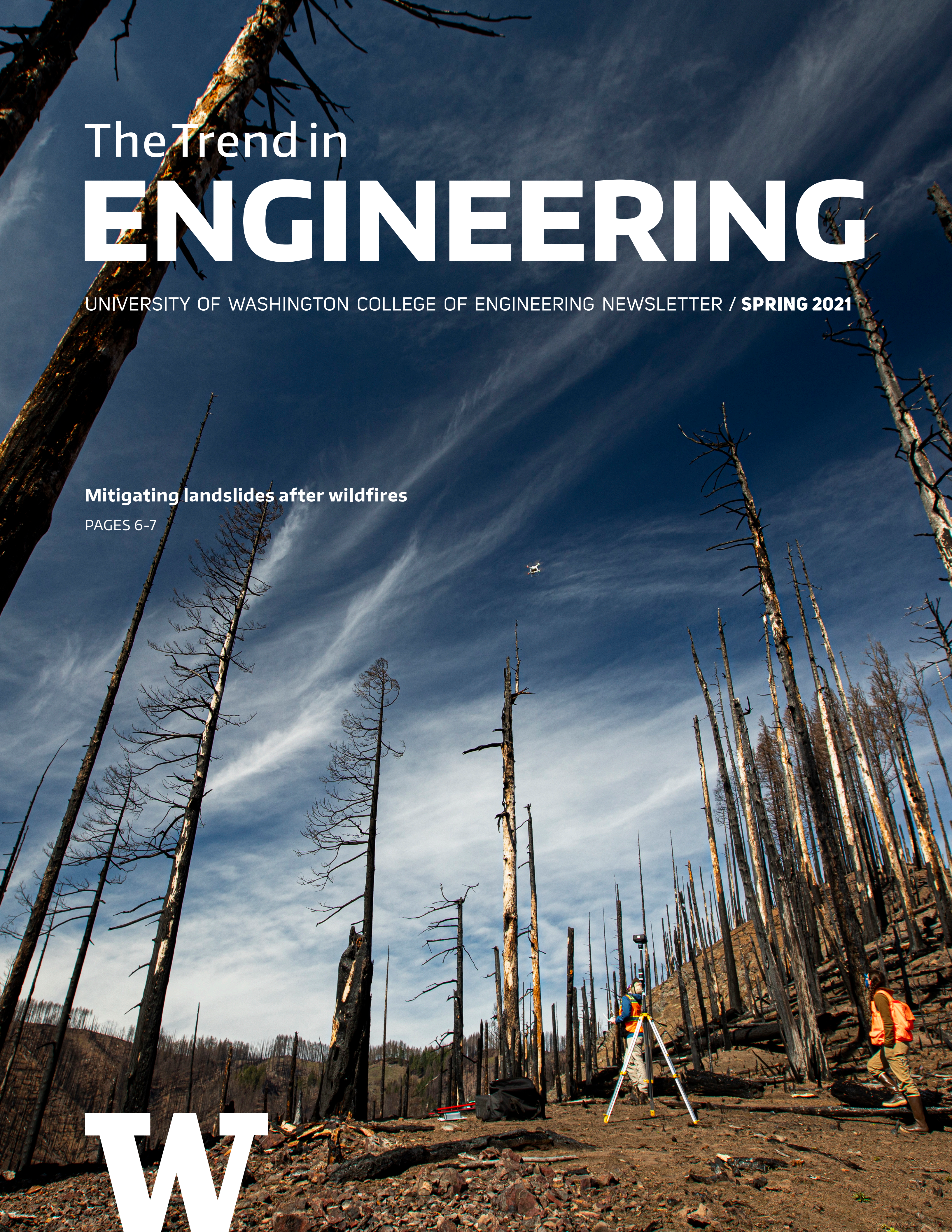
The Trend in ENGINEERING

UNIVERSITY OF WASHINGTON COLLEGE OF ENGINEERING NEWSLETTER / **SPRING 2021**



Mitigating landslides after wildfires

PAGES 6-7

FROM THE **DEAN**

Last spring, the University of Washington became the first in the country to announce that classes would be conducted remotely. At the time, we had little idea what the future held. Through this challenging year, we've experienced individual and collective hardship, loss and injustice. And, we've been reminded of the power of community.

As UW President Ana Mari Cauce has said, just keeping the train on the tracks at our University would have been a significant accomplishment, but our community's achievements have far exceeded that benchmark. This is certainly true for the College of Engineering. In our labs, researchers have attacked COVID from all sides. Our faculty and staff have pushed forth with research and innovated their teaching. Our students have been resilient. Perhaps most significantly, our community has taken up the call to ensure we rebound from this crisis grounded in equity and inclusion.

In preparation for a brighter future, I have been honored to work alongside faculty and staff this year on not only an ambitious strategic plan for the College, but on shifts toward making the College more welcoming for all. Karen Thomas-Brown has recently joined us as the College's new associate dean of diversity, equity and inclusion, and I look forward to expanding our work with her expertise.

As we move toward resuming in-person instruction and returning to hands-on, team-based project learning, the need for excellent facilities is of utmost importance. The new Interdisciplinary Engineering Building is a public-private partnership that the state has supported with pre-design and design funding. I'm thrilled to share that the state has committed $45.4 million in capital funds for the construction of the building. I'm so appreciative of our elected officials and thank them for investing in engineering expansion. Their continued support of engineering has allowed us to serve more Washington state students and to provide industry with well-trained engineers.

I remain committed to building a solid educational experience, to expanding opportunity for all students, and to advancing research and innovation for the greater good. I believe that together we will continue to transform engineering at the UW. I hope you'll join us on this journey.

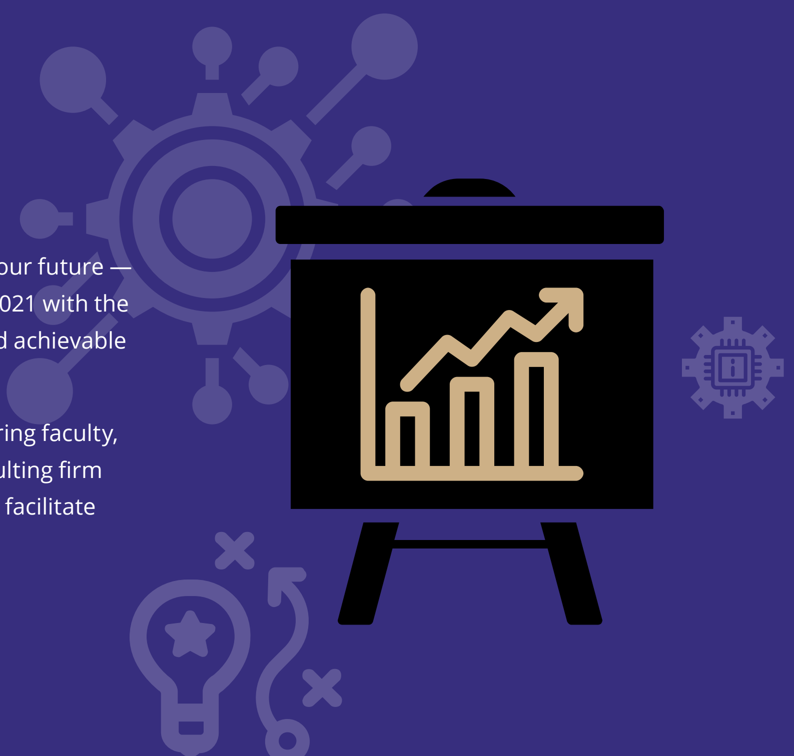
Nancy Allbritton, Ph.D., M.D.
Frank & Julie Jungers Dean of Engineering

COMING SOON:
Strategic plan 2021-2026

In Autumn 2021, the College will share its vision for the future of engineering.

The College of Engineering has launched an important initiative for our future — an inclusive and wide-ranging effort that will culminate in Autumn 2021 with the release of a strategic plan that articulates a bold, transformative and achievable vision for the College.

Along with a 25-member steering committee comprised of engineering faculty, staff and students, the College is working with AKA Strategy, a consulting firm with extensive experience in higher education strategic planning, to facilitate the process.



Learn more about the planning process and emerging themes at engr.uw.edu/about/strategic-plan

Karen Thomas-Brown
named Associate Dean for Diversity, Equity & Inclusion

Karen Thomas-Brown joins the UW from the University of Michigan-Dearborn (UM-D), where she was a professor in the College of Education, Health & Human Services. As associate dean for diversity, equity and inclusion, she will lead the College's efforts to become an accessible, welcoming and inclusive community by leveraging her expertise to develop best practices and guidelines.

At UM-D Thomas-Brown helped to create the Center for Disparity Solutions & Equity and served on the University of Michigan Anti-Racism and Fairness and Inclusion committees, the faculty senate and the state of Michigan Department of Education Anti-Racism Educator Taskforce.

Through diversity and inclusion consultancy, she has specialized in designing diversity and inclusion policy, assessing practices, measuring outcomes, and developing and implementing leadership training. She has led a series of corporate conversations on race in America in response to the protests over racial injustice and inequities.

Thomas-Brown holds a Ph.D. in geography from the University of the West Indies and University of Liverpool and professional certificates in executive leadership, performance leadership, change management, and diversity and inclusion from Cornell University.

Image courtesy of McGranahan Architects

Next steps for the IEB

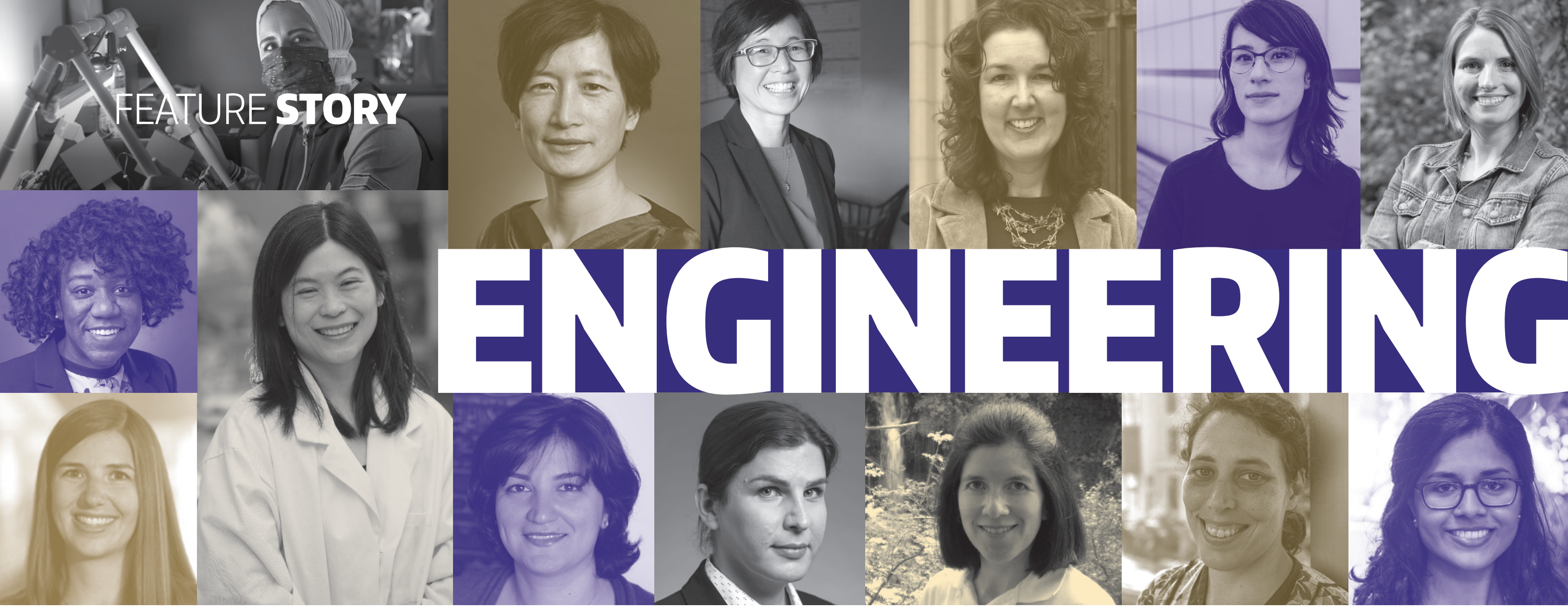
Serving as "engineering central," the new Interdisciplinary Engineering Building (IEB) will provide much needed space for student learning and engagement.

Plans for the College's newest building, the IEB, are underway. The UW has selected a contractor, Hensel Phelps, as well as a project architect, KieranTimberlake. Design work is in process with the input of a College-wide building planning committee to ensure that the interests of all departments are represented. The IEB will be situated on campus between the UW Club and the Engineering Library.

The IEB project is devised as a public-private partnership. The Washington State Legislature funded pre-design and design of the IEB in previous sessions. This session the state dedicated $45.4 million in capital funds to construct the building. These funds are to be matched with internal resources and private gifts.

The new building will provide much needed interdisciplinary space for project-based learning, which will benefit all departments by better preparing first-year students to matriculate into majors and support student participation in collaborate research and projects. Dedicated space for industry sponsored capstone projects will strengthen connections between the UW and industry. The new building will also house programming for leadership, diversity and access.

Learn more about our plans and how you can help at engr.uw.edu/facilities



ENGINEERING

By Sarah DeWeerdt

The ADVANCE Center for Institutional Change celebrates 20 years of supporting women faculty and developing leaders in STEM fields at the UW.

When associate professor of materials science and engineering Christine Luscombe was pregnant with her first child in 2017, she wondered how she would be able to take time off to welcome her baby without derailing her career. The dilemma, familiar to many parents, was especially acute for Luscombe because she would be the first in her department to give birth as a faculty member, and the department lacked maternity leave policies.

Fortunately, Luscombe knew where to turn: the UW ADVANCE Center for Institutional Change, a program that promotes advancement of women faculty in science, technology, engineering and mathematics (STEM) fields, including the College of Engineering.

UW ADVANCE faculty director Eve Riskin worked with Luscombe's department chair to sort out a maternity leave plan, and even helped find her a daycare spot. "They really step up to the plate and in cases where there's just no other example in that department they really advocate for you," Luscombe says of the program and its staff.

The benefits of diversity

Luscombe's experience is just one example of how ADVANCE has helped the College of Engineering attract and retain women faculty members. The percentage of female faculty has doubled since the program was launched 20 years ago, from 13.9% in 2001 to 26.3% today. UW Engineering has consistently had the highest or one of the highest percentages of female faculty representation in engineering schools nationwide. Six out of ten department heads in the College of Engineering are women.

What's at stake goes beyond statistics. "There's a wealth of literature saying that diverse teams come up with better solutions," says Riskin, who is also a professor of electrical and computer engineering. Diverse teams come up with more creative, out-of-the-box ideas. And they can help avoid subpar results, such as automatic soap dispensers that don't recognize dark skin, or crash test dummies that don't reflect women's smaller body sizes.

The benefits of gender diversity happen at the university level, too. Having a high percentage of women on faculty helps attract more female faculty members. Female students are more likely to perform better and stay in STEM when they see themselves reflected in their mentors; male and female students alike broaden their conception of what engineers look like.

ADVANCE at the UW

The ADVANCE program began in 2001 with a five-year, $3.75-million grant from the National Science Foundation (NSF), part of an NSF effort to encourage universities to examine their procedures and help women succeed as faculty members. Denice Denton, then the dean of the College of Engineering (and the first female engineering dean at a large research university), was the grant's principal investigator.

Denton brought an "engineering ethos — let's try it, let's iterate, let's problem solve, let's get it done," says Joyce Yen, director of UW ADVANCE. "I think that's still a legacy of Denton's leadership."

When Denton left the UW in 2004, she tapped Ana Mari Cauce, then professor and chair of psychology, to take over. Cauce was named dean of the College of Arts & Sciences while she was leading ADVANCE and remained involved until she became UW president in 2015.

Equity

"It's essential that higher education continues to deepen the bench of talented, well-trained leaders who represent the full spectrum of perspective and experience reflected in our students and the public we serve," says Cauce. "ADVANCE is helping to foster the diverse leadership we need and to create the cultural and institutional change that must come with it. It was one of my greatest honors to have been a member in its earlier stages."

ADVANCE's activities range from meetings with prospective women faculty members as part of the recruitment process to advice on navigating tenure to workshops for department chairs and deans. Many of the skills needed to succeed in academia, such as how to write a grant proposal or how to be a fair and effective dean, aren't formally taught, and people from traditionally underrepresented groups tend to be excluded from informal knowledge transfer. ADVANCE aims to rectify that.

Kristi Morgansen, who joined the UW in 2002 and is now chair of the William E. Boeing Department of Aeronautics & Astronautics, took part in one of the program's first peer mentoring groups. "I was the first and only female faculty member in my department at that time, so having some other women faculty to look to for peers really had to happen outside my department," she says.

"ADVANCE is helping to foster the diverse leadership we need and to create the cultural and institutional change that must come with it."

UW PRESIDENT ANA MARI CAUCE

Such opportunities for peer support and mentoring continue throughout the career path, including a monthly lunch series featuring women guest speakers in leadership positions. When Luscombe first came to UW, "considering a leadership position was not on my radar at all," she says. "But seeing these women take on very powerful positions in universities made me realize that pathway was possible." Today, she's serving as interim chair of her department.

Looking ahead

There's still work to be done, Riskin and others involved in ADVANCE say — particularly around race, ethnicity and disability status. And sometimes unpredictable challenges emerge, as has happened with the coronavirus pandemic, the career burden of which has fallen disproportionately on women, especially women of color.

Earlier this year, ADVANCE awarded grants to six engineering faculty members dealing with increased caretaking responsibilities as a result of the pandemic. These grants are designed to tide faculty over when they have a child, a health crisis or other life event that makes it difficult for them to maintain lab funding.

Programs like this may help explain why ADVANCE has lasted for two decades — and shows no sign of stopping. "It's so incredible that we have been around for as long as we have, and one of the things that I think is really powerful about that is that it means that we are doing something right," Yen says.

A BURNING NEED

RESEARCHERS GATHER DATA TO UNDERSTAND AND MITIGATE POST-WILDFIRE LANDSLIDE HAZARDS.

By Brooke Fisher Photos by Mark Stone / University of Washington

The megafires that turned more than seven million acres of West Coast land into smoldering rubble last summer left behind something valuable for researchers: perishable data.

“Seeing this ongoing and growing threat from wildfires, I think it is a prelude of what’s to come,” says civil and environmental engineering (CEE) professor Joe Wartman, who directs the Natural Hazards Reconnaissance Facility, known as RAPID. “There are long-term lingering effects of these wildfires that we don’t fully understand — and which can significantly impact affected communities.”

Funded by the National Science Foundation and headquartered in CEE, RAPID supports data acquisition in the aftermath of natural disasters. It’s the first center of its kind in the world. Researchers like Wartman work with universities, government agencies and international organizations to conduct natural hazards reconnaissance missions. Since launching in 2018, RAPID has responded to more than 70 natural disasters, including hurricanes, earthquakes, tsunamis, landslides and wildfires.

After the 2020 megafires, RAPID partnered with researchers on the West Coast to gather perishable data. The most immediate use of the data will be to better understand a type of landslide called post-fire debris-flow, which has resulted in numerous deaths.

NEEDED: A BETTER WARNING SYSTEM

Although extinguished, megafire flames have sparked another looming disaster: post-fire landslides triggered by heavy rain. This hazard results from chemical changes to soil during extreme burning, which can form an organic coating on the soil that repels water, causing rain to run off rather than be absorbed into the ground. Collecting mud and debris, the runoff can be life-threatening as it rushes downhill.

To improve warning systems, researchers are updating the federal government’s models for post-fire slope stability hazards. This project has gained urgency following several deaths: 23 people were killed in Southern California in 2018 and one in Oregon in January 2021.

However, although post-fire landslide warning systems exist in Washington and Oregon, they are largely ineffective. This is because they're based on data from Southern California's advisory system and weather conditions that have produced landslides in the past.

"The issue with that is they do not account for the effects of fire," Wartman says. "What's really important about this data set and one reason why the early warning advisories can be inaccurate is that they are developed for routine conditions where there was no fire involved."

Utilizing data from California is problematic because the climate, geology and vegetation is distinct from the Pacific Northwest, causing post-fire hazards to behave differently. While landslides are common in Southern California for the first year following a fire, they are uncommon in the Pacific Northwest until several years later. Researchers suspect this may be due to different vegetation and tree root decay.

"In the Pacific Northwest, it takes three to four years for the tensile strength of tree roots to decay, causing them to lose 90% of their strength," says lead researcher Josh Roering, a professor of earth sciences at the University of Oregon. "The trees would have provided root reinforcement on the soil. You can think of it like nature's rebar."

A case in point, says Roering, is the Eagle Creek fire, which occurred in Oregon's Columbia River Gorge in 2017. Recently, a significant storm came through and triggered a post-fire landslide that took the life of a woman driving along Interstate 84 in January 2021 — four years after the original fire.

GATHERING DATA, SPARKING RESEARCH

Even for researchers accustomed to collecting disaster data, the post-wildfire sites can be startling.

"There's a different kind of totality and depth to the destruction," says Wartman, who has participated in a dozen reconnaissance missions. "It's an assault on all the senses — the smell of fire and soot everywhere, which you can taste in the air. It's visually arresting to see everything distilled down to a pile of ashes."

Three sites in Oregon were selected for data gathering: Finn Rock, east of Eugene, which was devastated by the Holiday Farm fire; Bogus Creek in southern Oregon, struck by the Umpqua National Forest fire; and Dodson, east of Portland, impacted by the Eagle Creek fire.

"We have to be careful walking around," says Mike Grilliot, RAPID's operations manager. "A normal hill would have ferns and mosses that would feel solid, but it's like a slippery slope on a mountain. We take two steps forward and one step back."

Cover: At Bogus Creek in southern Oregon, RAPID engineers pilot a drone to collect aerial imagery.

Opposite page: Researchers carry instrumentation up a ridge to find a better line of sight to pilot a drone.

This page: RAPID operations manager Mike Grilliot operates laser scanning equipment.

To document the condition of post-fire hillsides in areas likely to experience debris flow, researchers collected high-resolution aerial imagery and lidar data, which will be used to generate 3D images that show detailed topographic information. This will be used to map post-fire sediment and debris loading of channels and to monitor erosion. By documenting the landscape in the immediate aftermath of a fire, especially before vegetation recovers, researchers can then revisit the sites following significant storms to document changes.

Once the data is ready for analysis, it will be made available to the broader research community through a repository called DesignSafe-CI, which not only archives data but has helped standardize procedures for sharing results. Wartman expects the data set will be utilized by researchers for several projects, such as investigating contaminated groundwater, tracking vegetation recovery, and studying large-scale erosion unrelated to landslides.

"There's a lot of interest in collecting post-wildfire data to understand how the landscape will heal and change in the aftermath," Wartman says. "We now have a data set that will provide a baseline on some of the longer-term environmental aspects of fire."

The CARBON FIBER STATE

By Andy Freeberg

A key enabling material of the 21st century, carbon fiber plays a notable role in Washington.

Just as silicon is the material that underlies the innovation ecosystem of Silicon Valley, so carbon fiber is to the state of Washington, the world leader in carbon fiber composite manufacturing.

Advances in air travel, renewable energy, space exploration, transportation and other industries rely on its growing use. As the state's top research institution, the UW is a leader in carbon fiber innovation — and in understanding its impacts on public health, safety and the environment. UW research promises breakthroughs in improved manufacturing techniques, better standards and validations, and support for the transition to more sustainable and versatile versions.

"Anything where quality and weight matter, these have become the materials to use," says mechanical engineering professor Santosh Devasia, who directs the Advanced Composites Center (ACC), a new initiative dedicated to advanced composites research and education.

What is a carbon fiber composite?

Stronger than steel and lighter than aluminum, carbon fiber materials are a key technology in carbon fiber composite manufacturing. Materials typically thought of as carbon fiber, whether in road bikes or airplane hulls, are really carbon fiber composites and comprise two main parts: the threads of carbon themselves, and a matrix, which is the material binding them together.

"With carbon fiber you have to know the direction your load will be applied and embrace the way you align the fibers to withstand that force," says Marco Salviato, associate professor of aeronautics and astronautics and an ACC co-director.

Above: Carbon fiber used for building the Boeing 787 aircraft. Photo courtesy of The Boeing Company

It was clear soon after carbon fiber came out of the labs in the 1960s that these materials were special. The Boeing Company began using carbon fiber in various components in the 1980s and gradually an entire supply chain sprung up. At 50% composite by weight, the 787 aircraft raised the bar and showed the world what could be done. Today there are an estimated 1,400 companies and 130,000 jobs in Washington that involve advanced composites.

UW's role in the carbon fiber ecosystem

Aviation is one of many industries relying on these materials. Blue Origin, PACCAR and Electroimpact — all College of Engineering industry partners, as is Boeing — are a few of the major companies invested in advanced carbon fiber in Washington.

Researchers say there's a long way to go to improve carbon fiber composites, particularly when it comes to data-driven manufacturing techniques and recyclability. To drive the future of carbon fiber and related materials, the ACC is constructing a 16,000 square foot facility north of campus at Magnuson Park.

The ACC will be a hub for setting standards, validating ideas and growing the ranks of engineers experienced in these materials. UW engineers already work with the materials regularly, using them for device prototypes, student clubs and an array of research projects. Those opportunities will greatly expand when the ACC is finished, cementing Washington's role as a world leader in carbon fiber for years to come.

Learn more at depts.washington.edu/uwacc

Mari Ostendorf elected to NAE

By Ryan Hoover

Membership to the National Academy of Engineering is one of the highest professional distinctions in engineering.

Mari Ostendorf, Endowed Professor of System Design Methodologies in Electrical & Computer Engineering (ECE), was elected to the National Academy of Engineering (NAE) in February. She is among 106 members and 23 international members newly elected to the academy this year.

"I am tremendously honored to be selected as a member of the NAE and humbled to be joining a group of colleagues who have made such important contributions to the field of engineering," says Ostendorf. "It is especially a privilege to be listed with my distinguished ECE colleagues, Professors Emeriti Akira Ishimaru and Irene Peden."

Membership in the academy recognizes individuals for their outstanding contributions to engineering — from research to practice to education, and for pioneering new and developing fields of technology or making major advancements in traditional fields of engineering. Ostendorf was elected for her contributions to statistical and prosodic models for speech and natural language processing and for advances in conversational dialogue systems.

By Sarah McQuate

"Alexa, monitor my heartbeat"

UW researchers develop an AI system to detect abnormal heart rhythms using smart speakers.

Researchers in the Paul G. Allen School of Computer Science & Engineering and UW Medicine have developed a way to screen for irregular heartbeats using smart speakers, such as Amazon Echo and Google Home devices. When tested on healthy participants and hospitalized cardiac patients, their system detected heartbeats that closely matched beats detected by standard monitors.

The speaker sends inaudible sounds into a room and, based on the way they are reflected back, can identify and monitor individual heartbeats. Because heartbeats are tiny chest motions, the team's system uses machine learning to help the smart speaker locate signals from both regular and irregular heartbeats.

"Regular heartbeats are easy enough to detect even if the signal is small, because you can look for a periodic pattern in the data," explains Allen School associate professor Shyam Gollakota. "Irregular heartbeats are challenging because there is no such pattern."

The team designed a machine learning algorithm that combines signals from the smart speaker's multiple microphones to identify the elusive heartbeat signal. This is similar to how Alexa can follow the instructions of one person in a room even when multiple people are talking.

Currently this system works best if a person sits in front of a smart speaker to get a reading. The team hopes that future versions could continuously monitor heartbeats while people are asleep, something that could help diagnose conditions such as sleep apnea.

"If you have a device like this, you can monitor a patient on an extended basis and define individualized patterns and care plans," says Dr. Arun Sridhar, assistant professor of cardiology in the UW School of Medicine. "This is the future of cardiology. The beauty of using these devices is that they are already in people's homes."

Above: Allen School doctoral student Anran Wang sits with the smart speaker prototype (white box in foreground) the team used for the study. Photo by Mark Stone / University of Washington

RESEARCH NEWS

The Long Fuse

By Jackson Holtz

The UW Center for an Informed Public and collaborators investigate mis- and disinformation surrounding the 2020 U.S. election.

The Election Integrity Partnership (EIP), a nonpartisan coalition of research organizations, including the UW Center for an Informed Public, released "The Long Fuse: Misinformation and the 2020 Elections" in March. This report is the culmination of months of collaboration, which has involved identifying, tracking and responding to voting-related mis- and disinformation during the 2020 U.S. elections. Human Centered Design & Engineering associate professor Kate Starbird is one of the Center's principal investigators.

Key findings include:

- Misleading and false claims and narratives coalesced into the metanarrative of a "stolen election," which later propelled the January 6 insurrection in Washington, D.C.
- Narrative spread was cross-platform: Repeat spreaders leveraged the specific features of each platform for maximum amplification
- The primary repeat spreaders of false and misleading narratives were verified accounts belonging to partisan media outlets, social media influencers, and political figures, including President Trump and his family
- Many platforms expanded election-related fact-checking and moderation policies during the 2020 election cycle, but application of moderation policies was inconsistent or unclear

According to the report, the 2020 federal election demonstrated that foreign and domestic actors remain committed to weaponizing viral false and misleading narratives to undermine confidence in the U.S. electoral system and erode Americans' faith in our democracy. Mis- and disinformation were pervasive throughout the campaign, the election and its aftermath, spreading across all social platforms, the report found.

Read the full report: atlanticcouncil.org/in-depth-research-reports/the-long-fuse-eip-report-read/

Cell organization sees the light

By James Urton

Researchers take a major step toward laboratory-grown organs and tissues.

Imagine visiting a surgeon to have a diseased or injured organ replaced with a fully functional, laboratory-grown substitute. This remains science fiction because researchers struggle to organize cells into the complex 3D arrangements that our bodies master on their own.

There are two major hurdles to overcome on the road to laboratory-grown organs and tissues. The first is to use a biologically compatible 3D scaffold in which cells can grow. The second is to decorate that scaffold with biochemical messages in the correct configuration to trigger the formation of the desired organ or tissue.

In a major step toward transforming this hope into reality, UW researchers developed a technique to modify naturally occurring biological polymers with protein-based biochemical messages that affect cell behavior. Their approach uses a near-infrared laser to trigger chemical adhesion of protein messages to a scaffold made from biological polymers such as collagen, a connective tissue found throughout our bodies.

"This approach provides us with the opportunities to exert greater control over cell function and fate in naturally derived biomaterials — not just in three-dimensional space but also over time," says Cole DeForest, an associate professor of chemical engineering and of bioengineering.

Detecting COVID-19 in wastewater

By Brooke Fisher

UW researchers identify outbreaks by neighborhood.

Running underneath just about every residential home, apartment building, college residence hall and nursing home is a surprisingly valuable resource for detecting and monitoring COVID-19 outbreaks by neighborhood: the sewer system.

To more quickly and economically detect COVID-19 outbreaks, and reduce the burden of individual testing, researchers are working to introduce a testing system that utilizes wastewater samples from Seattle neighborhood pump stations. Additional benefits include accounting for asymptomatic people and reaching vulnerable populations, such as lower-income communities with higher rates of infection and less access to healthcare and individual testing.

"Across the world, people have been thinking about using the sewer to check for the virus, but most focus on wastewater treatment plants, where the signal is very diluted as the wastewater comes together from all kinds of households and industrial facilities in the area," says civil and environmental engineering assistant professor Mari Winkler. "To locate the infection within a zip code, our idea was to check the pump stations."

Located in neighborhoods, pump stations help transport and funnel raw sewage to larger wastewater treatment plants, which typically serve municipalities. By collecting sewage samples from neighborhoods, community outbreaks can be identified while protecting people's privacy.

Their method involves extracting RNA from the samples and analyzing it for the SARS-Cov-2 virus. By dividing the amount of virus contained in the RNA by the amount of ammonia or phosphorus from the same samples, they can determine an approximate percentage of people with the virus.

Teaching AI to play piano

By Sarah McQuate

UW researchers introduce Audeo, a system that can generate music using only visual cues of someone playing the piano.

Thanks to machine learning and nearly 200,000 frames from YouTube videos of pianist Paul Barton, UW researchers have developed Audeo, a system that produces audio from silent piano performances.

"To create music that sounds like it could be played in a musical performance was previously believed to be impossible," says Eli Shlizerman, an assistant professor of applied mathematics and of electrical and computer engineering. "An algorithm needs to figure out the cues, or 'features,' in the video frames related to generating music, and it needs to 'imagine' the sound. It requires a system that is both precise and imaginative."

To decode what's happening in a video and translate it into music, Audeo first must detect which keys are pressed to create a diagram over time. Then it translates that diagram into something that a music synthesizer would recognize as a piano sound. This second step cleans up the data and adds more information, such as how strongly each key is pressed and for how long.

The group tested Audeo's music with music-recognition apps, which correctly identified the pieces 86% of the time. This is compared to 93% for the source videos.

"We hope that our study enables novel ways to interact with music," says Shlizerman. "One future application is that Audeo could be extended to a virtual piano with a camera recording just a person's hands. By placing a camera on top of a real piano, Audeo could potentially assist in new ways of teaching students how to play."

Hope FOR PEOPLE WITH SPINAL CORD INJURY

A new treatment allows some people with spinal cord injury to regain hand and arm function.

By Sarah McQuate Photos by Marcus Donner / Center for Neurotechnology

Almost 18,000 Americans experience traumatic spinal cord injuries every year. Many of those people are unable to use their hands and arms and can't do tasks such as eating, grooming or drinking water without help.

Using physical therapy combined with a noninvasive method of stimulating nerve cells in the spinal cord, UW researchers have helped Seattle area participants regain some hand and arm mobility.

"We use our hands for everything — eating, brushing our teeth, buttoning a shirt. Spinal cord injury patients rate regaining hand function as the absolute first priority for treatment. It is five to six times more important than anything else that they ask for help on," says Dr. Fatma Inanici, a postdoctoral researcher in electrical and computer engineering who completed this research as a doctoral student in the UW School of Medicine.

"At the beginning of our study, I didn't expect such an immediate response starting from the very first stimulation session," Inanici says. "As a rehabilitation physician, my experience was that there was always a limit to how much people would recover. But now it looks like that's changing. It's so rewarding to see these results."

A NON-SURGICAL APPROACH

After a spinal cord injury, physical therapy may help patients attempt to regain mobility. Studies have shown that implanting a stimulator to deliver electric current to a damaged spinal cord could help paralyzed patients walk again. The UW team, composed of researchers from the Center for Neurotechnology (CNT), developed a non-surgical method of stimulation and combined it with standard physical therapy exercises. For their method, small Band-Aid-like patches are placed on the skin around the injured area on the back of the neck, where they deliver electrical pulses.

The researchers recruited six people with chronic spinal cord injuries for a five-month program. All had been injured for at least 18 months. Some couldn't wiggle their fingers or thumbs while others had some mobility at the beginning of the study. For the first month, researchers monitored participants' baseline limb movements each week. Then for the second month, the team put participants through intensive physical therapy training three times a week for two hours at a time. For the third month, participants continued physical therapy training but with stimulation added.

For the last two months of the study, participants were divided into two categories: Participants with less severe injuries received another month of training alone and then a month of training plus stimulation. Patients with more severe injuries received the opposite — training and stimulation first, followed by only training second.

While some regained some hand function during training alone, all six saw improvements when stimulation was combined with training.

Above: As they improved, participants in the study progressed to more difficult versions of training exercises, such as going from picking up ping pong balls to picking up tiny beads.

Opposite page: Chet Moritz, left, and Fatma Inanici, center, observe as a participant, right, measures grip strength. The black cases on the participant's arm are sensors to measure arm muscle activity. Photo taken in 2019

MAKING AN IMPACT

"People who had no hand movement at the beginning of the study started moving their hands again during stimulation and were able to produce a measurable force between their fingers and thumb," says Chet Moritz, the CJ and Elizabeth Hwang Professor in Electrical & Computer Engineering. "That's a dramatic change, to go from being completely paralyzed below the wrists down to moving your hands at will."

Some participants noticed other improvements, too, including a more normal heart rate and better regulation of body temperature and bladder function.

The team followed up with participants for up to six months after training and found that these improvements remained, despite no more stimulation.

"We think these stimulators bring the nerves that make your muscles contract very close to being active. They don't actually cause the muscle to move, but they get it ready to move. It's primed, like the sprinter at the start of a race," says Moritz, who is also the co-director of the CNT. "Then when someone with a spinal cord injury wants to move, the few connections that might have been spared around the injury are enough to cause those muscles to contract."

The research is moving toward helping people in the clinic. The results of this study have already informed the design of an international multi-site clinical trial that will be co-led by Moritz. One of the lead sites will be at the UW.

"We're seeing a common theme across universities — stimulating the spinal cord electrically is making people better," says Moritz. "But it does take motivation. The stimulator helps you do the exercises, and the exercises help you get stronger, but the improvements are incremental. Over time, however, they add up into something that's really astounding."

Learn more about neuroscience and engineering advancements at centerforneurotech.org

Breakthroughs

New sensors spot coronavirus proteins, antibodies

Institute for Protein Design researchers, including bioengineering graduate student Alfredo Quijano-Rubio, have developed a way to detect the proteins that make up the COVID-19 virus, as well as antibodies against it. Their design, which involves protein-based biosensors that glow when mixed with components of the virus or specific COVID-19 antibodies, could enable faster and more widespread testing.

Researchers discover new law of physics

Computational Fluid Mechanics Lab researchers have discovered a new law of fluid mechanics that will aid the future of aircraft design. The "Law of Incipient Separation" defines the maximum slope of an aircraft fuselage to avoid the separation of airflow that increases pressure-drag. Drag is the aerodynamic force that opposes forward motion.

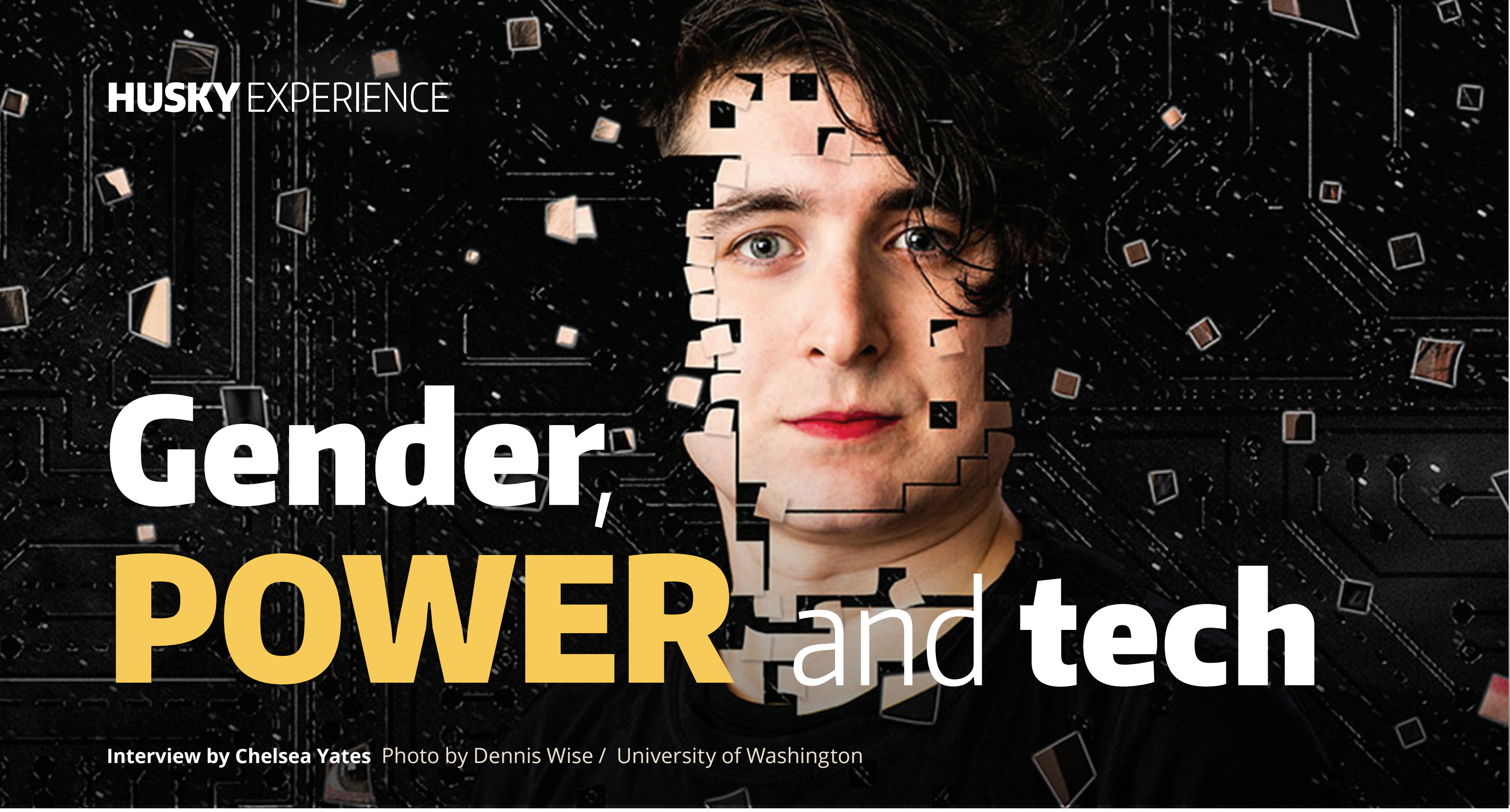
Developing mobility tech for underserved groups

Taskar Center for Accessible Technology and Washington State Transportation Center researchers are working with Microsoft, Google, Washington Department of Transportation and others on mobile application technology to help underserved groups get from place to place. The researchers have received $11.45 million from the U.S. Department of Transportation.

Advancing DNA devices

Adding nanoscale components, such as biological molecules, to electronic devices can power chips that integrate molecular biosensors with optics and electronics. But these devices can be difficult to produce because it's challenging to place nanoscale parts. Now, UW and Caltech engineers have developed a method that uses folded DNA to place molecules in a specific location and orientation.

Read more research news at engr.uw.edu/news



Gender, POWER and tech

Interview by Chelsea Yates Photo by Dennis Wise / University of Washington

Os Keyes has been investigating inequalities and artificial intelligence (AI) since starting Human Centered Design & Engineering's doctoral program in 2017. One of the first recipients of Microsoft Research's Ada Lovelace Fellowship, Keyes is known for their research into bias and surveillance technologies.

How is AI biased?

Any system you develop depends on current efforts of human beings and data they've collected for different purposes, with different intentions, and with different levels of care. The result is that today's societal assumptions and expectations are baked into AI. Since race, gender and disability are things we form assumptions about, they're going to be present.

Tell us about your research.

There's potential for harm and discrimination with facial recognition technology, which assumes that gender has two categories, each with clear visual attributes, and that these attributes are consistent across the globe. Like, a person with short hair must be a man and one with long hair must be a woman. This can have serious consequences for individuals who don't neatly fit into one category or the other. By reinforcing limited views of gender based on conventional norms, this technology plays a role in shaping our views of gender. We know that facial recognition technology is more likely to misgender or flag trans people as suspect. These systems are dangerous because they yield inaccurate information and can result in potentially fatal outcomes, depending on how they're used.

In what other areas of tech do we find gender bias?

In short, everywhere. Virtual "assistants" like Alexa and Siri are gendered women while "smart" computers like Watson are gendered men. We find bias in targeted advertising. Recently it was discovered that women were offered lower credit lines than men from Apple Card despite having better credit history because the algorithm being used was biased. Technologies used in job placement have screened men and women differently, which can impact who gets an interview and who doesn't. And health care technologies are full of bias, as health data skews toward male bodies.

What can be done to address bias?

Diversifying the range of people in tech is necessary but not enough because it ignores the broader questions of power: Who's designing? Who's funding and why? Who's using the tools and who's not? Who's buying? Who's profiting?

When we talk about bias, we're really talking about power. Biases exist within a power structure, meaning that whoever holds power benefits from it, and those without power do not. Biases and inequalities emerge from this dynamic. More representation won't "fix" the issues of bias and discrimination that arise because of power, and biases in tech cannot be corrected solely by people who are assumed to experience those biases. Addressing the injustices that result from technology does not just require a broader set of engineers, but a reimagining of the premises that software is typically developed under.

Read the full interview with Keyes at engr.uw.edu/gender-power-tech

Building and sustaining COMMUNITY

By Kate Stringer

For Nathalie Thelemaque, it's not enough to research how to design buildings or bridges. She wants to understand the impact that infrastructure has on marginalized communities so she can help create more sustainable systems.

"Especially with growing climate change concerns, it's important that we're looking into the different impacts, because not every community faces the same impacts," says the civil and environmental engineering (CEE) graduate student.

This past year, Thelemaque has participated in GO-MAP, a UW Graduate School program that supports graduate students of color. Despite the pandemic, she says GO-MAP's virtual programs have helped her connect with other students. Through GO-MAP, she's currently helping to recruit students of color to graduate school.

In CEE, she's been working to build community among students. Recently Thelemaque shared her experiences of imposter syndrome — the feeling of not belonging in a group — with an undergraduate class.

"It's as common as the cold; I feel like everyone gets it at least once," she told the students. "But what can make or break you is the ability to communicate your feelings with others."

For Thelemaque, turning to her community for support amidst fears or doubts in graduate school has been the best way to remember that she belongs.

"I'm very grateful for GO-MAP — they recognize that it's necessary to have a diverse set of opinions and understand that everyone isn't on equal footing in being able to go to graduate school," she says.

Advancing CORAL RESEARCH

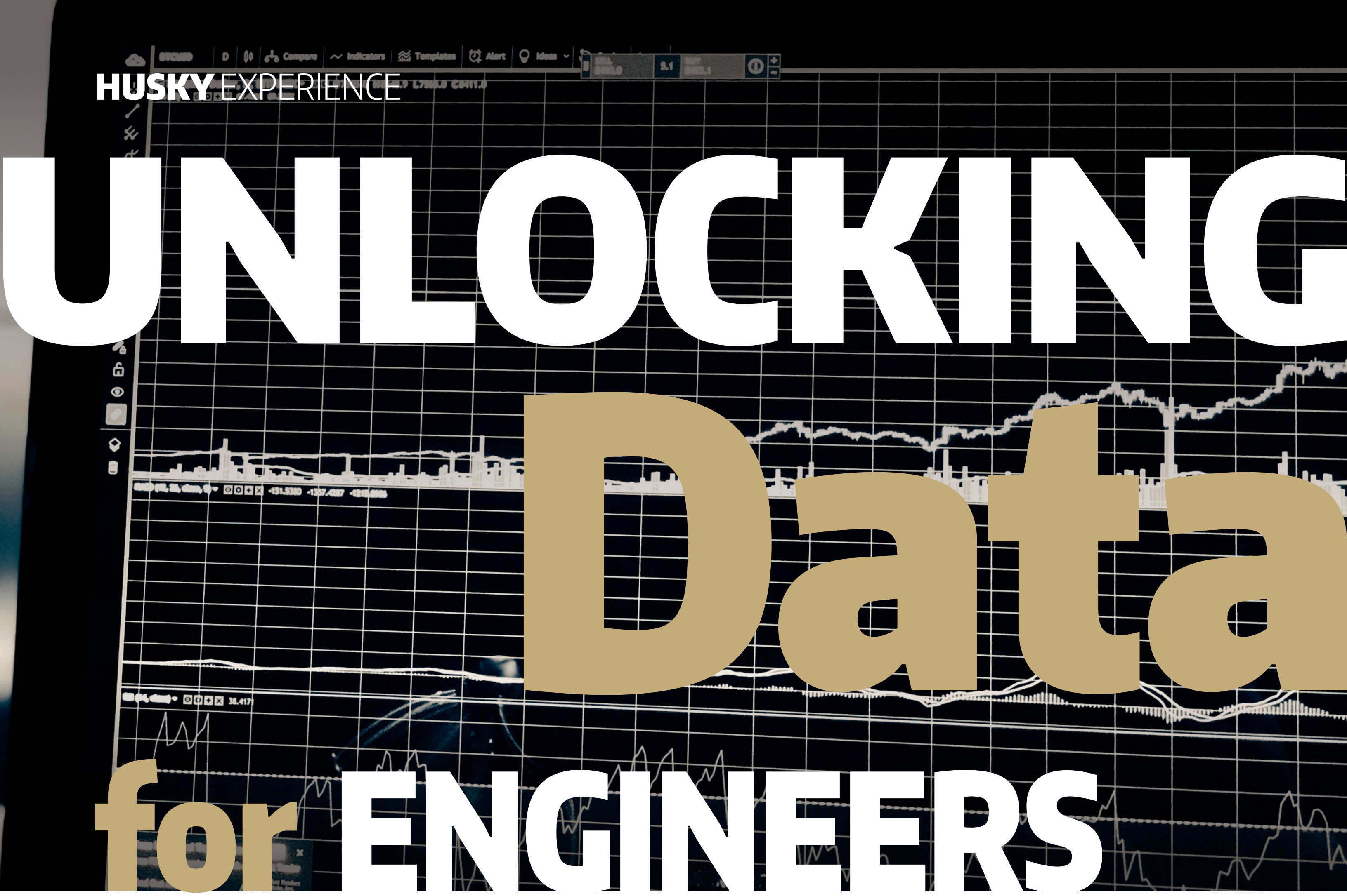
By Amy Sprague

In Aeronautics & Astronautics (A&A)'s Laboratory for Engineered Materials & Structures, Isaiah Cuadras has combined two passions — aerospace systems and ocean conservation — to help advance coral research. Specifically, the A&A senior is investigating ways to use fluid dynamics to improve water flow around corals in the lab.

"In coral research, chemists and biologists try to identify the corals' response to chemical stressors to correlate changes in the chemical composition of the ocean with the effects of climate change," Cuadras explains. "However, test environments may subject coral to fast and potentially harmful water flows, so it's difficult to figure out what causes stress and damage."

He is optimizing a coral-on-a-chip, a millifluidic device that channels water past corals in the lab, to temper water flow and reduce stress on the corals. Cuadras was introduced to ocean conservation in 2019 through a UW Engineering summer program in Australia. Around that time, he connected with A&A associate professor Jinkyu Yang, who runs the Laboratory for Engineered Materials & Structures and had recently received a National Science Foundation grant for coral research.

"Marine biologists have been using a coral-on-a-chip technology, though it still has substantial challenges," explains Yang. "Isaiah's computational fluid dynamics simulations have saved us a tremendous amount of time and effort."



UNLOCKING Data for ENGINEERS

Last fall the UW's eScience Institute launched a new data science minor. Open to undergraduates across campus, it can be particularly beneficial to engineering students. College of Engineering and eScience Institute faculty and students weigh in on why students should consider adding data science to their skillset.

Data science at the eScience Institute

Dave Beck, *chemical engineering research associate professor and eScience Institute director of research and education*

Data science is for anyone who recognizes the promise of data-driven discovery. It isn't a stand-alone discipline; it's an applied science relevant to every area of study. Students focus on their major's core curriculum then enhance it by developing and applying data skills.

Undergraduate data science courses include classes in statistics, machine learning, visualization, data management and software engineering, plus data studies classes so students understand how to apply skills ethically. The minor consists of six courses, or 25 total credits. To encourage cross-disciplinary learning, at least 15 of those credits must be outside of the student's major.

Along with housing the UW's data science minor, the eScience Institute offers several opportunities for undergraduates to gain data science experience. Students can join our Software Carpentry program and learn basic software engineering and development, apply to our Data Science for Social Good program and work alongside data scientists, or drop by our office hours to ask questions about data science as it relates to research and careers.

Data science is becoming a standard tool in the engineer's toolbox. Today's engineers are less likely to work on factory floors than they are to use data to inform and manage that work. To be competitive in today's job market, students should gain literacy and fluency in data science methods and understand the implications for society.

Creativity and new ways of engagement

Anne Farley, *chemical engineering undergraduate*

I was introduced to data science through two computing classes required for my engineering degree. It just clicked with me, so I took more courses in data programming, web programming and informatics. I learned the basics of a few languages, how to use platforms like Github and work with large data sets.

I'm excited to apply these skills through my chemical engineering (ChemE) capstone project, which explores machine learning models for solar cell life expectancy. I'm one of three undergrads participating in ChemE graduate level courses Data Science Methods for Clean Energy Research and Software Engineering for Molecular Data Scientists, which is pretty exciting.

Data science can help engineers save time, model solutions and tackle harder and more complex problems. It is also integral to improving communication through data visualization. Beyond application, data science enables creative problem solving and gives me new methods of engaging with my field.

Exposure to data science is vital for all engineering undergrads. Whether or not they choose to pursue it as a minor, developing adequate understanding and skill in this field will unveil a wider set of career and academic opportunities. Plus, it's fun!

Broad applications for impact

Adam Alayli, *materials science and engineering undergraduate*

What I like best about data science is how applicable and accessible it is. I wanted to study it in college, but I also wanted to study engineering. Fortunately, data science is an applied tool, so it's relevant to any field, and it builds on math and science skills that engineering students are already learning through other classes. I've been able to develop my data science skills while majoring in materials science and engineering (MSE).

MSE is all about looking at patterns and trends in materials as well as modeling techniques and predictability, so data science fits perfectly. This year the department started offering a three-part data science course series, which I'm taking. For my senior project, I'm working with MSE instructor Luna Huang to automate building large data sets for machine learning. For my capstone, my team is using data science to identify research similarities between UW Engineering and School of Medicine researchers to encourage more collaboration.

While at the UW, I've worked on data science projects at the Fred Hutchinson Cancer Research Center. I helped develop a tool for cancer research visualization and then transitioned to machine learning projects. After I graduate, I plan to attend med school. There's a lot of overlap between engineering and medicine. I want to work in that space while continuing to do data science.

Industry demand for data-smart engineers

Jihui Yang, *College of Engineering vice dean and materials science and engineering professor*

As College of Engineering vice dean, I meet with industry representatives interested in building research partnerships and hiring our students after graduation. Nearly every company has expressed a need for employees with a data science background. Many have vast amounts of complex data, which is useless unless they have people who know how to manage and analyze it, then apply it to make predictions and guide research and development.

For students interested in graduate school, data science is just as important as it is for those planning to enter into industry. It's a powerful research tool, providing new ways of executing research. It can be used for dealing with complex, dynamic systems and applied to many kinds of engineering challenges — from global health and clean energy to airplane design and quantum computing.

Data science is as foundational to engineers as mathematics. Today all areas of engineering are rich in data. Students who want to be more well-rounded engineers should pursue it, and the UW is a great place to do so. We have some of the best computer and data scientists, an incredible resource in the eScience Institute and a culture of cross-disciplinary collaboration. Plus Seattle is home to vibrant industry and some of the world's biggest tech companies, who want to hire engineers fluent in data science.

Keep up with all things data science at the UW at escience.uw.edu

Bioengineering startup AltPep advances its technology for the early detection and treatment of Alzheimer's and other amyloid diseases.

By Chelsea Yates

Alzheimer's research GETS A BOOST

More than 5 million Americans are living with Alzheimer's disease — a number projected to rise to 14 million by 2050. While there are treatments that can provide symptomatic relief, currently there is no cure. Diagnosis isn't great either: Alzheimer's can incubate undetected for 10-20 years before an individual begins showing symptoms.

Seattle-based biotech AltPep wants to change that. The company, which spun out of bioengineering professor Valerie Daggett's research lab in March 2019, has developed a platform that allows for both early diagnosis and treatment of Alzheimer's. In January it raised $23 million in Series A investment funding to advance its work.

"COVID slowed us down this past year, so right now everything still feels new," says Daggett, who serves as AltPep's CEO. "But we're ramping up. We want to make detection tools available and eventually a treatment, too."

AltPep's technology

AltPep's tools identify diseases resulting from toxic misfolded amyloid proteins. Essential to all living organisms, proteins are composed of amino acids linked together into chains called peptides. To perform biological functions, these peptides fold into structures. But sometimes they unfold, misfold, and form toxic aggregates that trigger disease. These amyloid diseases affect the central nervous system and include Alzheimer's, Parkinson's and more. Over one billion people worldwide experience amyloid diseases today.

The technology driving AltPep involves protein structures called alpha-sheets linked to toxic misfolded proteins. These alternating peptides can be used to detect the toxic elements — key to screening and diagnosis — and can intervene in the process, providing a pathway to a disease-modifying treatment.

A UW effort

Valerie Daggett

The development of AltPep's platform extends back to the 1990s when Daggett's team began using computer simulations to investigate how proteins unfold. This led to their alpha-sheet discovery, years of testing, and research partnerships with clinicians across UW Medicine and the Seattle VA Medical Center.

"This work has truly been a UW effort. From day one, colleagues have been gracious with lending their expertise, equipment, you name it. It would never have happened without many years of collegiality," Daggett says.

UW's commitment to innovation has also fueled the journey. "UW CoMotion, the Washington Research Foundation and my department have been very supportive," she adds.

AltPep recently moved out of CoMotion's incubator space and into a 7,500 square foot facility off-campus. Daggett's bioengineering lab continues to advance the basic alpha-sheet research, while AltPep focuses on development and commercialization of the technology.

"Thanks to our investors, we've now got the space and equipment needed to produce and automate our diagnostics and accelerate our therapeutic program," Daggett says. "It'll be a while before there's a cure for Alzheimer's, but that's where we're headed. A critical first step is detection of the molecular trigger for earlier presymptomatic intervention before irreparable damage occurs."

Learn more at altpep.com

PARIS'S LAW CELEBRATES 60 YEARS

By Chelsea Yates

First published in *The Trend*, former UW Engineering professor Paul C. Paris's ideas revolutionized airplane design and gave way to the field of fracture mechanics.

This year we look back on 60 years of Paris's Law: the equation, which predicts how fast a structural crack will grow under repeated stress, revolutionized airplane design.

"Paris was one of the architects of fracture mechanics, now a standard part of engineering education," says Ramulu Mamidala, the Boeing-Pennell Endowed Professor in Mechanical Engineering (ME), who teaches Paris's Law in his graduate courses. "It created the basis for new analytical methods to address fatigue crack problems and is still very relevant today."

INTRODUCING PARIS'S LAW

In the mid-1950s, three passenger jet crashes put the commercial airline industry on high alert. Investigators surmised what had happened — cracks had developed in the fuselages, and the planes shattered — but they weren't sure why. At the time, engineers were unaware of how fatigue, fracture and stress were related.

"Until Paris, there was no theoretical explanation for predictions of failure caused by cracks," Mamidala explains.

The Boeing Company was developing its first passenger jet when Paris, newly minted with a mechanics master's degree from Lehigh University, joined as a research associate in 1955. He was asked to look into what caused the recent crashes.

He set to work on what would become Paris's Law. From 1957-60, Paris was an assistant professor in the UW's civil engineering department; during that time he wrote his first paper, which expanded ideas introduced a few years earlier by another fracture mechanics pioneer, George Irwin, and suggested that a crack's growth rate depends on the stress intensity factor.

Though Paris's ideas presented a way to quantify and predict structural integrity, his approach was considered unconventional, and none of the leading journals published it. So, in January 1961, after leaving the UW to return to Lehigh for his Ph.D., Paris published his paper, "A Rational Analytic Theory of Fatigue," in *The Trend*.

IMPACT AND LEGACY

Paris's ideas were widely embraced by scientists and engineers. Before the decade ended, the U.S. Air Force and Federal Aviation Authority required fracture analysis to be part of all aircraft design. Today Paris's Law touches nearly every area of engineering — from aerospace and infrastructure to biomedicine and new materials research — anything that involves machine parts and vibrations.

Although Paris's time at the UW was brief, he left a lasting impact in mechanics, structures and materials research across the College. ME Professor Emeritus Albert Kobayashi became a world-renowned expert in fracture mechanics, pioneering studies of dynamic crack propagation. Several students — including Royce Forman, '62, R.C. Shaw '66, Frederick Smith '66, and William Bradley, '69 — furthered the field as well. It's estimated that Paris's *Trend* paper has been cited more than 15,000 times.

"I've always heard that Paris was an exceptional teacher, mentor and problem-solver," says Mamidala, who received his Ph.D. from ME in 1982 and also studied under Kobayashi. "I am fortunate to be a part of this legacy and to have followed the footsteps of those who paved the way."

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Engineering students WIN BIG

Engineering teams impressed the judges at this spring's virtual health and environmental innovation showcases, hosted by the UW Buerk Center for Entrepreneurship.

HEALTH INNOVATION

At the Hollomon Health Innovation Challenge in March, second place went to materials science and engineering's Nascent Diagnostics for its non-invasive biosensor array that improves disease diagnosis and monitoring. The chemical, electrical and mechanical engineering team Under Pressure placed third for its non-invasive blood pressure monitor for the operating room.

Student teams at the all-virtual Hollomon Health Innovation Challenge. Image by the Buerk Center for Entrepreneurship

Engineering teams also won special prizes. Mask Seal Testing, a team of mechanical, electrical and computer engineering students, created a test that uses thermal imaging to check for leaks in N95 masks worn by health-care workers. The bioengineering, mechanical engineering and business student team OsmoProcessor developed an approach to improve diagnostic device accuracy for detecting pathogens. The mechanical and electrical engineering team EVBreathe developed a device that navigates a patient's airway. And Direct Dose, a team of mechanical engineering and neurological surgery students, designed an implantable device to reduce opioid use while improve pain management following surgery.

ENVIRONMENTAL INNOVATION

At the Alaska Airlines Environmental Innovation Challenge in April, judges awarded second place to GreenLoop, a business, biology and computer science student team developing a biodegradable product to address the plastic waste problem plaguing farmers in India. Special prizes went to PotentiaLi Energy, an electrical engineering and business student team developing a clean-energy bicycle charging system, and mechanical engineering's Clear Ascent, for its approach to tackling the aviation industry's contribution to the climate crisis.