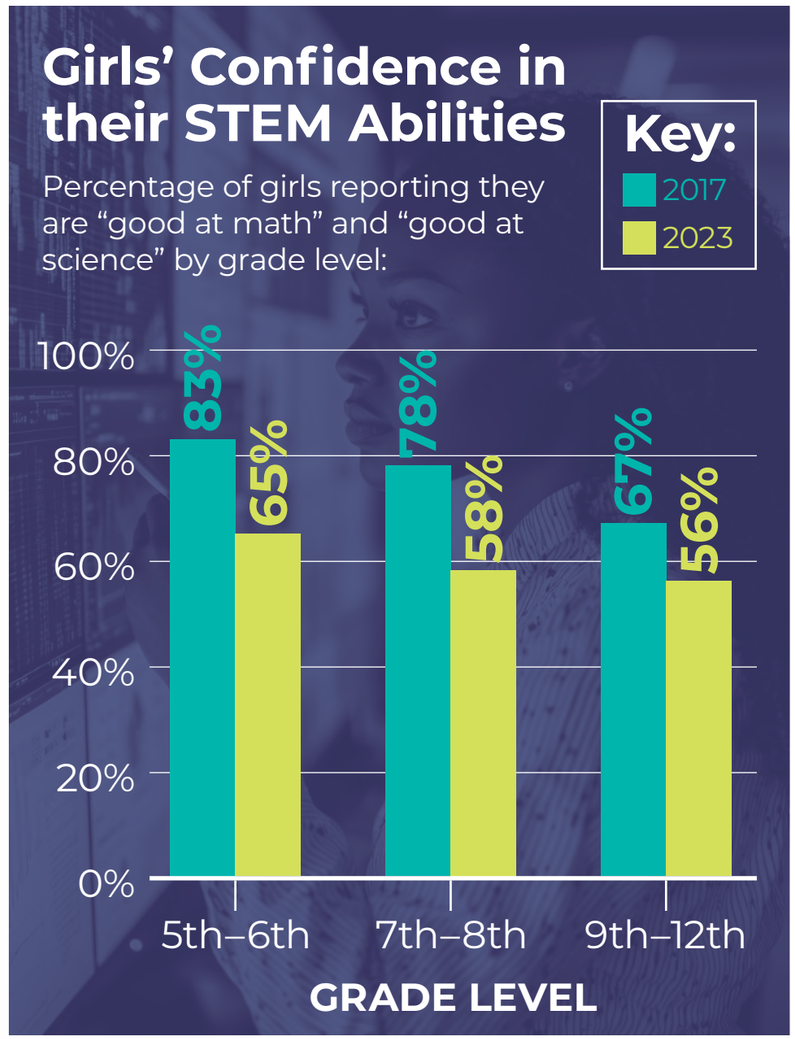
Percentage of girls considering a STEM career:



DESIGN BY FRANCIS IGOT

Girls' Confidence in their STEM Abilities

Percentage of girls reporting they are "good at math" and "good at science" by grade level:



BY DEBORAH LEE ROSE

MOO-BOTICS

A robotics researcher turns to cows, aiming to improve their treatment, optimize food production, and reduce climate-warming gases.

Consider the cow: Long depended on, in some places revered, increasingly farmed en masse to meet modern-day demands for food. But cows aren't just a source of milk and meat; they also emit methane, which contributes to global warming. In the face of these contradictions, Upinder Kaur has been ruminating on these ruminant animals.

An assistant professor of agricultural and biological engineering at Purdue University, Kaur is concerned for the health of cows in commercial settings, in which more than 10,000 animals may be housed together. At the same time, she recognizes that optimizing animal welfare means more food for the world's projected population of 10 billion people by 2050. In addition, Kaur knows data have been insufficient to accurately quantify cow emissions and their impact on climate change. Engineering solutions to these challenges are interconnected, she believes, and can be advanced with the state-of-the-art robotics she is developing to monitor the animals in real time.

"An indwelling robot with sensors allows us to do dynamic and much more accurate measurement of ruminants' biomarker activity and methane emissions," she explains.

Growing up in Delhi, India, Kaur was curious about biology and technology. As a girl, she had a cherished paper model of the space shuttle *Columbia*, whose crew included US astronaut and aeronautical engineer Kalpana Chawla, the first woman of Indian origin to fly in space.

In college, Kaur pursued mechanical engineering, and ultimately a PhD in robotics from Purdue. Her ongoing research links biology and technology to design in vivo robots for precision animal agriculture, focusing on both the physical and social welfare of individual cows—much like family farmers are able to do.

In large-scale crop agriculture, automation systems have helped optimize resources and improve productivity and care. Kaur is now turning such solutions to commercial animal agriculture, a greater challenge due to the potentially rapid changes in animal health.

Her experimental bots collect real-time data from the rough-and-tumble environment of a cow's stomach. A fist-sized, microsensor-laden robot is inserted into the rumen, one of a cow's four stomach compartments, through a fistula, or surgically created hole, in the cow's side. The robot captures continuous information on health biomarkers, such as pH, and measures internal gas volume and methane content by laser. Finally, it wirelessly transmits updated data at 433 megahertz to a receiver on the cow's special collar. The robot's onboard computer reduces the power needed to transmit data through the cow's thick, energy-absorbing tissues.

This robotic system could help commercial dairies detect rapid health changes that affect a cow's welfare or milk output. And the ability to quantify the amount of methane inside a cow that ends up outside is environmentally vital, she notes. Absent any interior robotics, measuring bovine methane externally is costly and constrained. A $150,000 sensor-studded mask must be fitted over a cow's mouth. Since the mask interferes with eating and drinking, it can only stay in place briefly and misses methane that the cow produces while it's eating or between readings. Plus, the mask only measures emissions from the mouth. These limitations leave scientists without critical information to determine the animals' true impact on climate change.

Kaur envisions miniaturizing her rumenbot to traverse the animal's churning digestive system and collect more data, as well as to harness the sloshing motion of 80–100 gallons of digestive juices and turn ruminant kinetic energy into electrical energy to power the robot's battery.

"My purpose is to solve real-world problems that impact people globally, using technology," Kaur reflects. "Even as we're meeting the newest engineering challenges, like designing autonomous cars, there are pressing needs for autonomous technology to address world crises, from hunger to the survival of Earth's environment."

Deborah Lee Rose is an award-winning Prism *writer and editor, and author of STEM children's books including* Penguins Ready to Go, Go, Go!

JOSEPH BULL

*November was **National Native American Heritage Month**, celebrating the contributions of Native Americans, Alaska Natives, and Native Hawaiians.*

***Joseph Bull** is an enrolled member of the Delaware Tribe of Indians. In 2022 he became the first and only Native American engineering dean in the country, at Portland State University's Maseeh College of Engineering and Computer Science. Bull aims to make the university a premier destination for Indigenous STEM students.*

This interview has been edited for length.

Why do you think having a Native engineering dean took so long?

[In the 2023 National Science Foundation] survey of earned doctorates, only six Native Americans got PhDs in engineering.

You have to get a PhD, then a faculty position, then tenure, then be promoted to full professor, and then either associate dean or department chair before you would be a competitive candidate [for] dean.

There just aren't that many people. It's not that Native folks are deficient. There are things that Native folks have done really well that Western science and engineering are just now catching up to. It comes back to systemic things that we need to change, and part of that is how we teach engineering.

[And the history of Indigenous] boarding schools probably makes some folks a little distrustful of education. So it's complicated.

Can you discuss some of your methods to support Native students?

We've developed a program, the FUTURES initiative, within the engineering college. [It's] focused on building cohorts and a sense of belonging across departments. If you're the only one in a department or program, you may not feel that you have … community.

We've added two Native American engineers who are CEOs of companies to my external advisory board. We had [an event] for Native students in the college [with them]. Seeing what's possible was really informative for the students.

We have a grant [from] the Sloan Foundation focused on change in STEM PhD programs. How do we change the culture and make the PhD education process better for underrepresented folks, primarily Indigenous, Black, and Latino.

This past fall, [the engineering college held its] first Inclusive Teaching & Mentoring Symposium. We had an all-day workshop [on] how we could make our programs more inclusive [to] kick off revision of our undergraduate curriculum. [It will] have a common first year [to create] a sense of belonging.

What are some necessary culture changes?

It's partly an appreciation of the things that Native folks have done really well. The idea of thinking seven generations ahead … we probably wouldn't be having the conversations around climate change that we are now if as a society we had [done that]. So infusing things like that into our curriculum.

It's partly making our spaces more welcoming. We've been trying to be intentional [about] having spaces that reflect an Indigenous theme. [Our] science center was completely renovated, and the design was led by mostly Native students. The architecture, the design of the interior, and the artwork have a very strong Indigenous focus. [The building] centers that we're on Native land and that Native approaches are integral to how we view STEM.

We have a Native American student and community center that just celebrated its 20th anniversary. So we're really trying to sprinkle across campus this theme of an Indigenous approach to STEM and "you belong here," partly by how we design things, partly by programming.

> **THE TENDENCY FOR NATIVE FOLKS IS OFTEN TO UNDERSTAND THE RELATIONSHIPS AMONG THINGS.**

How else are you incorporating Indigenous perspectives?

Engineering is hugely impactful on many of the challenges facing society. We don't always talk about that; we often jump into the technical [aspects]. Math turns into an end to itself rather than a tool for solving problems. So recentering how does this impact things that we care about. And research shows that's often why people of color leave STEM disciplines, because they *don't* see the impact .... Young people in general now want to [make a difference]. So that's an example where changes that center Indigenous approaches make it better for everybody else.

Another [element is the] focus on relationships—not just among people, but also in how we approach engineering and science. [For example,] things that people thought were cures to disease in single-cell experiments turned out not to work in either animals or people because they left out important relationships with other cells in the body. The tendency for Native folks is often to understand the relationships among things, whereas Western science [typically wants to] isolate something and study it. So having that mix of approaches is really important.

NEXT-GEN DESIGN

One path to a larger, more diverse engineering workforce: a project-based, NSF-backed high school course offering the prospect of college credit.

BY THOMAS K. GROSE

ABOUT A DECADE AGO, the National Science Foundation recognized that US higher education wasn't turning out enough engineers to satisfy tech industries' voracious appetite for talent. The agency sought new ways to introduce K–12 students to the field, hoping more of them would eventually join its ranks, recounts Don Millard, NSF's deputy assistant director for engineering. While many secondary schools had stepped up teaching of STEM subjects, he says, "the E in STEM was largely left out." So when a group of engineering educators and researchers came calling in 2017, seeking funds to create a national, high school-level engineering curriculum, they found a wide-open door.

A year later, the academics, led by Darryll J. Pines, then engineering dean at the University of Maryland, won a three-year, $4.1 million grant to develop a pilot curriculum. It would, NSF declared, "help remove the mystery and democratize the learning and practice of engineering," while encouraging more underrepresented groups to envision themselves joining the largely White male profession.

With that first infusion from NSF, the academics set out to create a hands-on, project-based elective centered on two simple principles: 1) Students could enroll in the course having studied only algebra I, not higher-level math, and 2) any teacher could teach it, even without a science or engineering background; the program would provide them with training and guidance. Beyond teaching the fundamentals of the engineering design process, the 30-week course would instill in students a greater appreciation of the importance of engineering to society.

The course design was steeped in research on what works in engineering education, a topic Stacy Klein-Gardner, an adjunct professor of biomedical engineering at Vanderbilt University, and her colleagues had spent years studying.

Six years after that initial grant, it's generally agreed that the effort has surpassed expectations. Now called Engineering for US All (e4usa), the program is embedded in more than 100 high schools, counts 39 universities as partners, and boasts 7,700 (and counting) student participants. What's more, demographic data on students released by participating high schools reveal far more diversity than currently exists in most engineering schools and the profession. Female students represent 38 percent of the total; White, 46 percent; Black, 31 percent; Hispanic, 29 percent; Asian, 13 percent; mixed race, 7.3 percent; American Indian/Alaska Native, 1.4 percent; and Native Hawaiian/Pacific Islander, 1 percent. (Students could check as many races as applied for that category.) Students with disabilities make up 8 percent.

MAJOR INVESTMENT

Such results haven't come cheap. As of October 2024, e4usa had received some $16 million from NSF and other funders, including the state of Maryland and the A. James & Alice B. Clark Foundation, a major donor to the University of Maryland's engineering school. In 2021, impressed with e4usa's progress, NSF provided it with a second grant amounting to $4 million. Another $1.74 million in supplemental funds has been added.

With an eye to continuing well beyond the duration of a typical grant, e4usa has reconstituted itself as a nonprofit organization, installing Klein-Gardner as executive director. "It gives us a sense of independence, for sure," she says. "Sometimes that's a little scary, but it's fun." The change makes it easier to seek donor funds and stay in business without relying on NSF. Klein-Gardner and her team thought the flow of NSF money would end this year, given its change in status. So they were surprised when the foundation authorized a third grant — in the neighborhood of $3.4 million — which was set to be released late this year.

The decision to make algebra I the only math prerequisite was key to attracting a diverse cohort of students, says Pines, who became UMD's president in 2020 and also chairs e4usa's board. That's because "if it's precalculus or calculus, then you're already pre-filtering out those individuals who haven't taken those courses," a group that often includes large numbers of girls and racial and ethnic minorities. The plan was to get students to learn and use the engineering design process on real problems, Pines explains, and once they're engaged to then "connect it back to math, so they would end up taking higher-level math and STEM disciplines in the future." But the program also succeeds in persuading students who have taken harder math and science courses to pursue careers in engineering, rather than, say, biology, chemistry, or physics, NSF's Millard says.

FIRST REACTION: NEGATIVE

While NSF's relationship with e4usa dates from 2017, the idea for such a program wasn't new. As early as 2005, some ASEE-affiliated academics had held preliminary discussions with the College Board, which oversees Advanced Placement (AP) course development and tests. Although nothing came from the talks at first, interest continued within ASEE. In 2011, James H. Aylor, then engineering dean at the University of Virginia, suggested surveying the Society's Engineering Deans Council (EDC) on the idea of a high school AP course in engineering. At the time, he was head of the council's K–12 Engineering STEM Task Force (renamed in 2012 as the P–12 Engineering Education Commission). When Pines took over the commission in 2012, he picked up on Aylor's suggestion. But when he asked fellow EDC members at a meeting in New York if they supported creation of an AP course, "the initial reaction was, and I'll just use these words: 'H' no! And it was visceral." Deans worried that an advanced placement course, worth college credit, would take the place of first-year programs crafted to inculcate freshmen with their particular schools' culture.

Still, Pines continued to press the case. Over the next six months, he wore down the opposition, to the point where in April 2013 the EDC asked Pines's commission to begin research on the idea together with the College Board. The board turned out to be "extremely receptive" to the idea—in part because, unbeknownst to Pines, the Obama administration had lobbied the organization for just such a course. In 2014, the College Board agreed to fund a joint effort to create a framework with the commission. However, it pulled the plug the following year because of budget constraints. Two years later, the researchers decided to seek help from NSF and met with Millard.

DIVIDE AND CONQUER

Research continues to inform updates to e4usa's curriculum. Many team members have taught or helped create first-year introductory courses at colleges, Klein-Gardner says, "so it was a matter of thinking about how do you take that and make it where a 9th grader could do it and make it age- and pedagogically appropriate." The original course comprised eight units over a school year, and was field-tested in 2020. The pandemic impeded data collection, but within a couple of years, the team realized that no schools were completing all eight units. So in 2023–2024, the course was divided into two one-year courses: the first four units became e4usa+making, covering engineering in society and ethics, with a bit more CAD work added in. The last four became e4usa+design. Both courses are project-based; students research a problem, design a solution to it (or an aspect of it), then build, test, and optimize a prototype.

– Stacy Klein-Gardner, e4usa's executive director, speaking of the program's shift in status from university project to nonprofit

From left to right: e4usa students 1) master the use of microscopes to analyze materials; 2) develop the crosswalk system; and 3) demonstrate their cryotherapy gloves designed to help chemotherapy patients preserve nailbeds. High schools participate from across the US and 4) in Ghana.

Typically, e4usa+making projects are shorter and simpler and focus on local needs; e4usa+design requires students to work on a global problem based on one of the National Academy of Engineering's 14 Grand Challenges or one of 17 UN sustainability goals, plus a local goal relevant to them. Both courses emphasize important professional skills, particularly teamwork, communication, and project management. Students must take e4usa+making before e4usa+design. A third course, e4usa+programming, currently at the pilot stage, is an introduction to computer science and MATLAB.

TRAFFIC LIGHTS AND ZOO ANIMALS

The original eight-unit course, now dubbed Legacy, remains in use at about a third of participating schools. At Plymouth Whitemarsh High School in suburban Philadelphia, for example, physics teacher Jim Muscarella was already teaching two semester-long engineering courses but adopted e4usa+legacy as a full-year capstone course. He came across e4usa at an ASEE conference and "realized that we were doing a lot of the same things. I decided I wanted to be on board with this crew. I liked the community-based projects that they were touting."

The program offers teachers guidance in developing projects and shares examples of successful ones. In one of Muscarella's activities, e4usa students designed and built a remote-controlled crosswalk system. Set up in hallways or on the playground, it helped students with special needs practice road-crossing safety. Brentwood High School, near Nashville, has partnered with the local zoo on several student projects, including a special lift to help zookeepers handle animals that are very heavy, have unusual centers of gravity, or both.

Engaging e4usa projects not only hold students' interest but also demonstrate that "engineers are first and foremost creative," Millard says. There's also an altruistic element to many projects, which is attractive to young women, many of whom want to learn skills they can use to "help people or help the environment," Klein-Gardner says. The projects show students "the joy of engineering," she adds. They learn that math and science, as well as hand tools, CAD, 3D printing, and programming, "are the tools that help you solve real problems for real people."

The e4usa high school engineering courses are rigorous enough for college credit at 24 US institutions, among them Virginia Tech, Purdue, and the University of Maryland. However, colleges' acceptance of the program varies. Credits granted to incoming students who have taken e4usa classes are usually not in engineering, but may fulfill an elective requirement. And most engineering colleges don't consider e4usa a substitute for introductory engineering courses. One of a handful of exceptions is the University of Oklahoma, which has swapped in e4usa for its previous intro course.

BETTER-PREPARED STUDENTS

Deans who were once wary of starting engineering education in high school now say that students exposed to e4usa are more equipped than many of their peers. "What's not to like about knowing you're getting a student that has an idea of what they're signing up for and sees the joy of engineering already?" Klein-Gardner asks. Paul W. Brandt-Rauf, dean of the School of Biomedical Engineering at Drexel University, sees e4usa "as an important recruiting tool, definitely," spreading the gospel of engineering to students who would otherwise lack awareness about what it is and its importance to society. "If you're not exposed to it early on, it's less likely you're going to pick it as an option." There's another plus: When students enter college, "there's no doubt about it. They're ahead of the game," he says. "We see these students are very well prepared."

Maintaining college-level standards requires consistently strong teacher training. While many e4usa instructors were science teachers to begin with, others have come from nontechnical backgrounds, including history and music. One of the hypotheses in the original NSF proposal was that "we could teach any high school teacher the engineering design principles and the engineering design process." However, "we didn't really know that to be true at the time," Pines admits. But e4usa is intent on providing sufficient preparation to prove that hypothesis. The program requires all teachers to take the initial, year-long professional development course, regardless of their experience, and taps experts from local industry or universities to help them after the course to brainstorm project ideas and troubleshoot any problems that arise. The cost—the only cost schools are charged—is $2,500 per teacher.

Going forward, "we are hoping for exponential growth," Klein-Gardner says. Besides more schools, students, and university partners, e4usa is working on expanding its curriculum. Researchers at Arizona State and several other schools have teamed up with FIRST (For Inspiration and Recognition of Science and Technology), brainchild of inventor Dean Kamen, to develop an engineering and robotics program that could be blended into schools' curricular or after-school programs. The initiative created the Experiential Robotics Platform (XRP), a startup kit for building robots in the classroom. The researchers are now working to scale up the platform for wider use and create instructional materials. Ideally, the work will evolve into a new e4usa course.

Meanwhile, NSF shows no sign of cutting off funding. "Engineering for us all is the goal, right?," says Millard. "So we still have something to pursue, to figure out how we can do this for us all." He adds, "This is a passion project."

Thomas K. Grose is Prism*'s chief correspondent. He is based in the United Kingdom.*

Photos courtesy e4usa (1, 3, and 4) and Jim Muscarella (2)

OUR Stories, OUR Selves

Educators are harnessing storytelling to help engineering students succeed.

By Rina Diane Caballar

ERIC JANKOWSKI first tried out storytelling as a chemical engineering doctoral student. At a friend's house, he had met the cofounder of the Story Collider, a nonprofit focused on demonstrating "the vibrant role that science plays in all of our lives through the art of personal storytelling." Brian Wecht, then a theoretical physicist, convinced the doctoral student to perform at a live show. In an Ann Arbor, Michigan, library basement, Jankowski clambered on stage and recounted how he'd embarrassed his high school biology teacher with inappropriate jokes while presenting to a large chemical company on the class's river sampling project—despite the teacher's previous warnings.

Jankowski didn't expect the experience to be so transformational. But people applauded, and some even approached him afterwards, praising him for sharing his blunder bravely. "Getting this positive feedback about failure was so different from the academic culture I was steeped in at the moment," he says. "As a graduate student, you're often frightened about being perceived as incompetent, and you're avoiding admissions of failure at almost every turn."

More than a decade later, Jankowski continues to apply his storytelling skills at Boise State University as an associate professor of materials science and engineering. In 2017, he asked the Story Collider team to help Boise State's engineering faculty learn how to share their stories. He had been inspired by a California biology professor who studied the effects of Story Collider podcast episodes and similar tools on the science identity of students (*https://bit.ly/3Z3aZfD*).

The initial Boise State coaching session involved a small cohort, including Krishna Pakala, an associate professor of mechanical engineering. Pakala had attended one of the Story Collider's live shows, where his curiosity had been piqued. Pakala and Jankowski had also connected previously during student-supporting activities and at teacher-training events. "I look to him for teaching mentoring," Jankowski says of Pakala.

After the session, the two discussed the potential of using storytelling in engineering education. Jankowski had already tried it out with his thermodynamics class, so Pakala did the same for his junior-level heat transfer course. The results were encouraging—despite some initial hesitation, overall students responded enthusiastically. The two decided to request funding from the National Science Foundation to explore how telling personal stories could help students forge a sense of identity and belonging as engineers.

Natalie Ayala's storytelling experience helped her feel accepted in engineering as a Hispanic woman. Ayala image courtesy of Joseph Rodman

Narrative Weavers

With the NSF grant awarded in 2022, Jankowski and Pakala, along with two faculty members in marketing and educational technology, are implementing a three-year project to embed storytelling in engineering courses. Their aim is to improve the retention and graduation rates of undergraduate students in the field.

"We started our project because we saw a real issue with our students—especially women and [members of] underrepresented groups—dropping out of engineering. Many of them feel like they don't belong or question if they are the right kind of person" for the field, explains Pakala, who leads the project. "Our hope is that by changing how students view themselves, we can help them stick with engineering and succeed."

Unlike conventional strategies that focus solely on academic support, storytelling can help bring experiences to life, Pakala says, allowing students "to see their challenges, dreams, and successes reflected in others." The approach "builds empathy and connection, inspiring confidence and resilience. By humanizing students' journeys, storytelling creates an environment where all students feel valued and understood, making success in engineering not just possible, but [also] personally meaningful."

Before each fall semester, faculty and staff across Boise State are invited to engage in a storytelling retreat guided by Story Collider staff. While most participants are from engineering disciplines, some come from other STEM fields, health sciences, or business. Attendees implement what they've learned in their courses—whether introductory or senior-level—dedicating an entire class period to a storytelling activity, also facilitated by the Story Collider.

Students are asked to view themselves as the main character and reflect on a meaningful event in their life and its outcome. They craft a narrative around that experience, focusing on its impact on who they are as engineers. Students then submit a recorded video of themselves narrating their written work. Together, the teachers and Story Collider facilitators select several students to present at a live show on campus, advertised to the university and wider Boise communities.

Vulnerability on Display

Public speaking is a nerve-racking endeavor for many, and it was no different for engineering students Natalie Ayala, Ian Peña, and Gregor Posadas. On the day of their live show, they were all terrified. But beneath those nerves was a bit of excitement, too.

Peña, who has an anxiety disorder, drew on the coping techniques he had built over the years, including breathing and positive self-talk. "I was sweating. My mouth was dry," he recalls. Once on stage, however, "I felt like I was executing a mission I had been set on. I was following the formula we had rehearsed"—that is, a five-minute oral version of their story demonstrating an arc of change in themselves as the narrative progresses. Afterwards, he "felt like a million bucks."

Getting students comfortable with being vulnerable in front of an audience is one of the biggest challenges of the project, notes Pakala, currently board of directors president for the Story Collider, which is based in New York but hosts shows across the US. Creating a safe and supportive space helps, as does providing ample feedback throughout the process "so they don't feel like they're doing it alone. We tell them that the stories stay in the room, but the lessons leave."

Posadas, who recounted his journey migrating from the Philippines to the US and working toward his civil engineering degree, recognized not only a sense of relief but also gratitude after his turn, "because people actually took the time to listen to me, and my whole experience as an engineering student … got validated."

For Ayala, the motivation behind performing was twofold: 1) to reconnect with herself, looking back to starting at a place of fear and self-doubt as the only Hispanic girl in her middle school introduction to engineering class, and 2) to advocate for underrepresented groups. "I wanted to be a voice for other people to let them know that we do belong in the STEM community, that we have a place here, and that no one can take that away from us."

As she spoke about being perceived as a below-average student without much potential in grade and middle school, due to her ethnicity, Ayala felt like a huge weight was being lifted off her shoulders. She heard classical music playing from a piano on the floor below the venue, and it was as if all her emotions were being held through that music and the room. "I could feel everybody just connecting with me in that moment."

At the end of her performance, an immense peace came over Ayala. She finally was able to let go of the labels put on her, embracing the true and best version of her current self: an engineering student and part of the STEM community. People came up to her and shared similar experiences of rising above others' low expectations of them, "and it just felt like I wasn't alone," Ayala says. Being Hispanic and a woman mattered, but "I wasn't treated differently because of those things that identify me. It made me realize that I belonged … and that I was accepted."

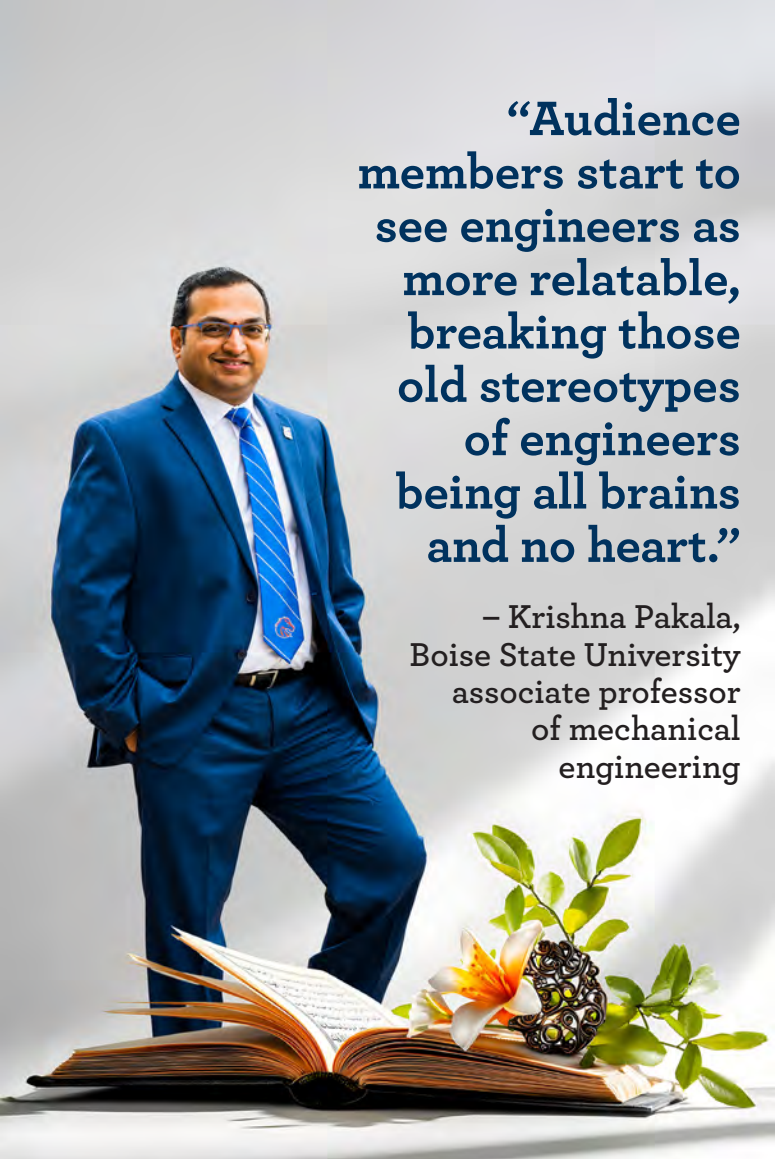
Unique Yet Universal

These experiences support the preliminary findings Pakala and team have gathered through surveys and interviews over the past two years. Students who participated in the storytelling sessions identified more strongly with their major and gained confidence in their abilities. Peña, for instance, explains that delivering his story "was so good for my self-esteem," because he was able to build his presentation and public speaking skills as an engineering student. Posadas came to grips with his imposter syndrome, "because I feel like a lot of my peers [would] have felt something similar as they were going through their own studies."

What Pakala finds most exciting about the results is the uplifting effect on students from underrepresented groups. For example, based on an engineering identity scale the team developed, some of the women have "shown twice the improvement in how they see themselves as engineers" compared to others. "It just proves how powerful storytelling can be in shaping how people view themselves," he notes.

Storytelling solidified students' sense of belonging and connection to both the field of engineering and their peers. After listening to what others went through and how it contributed to the development of their own characters, Posadas realized that his struggles were "a unique but at the same time universal experience."

Moreover, the bonds formed extend beyond the classroom, with students establishing support networks during the semester and new connections turning into long-lasting friendships—a significant takeaway for Jankowski, who also sits on the board of directors at the Story Collider. "Storytelling helps us be in community with each other,



and there is wisdom embedded in community that is so much deeper than any one of us can hold.”

For Pakala, smashing societal notions is a surprising result of telling tales. “One of the coolest things is seeing how these stories change the way people think about engineers,” he says. “Audience members start to see [them] as more relatable, breaking those old stereotypes of engineers being all brains and no heart.”

Stories in Action

The narrative skills that Ayala, Peña, and Posadas have gained are now being put to good use. Ayala, who aspires to become an aerospace engineer, is harnessing storytelling to build relationships with her professors and fellow students. Meanwhile, Posadas, now a combat engineer in the United States Army Reserve pursuing his master’s degree, is pondering how he can use tales about the built environment to make civil engineering more accessible to the public.

Peña often finds opportunities to employ storytelling—be it in a class presentation as a third-year mechanical engineering student, explaining the significance of his research findings in Boise State’s Thermal Transport and Solar Energy Lab, or especially in his recently concluded role in student government (associate vice president of student relations). He dreams of landing a job at NASA by being able to weave a story that helps him stand out. Community outreach and education is critical to NASA’s mission, Peña explains, and it’s where he sees himself exercising his narrative muscle to get people on board with the space agency’s work.

Storytelling can also be a valuable skill for engineering educators. “No matter how approachable you think you are, the power dynamic of the classroom can be cut through by an honest accounting of a personal vulnerability,” Jankowski says. He credits the story he told his materials engineering class about misinterpreting a man checking under a bathroom stall as a very respectful bow for the fact that students started to attend his office hours.

The professor encourages students to relate their experiences as well. During an office hour conversation, a student shared a story about competitive cycling, and Jankowski asked him to speak to the class about carbon fiber composite materials from a racing perspective. “Being able to talk about the feel of different frames and how those composites are structured made the polymer composites week of class come alive for us.”

He also understands his colleagues better after listening to their stories. “Helping faculty share their humanity and be more approachable and less imposing to students is [of] value,” he adds. “Being able to work together to either try ideas out in classrooms or work toward making our own teaching better are all good things. There [are] multiple ways to use reflective practices and personal storytelling to good effect.”

Pakala echoes this sentiment. “You wouldn’t usually associate storytelling with engineering, [which] is all about technical skills and hard data,” he says. “Students’ personal experiences—like overcoming a tough challenge—are just as important as the technical stuff. Storytelling helps students reflect on those moments.”

Spreading the Word

In 2023, the team received another three-year grant from NSF for a similar project with master’s and PhD students. The core methodology remains the same, with students attending a daylong workshop and each semester culminating in a public storytelling session on campus with other students and the broader public invited.

“Undergrad [students] are still figuring out who they are. There’s a lot of identity development that’s happening in real time,” explains Jankowski. “Whereas graduate students, to a greater degree, know who they are and maybe have some more traumas to talk about or more successes to share.” He continues: “There’s generally a higher maturity in both the story craft and content from the graduate students, and they also have more time to engage [with the storytelling program].”

For the next few years, the team is planning additional storytelling events and workshops to grow their impact in different contexts and disciplines—for example, helping future healthcare professionals learn to communicate complex information empathetically to patients. Pakala and Jankowski are also looking into capturing more data that could potentially link storytelling with higher retention rates in engineering programs.

Another step: publish and disseminate their results. “The ultimate goal is to make sure that what we learn is shared with other educators and hopefully spark similar programs at other schools,” Pakala says.

Envisioning the future, he hopes personal narratives can have a broader and deeper impact. “The stories we tell ourselves shape how we see ourselves,” says Pakala. “We believe that personal storytelling could be a powerful way to help our students see themselves as engineers.”

Rina Diane Caballar is a freelance writer covering technology and its intersections with science, society, and the environment.

Krishna Pakala’s image courtesy of Chandler Thornton

BY EMILY KNAPHUS-SORAN, EVE RISKIN, AND JANA MILFORD

GEARING UP

Engineering students benefit from an extra year of preparation in the "redshirt" model.

The engineering workforce benefits greatly from the knowledge and perspectives of bright minds from a variety of backgrounds. However, four-year engineering programs are typically designed for students who are calculus-ready, so many students from under-resourced secondary schools that do not offer advanced math courses face obstacles to engineering admission and degree completion. In addition to the workforce missing out on these students' contributions, such barriers limit access to the upward economic mobility that an engineering degree can provide.

In 2009, the need for an extra year of targeted support for these students inspired the creation of an engineering "redshirt" program at the University of Colorado Boulder. The name was derived from "redshirting" in college athletics, in which athletes who show great potential but are not yet ready to compete at the college level are given an additional year to prepare.

The University of Washington and Washington State University adopted the Redshirt in Engineering model in 2013. In 2016, the NSF-funded Redshirt in Engineering Consortium was formed to advance the three existing programs and expand the model to three new universities: Boise State University, University of California San Diego, and University of Illinois Urbana-Champaign.

While there was considerable variation between programs, conversations among members of the Consortium resulted in a definition of the Redshirt model centered on five key pillars: (1) a focus on supporting high-achieving students from low income or educationally disadvantaged backgrounds; (2) an expected five-year graduation timeline; (3) personal, professional, and study skills development; (4) "intrusive" advising (including proactive check-ins); and (5) community-building and social support.

Research and evaluation have demonstrated that Redshirt in Engineering programs help students develop a strong community of peers, overcome academic barriers to success in STEM courses, strengthen understanding of engineering pathways, and persist in engineering. While this body of work indicates that, overall, Redshirt programs support student success in engineering, differences exist in the scope and magnitude of outcomes across institutions and over time. An investigation of these deviations alongside insights from conversations between consortium members contributed to an emergent understanding of the essential elements of a strong Redshirt in Engineering program and refinement of the model. For example, programs were most successful at improving skills and performance in foundational STEM courses when they could establish a five-year graduation timeline that began with precalculus and offered dedicated Redshirt workshops, lab/quiz sections, and tutoring/study sessions.

The most robust Redshirt programs have been sustained by institutional resources, including budget allocations, support from fundraising personnel, and faculty time to write proposals to funding agencies. As such, the level of support required to implement a high-fidelity Redshirt in Engineering program with a full five-year curriculum requires institutional commitment to improving diversity, equity, and inclusion in engineering and computer science. Programs without funding for full-time program coordinators and/or dedicated Redshirt advisers have a harder time providing holistic support. Well-supported programs have also had the ability to establish their own Redshirt-specific courses, lab sections, workshops, and second-year programming that create an expected five-year graduation timeline.

While Redshirt programs are cost-intensive, they can offer an important pathway to engineering degree completion for their focal student populations and, in doing so, help increase diversity in engineering and computer science.

Emily Knaphus-Soran is a senior research scientist at the Center for Evaluation & Research for STEM Equity and an affiliate assistant professor of sociology at the University of Washington. She has served as the evaluator for several NSF-funded programs, including the Redshirt in Engineering Consortium. Eve Riskin is dean of undergraduate education and professor of electrical and computer engineering at Stevens Institute of Technology. She is an IEEE Fellow and recipient of a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. Jana Milford is professor emerita of mechanical engineering and environmental engineering at the University of Colorado Boulder, where she served as a faculty advisor for the Engineering GoldShirt Program.

This article is adapted from "The Redshirt in Engineering Model: Lessons Learned through Implementation Across Six Institutions," in Advances in Engineering Education *(Volume 12, Issue 1),* https://bit.ly/3UuUK9H.

READ, LEAD, SUCCEED

Book clubs can help faculty develop their teaching skills.

Faculty at research-intensive universities may have little time for teaching-focused professional development or trying new teaching strategies. Book clubs can offer a solution. They present an easy, low-cost, yet highly effective approach to faculty professional development. As most people already grasp a book club's basic format—reading and discussing a shared book—potential participants understand the expectations and may be more eager to join.

The Learning and Teaching Hub (LTH) for Arizona State University's Fulton Schools of Engineering (*https://lth.engineering.asu.edu*) provides faculty with professional development resources, communities of practice, and instructional coaching. As members of the LTH professional learning team, we initiated a teaching-focused book club with funding support from the Kern Entrepreneurial Engineering Network. Colleagues in the network had previously facilitated book clubs and found this to be an impactful professional development method for faculty.

We recruited participants through emails and hub newsletter announcements. One-hour online meetings took place three times a semester over the last two years. Each meeting started with a brief overview of the suggested readings followed by discussions on current teaching practices and new approaches. Our first book was *Small Teaching: Everyday Lessons from the Science of Learning.* It features research-based teaching strategies from cognitive psychology, neurology, and biology.

We also conducted research exploring participants' experiences. Findings revealed that book clubs helped foster professional growth, with faculty valuing the opportunity to connect with colleagues from diverse disciplines, share challenges, and explore innovative teaching methods. Participants found discussions to be the most valuable aspect, as they provided a space for exploration, reflection, and peer connection.

LTH has sustained the effort after the initial funding period, with faculty returning for multiple semesters and newcomers joining each time. Additional books have included *Teach Students How to Learn: Strategies You Can Incorporate Into Any Course to Improve Student Metacognition, Study Skills, and Motivation; Robot-Proof: Higher Education in the Age of Artificial Intelligence;* and *Geeky Pedagogy: A Guide for Intellectuals, Introverts, and Nerds Who Want To Be Effective Teachers.* Across four semesters, we have engaged 40 total participants, averaging 10–15 every semester. The online setting allowed faculty from different campuses and disciplines to share experiences and explore future collaborations.

We plan to continue hosting book clubs, recognizing their value as an accessible entry point for professional development due to the familiar structure for faculty and time savings via online meetings. Those considering similar initiatives should know that developing a supportive environment that encourages open reflection and sharing may take time; reinforcing the norm will be required every meeting and semester.

Additional tips:

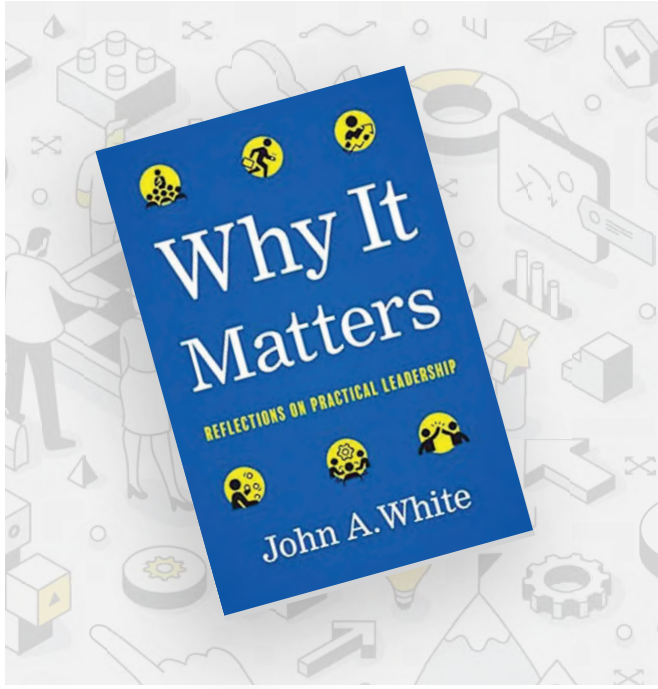
- Start with a small group (4–6 people). Scheduling meetings and getting everyone to actively participate will be easier with fewer people.
- Communicate the expectations (for example, readings to be completed in advance) and norms (for a safe space or engagement) from the beginning.
- Highlight the essential parts of the reading materials. Participants might not always have time to read everything.
- Offer flexibility in participation, conveying that just listening is okay. This reduces pressure and ensures everyone feels comfortable chiming in at their own pace.
- Encourage active listening and open dialogue, respecting different viewpoints. Set the tone by being a learner yourself, modeling curiosity. Acknowledge all contributions during discussions. This helps establish a space where participants feel comfortable sharing their thoughts, challenges, and concerns.

Book clubs offer a simple yet powerful platform for faculty professional development. How could a book club help inspire continuous learning and improvement within your teaching community?

Marcus Vinicius Melo de Lyra is a PhD candidate at The Ohio State University, focusing on teaching development and early-career faculty experiences. As a research faculty member at ASU, Medha Dalal's work seeks to address complex engineering education challenges by building capacity for stakeholders at the grassroots level, while also informing policy. Kristen Peña, senior program manager at ASU, develops professional learning initiatives for engineering faculty. *This article is adapted from a work-in-progress paper presented at the 2024 ASEE Annual Conference & Exposition. The authors acknowledge contributions of Marnie Wong, associate teaching professor at ASU, in co-facilitating the book clubs.*

EMPATHETIC LEADERSHIP, ROBOTS FOR KIDS

Why It Matters: Reflections on Practical Leadership
By John A. White
Greenleaf Book Group Press, 2022



© Amazon/Freepik

[This book] is a must-read for anyone seeking to enhance their leadership skills. White skillfully emphasizes the vital roles of empathy, kindness, and effective communication in leadership using compelling personal stories and a touch of humor. The transparency and vulnerability in his stories demonstrate the actual challenges of leadership, showing the good, the bad, and the ugly. This book is an invaluable asset for both current and future academic leaders.

Joseph J. Rencis
Associate Dean and Professor
School of Engineering, College of Aviation
Embry-Riddle Aeronautical University Worldwide

© Amazon/Envato

There's a Robot! Series
By Carlotta Berry
Rebellion Lit LLC, 2024

The *There's a Robot!* series introduces a diverse group of children interacting with robots, learning how robots work, and sharing their excitement about robotics with others. My 3-year-old son immediately connected with the story of Malika in *There's a Robot in My Closet*, asking questions about Malika's robot Rovie and commenting on [the character's] struggles to introduce Rovie to her busy family. The book has been a fun addition to the bedtime story rotation, and the series would also be a great choice for young independent readers with an interest in STEM!

Irene M. B. Reizman
Associate Professor
Alfred R. Schmidt Endowed Chair for Excellence in Teaching
Department of Chemical Engineering
Rose-Hulman Institute of Technology

Have a good book to recommend? Email prism@asee.org *with a brief writeup of a mainstream read (not textbook) that would be useful, interesting, or enlightening to fellow engineering educators. Please include why you recommend it. Wildcard submissions are also welcome (a non-job-related book that you think others should read, such as a poetry compilation, humor collection, or novel). We will run a selection of submissions in* Prism. *Writeups may be edited for length and clarity. Looking forward to your recommendations!*

MISSION-FOCUSED

With new strategic goals and a clear vision, ASEE is moving engineering education forward.

By Jacqueline El-Sayed

Hope you are well! This year I am starting my third year as ASEE CEO, sixth year on the ASEE headquarters team, and third decade as an ASEE member. How the time flies! ASEE's community has been so important to me during my growth as a professional, and it is my honor to give back to it.

Last year, ASEE launched our Listening Tour to hear from members, staff, and stakeholders. At the 2024 ASEE Annual Conference in June, our board approved the strategic goals informed by your survey responses and by virtual and in-person feedback sessions. As a not-for-profit organization, ASEE's focus is mission rather than profit, with our 2025–28 strategic plan as our guide. One of the central themes from your feedback is that ASEE is an instrumental community of practice to drive the Society's vision: education that helps students and engineering professionals create a better world.

Together, we are working to build resources and programming that will move our nation forward. As I shared in my June Annual Conference presentation, as CEO I have intentionally developed new revenue streams and aligned existing ones, including our externally funded programming, to provide increased member value, broaden participation, facilitate communities of practice (COPs), and offer thought leadership for the future of engineering and engineering technology education.

In the last year, we have continued our track record of phenomenal conferences, record-breaking abstract submissions, and award-winning publications (including *Prism*!). We are especially looking forward to ASEE's Annual Conference in Montreal, Canada, in June 2025 as an international engineering education event.

We continue to develop opportunities for members to engage. Here are just a few:

- ASEE's Capacity Building for Research at Minority-Serving Institutions program (CyBR-MSI), funded by the National Science Foundation's (NSF's) Computer and Information Science and Engineering (CISE) directorate, provides instruction and support for MSI faculty as well as sponsored research offices to build capacity to do CISE core research. Only those MSIs that have not previously led CISE core research awards are eligible to join the CoPs. Three cohorts of attendees have been awarded research funding through this program. This past year, ASEE held the first PI meeting in Denver, Colorado, bringing together awardees to network and share lessons learned. Overall, the CyBR-MSI program has impacted more than 400 MSI faculty attendees from over 160 institutions.
- At the 2024 ASEE Annual Conference and the Engineering Technology Leaders Institute, we held planning meetings for the national community college convening slated for December in Indianapolis, Indiana. The event aims to strengthen the pathway between two- and four-year institutions and support students in achieving bachelor's degrees in engineering and engineering technology. The work is supported by NSF.
- ASEE's collaboration with the Lemelson Foundation has matured and expanded. The Engineering for One Planet Mini-Grant Program (EOP-MG) was awarded additional funding to continue to support faculty teams in integrating sustainability into their curriculum through facilitated CoPs and supportive mini grants. EOP-MGP has now supported three cohort CoPs and provided exciting sessions at ASEE's conferences.
- The Archival Publication Authors Workshop for Engineering Educators (APA-ENG), funded by the Kern Family Foundation, provided support for two CoP cohorts of faculty on the scholarship of teaching and learning and on drafting manuscripts. In the past year, the lessons learned from this program were used to develop two new ASEE Learning courses: Essentials of Effective Manuscript Preparation and Beginning Research in Engineering Education: Designing Quantitative and Qualitative Studies.
- The Minority Mentoring Program (MMP), funded by Chevron, has also expanded. The MMP facilitates mentoring between junior women faculty and experienced women mentors. The program has been expanded and just launched a new cohort.
- ASEE's engineering postdoctoral fellowship, eFellows, continues to place new engineering PhDs at campuses across the country, funded by NSF. This program's impact was recently recognized by the leader of the agency's Engineering Directorate at the recent Division of Engineering Education and Centers grantees meeting. The program's impact was so significant that we created a new website to share success stories (*efellowsimpact.asee.org*). In addition, NSF awarded funding for a fourth cohort!
- ASEE's consortia and national thought leadership produced formal products (publications, videos, books, etc.) on the Industry Summit, the Inclusive Engineering Mindset, and Defining and Building the Engineering Workforce of the Future.

On behalf of ASEE HQ, I hope you enjoy our most recent award-winning *Prism* magazine. As a longtime ASEE member myself, I have always enjoyed reading the magazine and learning more about our communities of practice, innovations, and shared work.

Jacqueline El-Sayed is CEO and Executive Director of ASEE.

ASEE ISSUES STATEMENT SUPPORTING ACADEMIC FREEDOM AND TENURE

In collaboration with other engineering societies, ASEE has released a new position statement on academic freedom and tenure. ASEE led the creation of the joint statement due to the Society's focus on engineering education, as well as its membership that is largely comprised of engineering academics.

Signatory organizations, who will also promote the statement via their own channels, include Advancing Indigenous People in STEM (AISES), DiscoverE, National Association of Multicultural Engineering Program Advocates (NAMEPA), Society of Asian Scientists and Engineers (SASE), Society of Women Engineers (SWE), The Minerals, Metals & Materials Society (TMS), and Women in Engineering ProActive Network (WEPAN).

For the full list, go to https://bit.ly/4en7RB3.

Statement in Support of Academic Freedom and Tenure

On behalf of the national engineering professional societies listed below, we are writing to express our views about pending and current state legislation that may weaken academic freedom and tenure in higher education.

We believe that freedom to express differing viewpoints strengthens both higher education and society as a whole. Academic freedom allows faculty to perform research without pressure to reach a particular conclusion, and it empowers scholars to explore ideas, challenge norms, and engage in open discourse. It fuels innovation, embraces diverse perspectives, and drives social progress.

We also believe that a strong tenure system is essential to helping ensure academic freedom. Tenure safeguards intellectual independence. It allows professors to pursue ambitious research, mentor students, and contribute to a long-term vision for their institutions and for society as a whole. Faculty members who are tenured cannot be summarily dismissed from the faculty of the institution, but tenured faculty members may be removed for cause (such as violating the institution's policies or procedures or for committing academic dishonesty). They may also be removed from employment based on financial constraints or when a program is terminated.

Laws that are currently being considered and others that have already been passed in certain state legislatures are weakening academic freedom and tenure and threaten to eliminate them entirely.

The signatories of this letter emphasize our support of academic freedom and the tenure system, and we oppose any law that acts to weaken them.

A TAXONOMY OF FUTURE ENGINEERING COMPETENCIES

By Russell Korte and Sarah DeLeeuw

With rapid and radical changes in engineering and technology, there is an urgent need to evolve the way we prepare engineering students for their careers. To better inform this shift, ASEE convened two groups of engineers and engineering educators for the Future-Ready Engineering Ecosystem (FREE) workshops, with the goal of developing a taxonomy of competencies for engineers of the near future.

The first group, about 50 people, included representatives from two major realms of the engineering ecosystem: higher education and industry. This group was charged with envisioning what engineering might contribute to our future—in particular, through such emerging technologies as artificial intelligence, machine learning, advanced manufacturing, quantum information science, data science and analytics, advanced communication networks/5G, and biotechnology.

Through various exercises, the group envisioned engineering's potential contributions to solving society's challenges in the next 10 years. The first convening focused on developing the comprehensive taxonomy of competencies needed by engineers to deliver value to society.

Participants across breakout groups emphasized not only technical competence but also professional and personal competence. We followed a common model of competencies that distinguishes three interrelated aspects—the KSAs: 1) Knowledge (what one knows), 2) Skills (what one can/will do), and Attributes (who one is or identifies as). The groups identified a wide range of competencies that were thematically analyzed, then categorized as either technical or personal/professional (see p. 27).

The second convening included approximately 150 participants from across the engineering ecosystem and focused on action plans to develop identified engineering competencies in engineering students—specifically in higher education. Guiding these action plans was a belief that engineers of the future would need a more holistic range of capabilities to collaborate beyond the historical boundaries of engineering fields.

Knowing that organizational change is complex and extremely difficult, the group developed a rubric to guide the process of developing more holistic engineers. The Framework and Rubric for Action describes change at three levels in higher education: individual/classroom, program, and institution. We also noted that shifting to a competency-based educational model is controversial. The taxonomy and rubric are presented as guidelines, not prescriptions, for the continuous change that is needed to better educate and prepare engineering students for the future.

Russell Korte is rapporteur and analyst of the FREE project and associate professor of human and organizational learning at The George Washington University. Sarah DeLeeuw is ASEE's director of research projects, innovation, and strategic direction.

Learn more and access Preparing Engineering Students for the Future: Report of the Future-Ready Engineering Ecosystem (FREE) Workshops, *by Jacqueline El-Sayed, Sarah DeLeeuw, and Russell Korte, at* https://free.asee.org.

THE FREE COMPETENCY TAXONOMY

TECHNICAL			PERSONAL/ PROFESSIONAL		
1.0 Technical Knowledge	**2.0** Technical Skills	**3.0** Technical Attributes	**4.0** Personal/ Professional Knowledge	**5.0** Personal/ Professional Skills	**6.0** Personal/ Professional Attributes
1.1 Know and understand emerging fields in engineering, including theoretical and practical knowledge of emerging technologies	**2.1** Manage and perform the work of emerging technologies and engineering fields	**3.1** A Scientist-Engineer	**4.1** Know and understand general and multi-disciplinary knowledge	**5.1** Continuously learn and explore	**6.1** Value integrity, ethical and moral values
1.2 Know and understand existing fields in engineering, including theoretical and practical knowledge of emerging technologies	**2.2** Manage, model, and process data to create meaningful information and knowledge	**3.2** A Problem-Solver	**4.2** Knowledge of global, cultural, and societal issues	**5.2** Lead, support, and collaborate with people	**6.2** Respectful, collaborative, and civically engaged
1.3 Know and understand perspectives of multiple disciplines, stakeholders, and communities	**2.3** Design, conduct, and communicate technical and scientific information	**3.3** A Project Manager	**4.3** Know and understand oneself	**5.3** Act in a globally inclusive manner	**6.3** Committed to personal and societal development, well-being, and lifelong learning
1.4 Know and understand practical reasoning	**2.4** Design solutions for people and planet			**5.4** Work in cooperative/ collaborative ways with diverse team members, stakeholders, clients/customers	
	2.5 Design for sustainability				
	2.6 Design, change, and integrate multiple systems (technical, human, business, financial)				
	2.7 Manage multi-disciplinary projects				

PRISM QUEST

Can you decipher the clues and discover the words from this issue?

Z	V	T	F	M	T	W	P	G	E	Y	F	E	L	L	E	J	J	H	V
N	E	C	T	S	T	E	A	D	Z	G	M	A	X	W	V	A	Z	G	C
I	L	Z	H	Y	G	I	S	T	A	X	O	N	O	M	Y	H	O	Q	O
C	N	P	M	S	N	C	S	C	O	Q	G	S	X	T	L	P	A	T	W
T	I	W	Q	T	D	N	I	Y	D	G	W	F	H	O	G	Z	I	I	S
F	C	S	T	E	R	E	O	T	Y	P	E	S	E	A	N	O	F	O	P
U	G	L	Z	M	L	H	N	P	A	I	N	T	E	I	M	W	G	P	C
W	Y	L	U	S	B	Y	X	S	D	T	H	H	W	G	S	Z	F	O	D
I	I	V	J	B	G	P	N	U	E	A	I	U	T	H	I	F	M	S	U
O	E	I	K	A	S	T	N	A	A	Z	H	Z	K	R	K	U	N	S	S
R	E	D	S	H	I	R	T	I	N	G	J	Z	D	C	H	W	Y	V	L
D	X	Q	I	K	L	S	K	R	L	Q	J	C	U	P	V	J	F	K	J
J	I	F	P	T	T	I	E	F	V	G	P	L	V	N	C	U	V	L	Z
C	O	N	F	I	D	E	N	C	E	U	T	O	F	P	G	G	B	N	R
X	Y	E	P	V	E	U	X	X	V	G	B	F	V	Q	V	X	U	M	Z

Clues:

1. Between 2017 and 2023, girls' interest in STEM increased but their _____ in their math and science abilities decreased.
2. Upinder Kaur has developed a _____ to collect real-time data from a cow's stomach.
3. e4usa has been a "_____ project" for NSF deputy assistant director for engineering Don Millard.
4. _____ can give students from under-resourced secondary schools an extra year of targeted support.
5. Colombian start-up Glasst has invented a _____ paint called Unpaint.
6. Joseph Bell is the first Native engineering _____ in the US.
7. According to Krishna Pakala, storytelling can help dismantle _____ of engineers.
8. _____ clubs can aid in faculty professional development.
9. The FREE report provides a taxonomy of engineering _____ for the future.
10. ASEE member Robert Bordley advocates for the use of _____ engineering in introductory engineering courses.

Confidence
Rumenbot
Passion
Redshirting
Peelable
Dean
Stereotypes
Book
Competencies
Systems

Thoughts on this new section? Too easy, too hard, just right? Send your feedback to prism@asee.org.

ASEE's DELTA (Δ) (Developing Engineering Leaders of Tomorrow in the Academy) Institutes are designed to provide engineering and engineering technology faculty with the knowledge and tools needed to succeed at all stages of the faculty career.

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