Carnegie Mellon University

the LINK

A GLOBAL MINDSET

BYRON SPICE

AMBIENT ENERGY SYSTEMS STORE ENERGY AS COMPRESSED AIR

SOLAR AND WIND POWER ARE WIDELY RECOGNIZED AS ENERGY SOURCES, BUT RESEARCHERS IN THE HUMAN-COMPUTER INTERACTION INSTITUTE (HCII) SUGGEST ANOTHER SOURCE OF RENEWABLE ENERGY IS LARGELY OVERLOOKED — AMBIENT ENERGY.

A research team led by **Lining Yao**, the Cooper-Siegel Associate Professor in HCII, has devised a number of valves, pumps and other devices that are powered by wind, water flow, sunlight and fluctuations in temperature or humidity. And — in what may seem like heresy in a major computer science school — this harvested energy is stored as compressed air, not electricity.

To make the heresy a bit more shocking, no electronics are used to control the system.

"It is a type of distributed energy harvesting," Yao said. "The idea is you can leverage fluctuations in your ambient environment and actually harvest a lot of energy that is normally ignored or otherwise is not the focus of classic mainstream technologies."

Qiuyu "Luca" Lu, a post-doctoral fellow in the HCII and the member of Yao's Morphing Matter Lab who led the work, said the team designed small air pumps powered by changes in temperature, fluctuations in moisture, and kinetic energy, such as wind power or water flow. The researchers also designed valves that likewise are controlled by ambient conditions, such as temperature, wind speed or the wet/dry cycle.

The researchers combined these components, along with various containers for storing compressed air, to create a number of interconnected systems found in a garden. Their work resulted in systems for dispersing seeds at the appropriate time, automatically irrigating plants or filling a bird feeder, and automatically inflating an insulating, protective collar around plants when winds turn strong and cold.

The beauty of the team's approach is that these systems don't just harvest energy. They also sense changes in the environment and use those changes to time actuation of a valve or pump, Yao said.

Lu noted that these nonelectronic pneumatic systems are at least theoretically more efficient than electricity-based systems. That's because a lot of energy is lost as heat when electricity is converted to compressed air.

"I think the nonelectronic approach can make the pneumatic system less complex," Lu said.

Their small size could also help these devices fill gaps in existing technology. "A big windmill, for instance, may need the wind to reach a certain speed before it actually can harvest energy," Yao said. "But if you mix in smaller devices you can actually be sensitive to milder air flow."

The researchers have made the models for all the devices available as open source, along with detailed instructions on how to make them.

In addition to Yao and Lu, the research team included Semina Yi, a master's student in interactive design in the School of Design; Yuran Ding, a former member of the Morphing Matter Lab; and colleagues at Tsinghua University in Beijing.

The researchers presented their work in October 2023 at the Association for Computing Machinery's Symposium on User Interface Software and Technology (UIST) in San Francisco, where they received a Best Paper Honorable Mention. This research was supported by the National Science Foundation. ∎

A team in the Morphing Matter Lab developed devices powered by wind, water flow, sunlight and fluctuations in temperature or humidity. This harvested energy, stored as compressed air, can fuel various systems, including one that automatically inflates an insulating collar around plants during windy, cold weather.

View the video: Harvesting, Storing and Utilizing Ambient Energy for Pneumatic Morphing Interfaces

the LINK

Computer Science at CMU underpins divergent fields and endeavors in today's world, all of which LINK SCS to profound advances in art, culture, nature, the sciences and beyond.

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Toward Impact That's Global

First, I want to express how proud I am of the Iris team and all they accomplished in sending the first student-built rover into space earlier this year. Though reality fell short of the planned goal to reach and explore the Moon, the team never wavered — pivoting with the challenges, focusing on new mission goals and leading to scientific firsts for the team.

During the hours after the launch — as it became apparent that the Astrobotic Peregrine lander would not be able to touch down safely on the Moon — the science community around the globe offered assistance, resources and encouragement. It was heartwarming and welcomed. The Iris team did the same five months prior when India's Vikram lander safely touched down near the Moon's south pole, but both the lander and the attached Pragyan rover did not respond to the wake-up signals, suspending the possibility of further scientific operations.

These gestures of goodwill come from a place of human empathy and realization of the difficulties of space exploration. They also follow in the tradition of scientists who seek success not for themselves or their own countries, but for the advancement of scientific discovery to benefit humankind. We seek knowledge as a global community, and we know that as our peers around the world advance scientific and research efforts, our own work will benefit.

This sentiment brings to mind the work that SCS and all of CMU are doing to build the bonds of global research. The idea of a global university is not new. Where once students from many nations traveled to attend influential institutions, SCS and CMU have global cooperation and relationship building in our DNA. CMU has put forth a concerted effort to think globally alongside our continued dedication to working with the most talented and driven individuals on problems that affect us all. And as we have let a thousand flowers bloom, we have not allowed borders to define our relationships.

Also of interest, SCS has taken the lead on leveraging our diverse teams to create fairness and equity in the applications of our efforts. The more diverse the voices in the creation of technologies, the better the science and the more widespread and effective the applications will be. This, too, is central to the SCS experience.

In this issue of THE LINK are stories of these types of partnerships. As we work to enhance technology to help solve global problems, we also strive to become global citizens who are dedicated to social responsibility.

From SCS faculty testifying before the U.S. Congress on building safer and more equitable AI for all, to the work being done to help build technical infrastructure in Africa, the people of SCS are mindful of our ability and responsibility to lead on the global stage. Rather than promoting our own point of view, the most profound influence of SCS remains when we participate in the process of building cooperative relationships that increase access and success for all.

Martial Hebert
Dean, School of Computer Science

NIKI KAPSAMBELIS

Empowering

How Educational Technology is

Futures:

Revolutionizing Africa's Learning Landscape

When the COVID-19 pandemic upended the world as we knew it, education became one of the most visible casualties.

From preschool through college, the pandemic disrupted in-person classroom attendance, the ripple effects of which remain a matter of much debate and research. But one fact became clear: online learning, which grew exponentially throughout the pandemic, was here to stay. And for some parts of the world, education technology — or edtech, for short — represents an opportunity to fill gaps that previously lingered for generations.

One place this is particularly true is Africa, where rapid population growth combined with a surge in the continent's tech scene has made edtech a particularly timely investment, said **Amy Ogan**, Thomas and Lydia Moran Associate Professor of Learning Science in CMU's Human-Computer Interaction Institute.

Africa is the youngest and fastest-growing continent in the world. According to the United Nations, more than half of global population growth between now and 2050 is expected to occur there. If those projections are accurate, Africans will represent one in four people worldwide within the next quarter century. Likewise, the continent's tech scene — particularly in Rwanda, Kenya, Nigeria and South Africa — is producing a wave of developers, meaning talent is available.

Amy Ogan, Professor in HCII presents edtech concepts to startups and tech companies as part of the Mastercard Foundation's EdTech Fellowship incubators.

Participants of the deep dive sessions at Ihub One, listening to edtech presentations, held in Nairobi, Kenya, and one of the tech hubs supported by the partnership between CMU and The Mastercard Foundation.

Birth of a Strategy

Among those collaborating is the Mastercard Foundation, which established the Young Africa Works strategy in 2018 with the goals of enabling 30 million young people to access dignified and fulfilling work by 2030 via improved education and vocational training, connecting employers and talent through technology, and offering access to financial services for entrepreneurs and small and medium-sized businesses.

As part of the strategy, the Mastercard Foundation established the Centre for Innovative Teaching and Learning to build an impactful edtech ecosystem in Africa. One of the programs under the Centre is the Mastercard Foundation EdTech Fellowship, which launched in 2019.

Carnegie Mellon, and particularly the School of Computer Science, enjoys a long tradition of building effective, intelligent educational technologies. Ogan began working on the fellowship in its first year. The pandemic disrupted the program, but also brought with it the realization that edtech was more critical than ever for the program to achieve its goals.

"It was a crazy time," Ogan said. After working in East Africa for eight years, with projects in Tanzania, Ivory Coast and Uganda, Ogan wound up teaching from her house in Rwanda. She saw firsthand how pandemic-related closures interrupted learning, just as they did around the globe.

Startups began to focus on finding ways to address the disruption to educational systems by using the rapid growth in phones and mobile technologies to fill those gaps.

Christine Niyizamwiyitira, Scholar in Residence at CMU-Africa, co-leads the Carnegie Mellon partnership with Ogan. Niyizamwiyitira, who formerly worked for the Rwanda Basic Education Board, said technology can help not only when schools close — as they did during the pandemic — but also when classrooms are overcrowded, causing some students to learn remotely.

Christine Niyizamwiyitira, Scholar in Residence at CMU-Africa and Co-lead of the Mastercard Foundation EdTech Fellowship.

When students don't have access to a home computer, edtech can help by developing tools that work on phones or by using WhatsApp, said Niyizamwiyitira.

"We are trying to be practical, because we are looking for hands-on skills in edtech entrepreneurs that respond to educational needs even in a low-resourced environment," Niyizamwiyitira said.

A Broader Reach

Although the Foundation initially planned to work with 12 companies, it decided to broaden its reach by reorganizing the Mastercard Foundation EdTech Fellowship to roll out technology incubators in countries across the continent.

Through the incubators, participants — whose companies include a mix of startups and some more established enterprises — receive training from CMU on ways to improve their products based on the science of learning. They learn how to arrange content to align with a curriculum so they can respond to the needs of teachers and students, and they receive faculty mentoring.

The program just completed its first year with three incubators, which were established in South Africa, Nigeria and Kenya. Each incubator worked with 12 companies; another five incubators are planned for 2024 in different countries. At its current pace, the Foundation's EdTech Fellowship will have supported a

minimum of 276 companies in the final year of funding the incubators. These companies are designed to become self-sustaining after the Foundation's support ends.

"The fourth year is more knowledge dissemination: research, working with companies to see what we've achieved and seeing if there is any gap to be filled," Niyizamwiyitira said.

A Startup's Perspective

One company that worked with an incubator in 2023 was Reflective Learning, which aims to solve backlogs in math and English education through an online tool that diagnoses knowledge gaps in individual students, then catches them up to where they need to be, said co-founder **Eugene Pelteret**.

"Math and language are quite unique in their structure in that they build all the way from when you are little up to the point where you actually write your final school exams," Pelteret explained. "If you have small gaps along the way, the normal curriculum just progresses and it's very easy to fall behind. Eventually, you sit in a math class where you're not understanding what's being taught, and you believe that you can't do math. Meanwhile, that's not actually true — you can, but you have to go back and find where the problem is."

The company works to bridge gaps in a more accurate and cost-effective way than a traditional tutor, he said.

In many ways, Reflective Learning's experience with the Young Africa Works incubator mirrored that of the students the company serves. As a young business, the practical constraints to growth can lead to small, missed elements, Pelteret said.

"The incubator helps to refocus some of those elements and helps you to fill some of the gaps," he added. "We've really valued the partnership. The Human-Computer Interaction Institute has just been phenomenal in giving us access to expert insights."

An iHub presenter delivers a Learning Science presentation in Nairobi.

Pelteret said the approach was individualized for each participant. Brand-new startups, for example, needed different resources than Reflective Learning, which was founded in 2017. And because edtech is relatively young, without much established research to date, having access to well-versed experts from CMU was helpful in determining if the company was on the right track.

"That academic credibility is really important," he said. "Entrepreneurship is quite a lonely journey. It requires a lot of yourself, from both a personal and professional perspective."

Young tech entrepreneurs take a break for a photo during the deep dive sessions at iHub.

A group photo from one of the Nairobi iHub deep dive sessions.

Novel Research Opportunities

The partnership offers CMU the opportunity to conduct research with companies that collect large data sets from the users of their technology. The range is wide, according to Ogan, including companies using chatbots and apps for adult education and those using iPad games to promote early childhood development.

Ogan is hopeful that CMU will be able to take learnings from the companies and translate them back into educational concepts taught in the HCII's Masters of Educational Technology and Applied Learning Sciences (METALS) program. Plans are already underway for a METALS capstone team to work on the Young Africa Works program.

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> This is an opportunity for us to engage in these kinds of partnerships that help us explore new questions that we couldn't ask without working with these companies.
> — Amy Ogan

"This is an opportunity for us that does not come along very often: to engage in these kinds of partnerships that help us explore new questions that we couldn't ask without working with these companies," Ogan said.

The incubators have worked primarily in English until now, although new languages are being added as new countries are selected for participation.

Pelteret said he hopes the project will allow companies like Reflective Learning to help Africa do more than simply catch up with more developed parts of the world; he'd like to get Africa ahead of the curve.

"Hopefully if we can do that as a continent, then we can start finding our own niche and our own strengths," he said. "I believe as Africans we certainly have them, we just need to take ownership of them and push into them. Then we can find our own space in the world sector." ■

CHRIS QUIRK

DROPSphere

LAST YEAR MASSIVE HEAT BLASTED GLOBAL CORAL REEFS, BLEACHING AND KILLING AN UNPRECEDENTED AMOUNT OF CORAL, REPORTED RESEARCHERS AT CORAL REEF WATCH, AN INITIATIVE OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA). THE INTENSITY OF THE HEAT DAMAGE CAUSED CORAL REEF WATCH TO ADD THREE HIGHER LEVELS TO THEIR CORAL BLEACHING ALERT PROTOCOL.

A bellwether species for planetary harm from climate change, coral reefs make up a small part of the marine environment, but have an outsized impact on oceanic wellbeing. Despite covering a minuscule area of the sea floor, coral reefs support almost a quarter of all marine species in one way or another. The reefs also contribute to the global economy, generating a jaw-dropping $9.8 trillion annually in ecological, economic and societal benefits, according to studies cited by Coral Reef Watch.

Coral reefs support almost a quarter of all marine species in one way or another.

Given their importance to planetary ecology, the National Centers for Coastal Ocean Science and the Global Coral Reef Monitoring Network place monitoring coral reefs among their highest research goals. Unfortunately, many deep-sea coral reefs are at depths far, far beyond the safe range for human divers. But **Matthew Johnson-Roberson**, professor and director of the Robotics Institute (RI), and **Tianyi Zhang**, a Ph.D. student in RI, had a big idea they squeezed into a small yellow package — the Deep Robot Optical Perception Sphere, or DROPSphere — RI's own yellow submarine.

DROPSphere — an autonomous submersible about the size of a hand truck Johnson-Roberson and Zhang designed and built to explore and record images of remote underwater locations and seabeds — turns out to be the perfect tool for getting down to deep-sea coral. "Underwater robotics is ideal for modeling marine environments, studying benthic [seabed] environments, and investigating cultural heritage such as shipwrecks," said Johnson-Roberson. "It is also a possibility for social good because it can track environmental impacts on things like coral reefs and help to mitigate the environmental impact and harm that humans are having on the planet."

Past underwater autonomous vehicles (UAVs) have not been readily available to researchers. "One of the big things I've seen in my career is that they are traditionally very, very expensive," said Johnson-Roberson. With a price tag often in the $2 million range, they are used primarily for oil and gas work. "Science, tragically, is getting a short shrift."

> **This project could open the door to a new group of deep-sea scientists.**
>
> Ashley Marranzino,
> National Oceanic and
> Atmospheric Administration

Matthew Johnson-Roberson,
Professor and Director of
the Robotics Institute

Tianyi Zhang,
Ph.D. student
in RI

Johnson-Roberson and Zhang decided to solve the money problem by creating a UAV of their own, made with off-the-shelf parts, that could fill a gaping research need. NOAA's Ocean Exploration Division provided funding for the project through the office's competitive grant program. "Exploring and surveying deep-sea habitats is expensive and requires a lot of resources," said Ashley Marranzino of the NOAA Ocean Exploration, Science & Technology Division. "The project offers an opportunity to make this science more accessible to a larger community by providing a less expensive alternative to the large UAVs and remotely operated vehicles that most of the community relies on currently." Another important aspect of the project will be the development software to help speed up the analysis of large video and imagery datasets generated by the surveys. "If successful, this project could open the door to a new group of deep-sea scientists," said Marranzino, "allowing them to conduct deep-water surveys from smaller vessels at a fraction of the cost."

To build the DROPSphere, Johnson-Roberson and Zhang started with a $500 Edge computer — which can run deep learning networks — added some deep-sea foam (which is buoyant but can also withstand high water pressure), a camera, inertial measurement units to track navigation, and a glass sphere to hold all the cameras and more delicate electronics. Finally they installed drone propellers to maneuver and steer DROPSphere. Total cost, around $30,000.

With a target depth of 4,000 meters, DROPSphere puts some of the deepest coral reefs off the coast of Hawaii within range. "The deep coral reefs are a super important part of the ecosystem in a variety of marine environments. And they're less studied than the shallow coral reefs for obvious reasons, because they're difficult to get to," said Johnson-Roberson.

DROPSphere, the hand-truck sized underwater autonomous vehicle built by Matthew Johnson-Roberson and Tianyi Zhang.

> **Deploying an underwater robot is special.** — Tianyi Zhang

Zhang has been managing the field tests on some shallower coral reefs in the Florida Keys, executing the first dives in the summer of 2023. "Deploying an underwater robot is special," said Zhang. "On campus, I can do 20 experiments on a robot in a day. Working with a UAV is much more difficult, and we have a five-day window each year to show that the unit works in the field. It's high pressure." After daytime deployments, Zhang spent most evenings at an Airbnb, which he converted into a workshop. "We would do electronics repair, validate the hardware, check the software at every level, the whole pipeline." Johnson-Roberson likened the operation to a wedding. "You charter a boat, you do a lot of planning, you have all the other scientists there, and a lot has to go right to have a successful field season, which I think we did."

Given the proposed depth of deployment of DROPSphere, the autonomy of the unit is critical. Johnson-Roberson and Zhang programmed the UAV to run a back-and-forth, lawnmower pattern over reef areas. The cameras and inertial measurement units calibrate the DROPSphere's trajectories for navigation purposes as it takes detailed pictures of the reef from diverse angles. The duo wrote code that stitches together virtual models of the reef from the source images, providing rich information on texture and color. The models contain enough detail for researchers to rotate the view of the reef around 360 degrees. "We want researchers to feel like they can walk around the reef and see it clearly from multiple angles," explained Johnson-Roberson.

> **We want researchers to feel like they can walk around the reef and see it clearly from multiple angles.**
>
> — Matthew Johnson-Roberson

The color information DROPSphere gathers is particularly prized by oceanographers to better assess coral reef health. However, translating the color data from the source images has posed challenges. "There's an inherent color distortion underwater since the water absorbs the red areas of the light, and there is also a lot of scattering of light," Zhang said. To fix this, they created color adjustment tools that "drain the ocean from the reef," as Johnson-Roberson explained, and present the coral color in the images as it would appear on dry land.

Sierra Landreth, an oceanographer and graduate research assistant at Florida State University, participates in the DROPSphere project. "Current research is focused on characterizing benthic community compositions along seamounts in the Pacific Ocean, and it is often difficult for scientists to gather data in the deep sea," she said. "Robots are an essential tool for us to get imagery of the seafloor at great depths, and the DROPSphere could assist us greatly in the characterization of underrepresented and under-sampled areas of the ocean floor."

Despite their remote location, deep-sea coral reefs play an important role in the health of ecosystems all the way up and down the water column, said Johnson-Roberson. "Scientists are really interested in learning more about how those environments grow, but also how we could build artificial reefs to help regenerate some of the harm and damage that humans are doing to our natural world." ∎
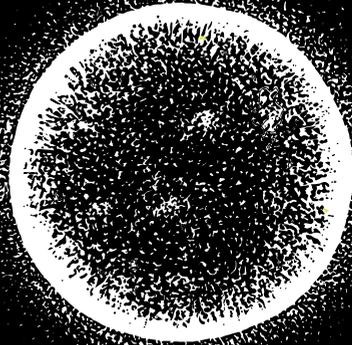
FOR CARNEGIE MELLON
UNIVERSITY'S IRIS TEAM,
EVERY MOMENT SEEMED TO
BRING A NEW CHALLENGE
WITH IT — AND THEY TURNED
EVERY CHALLENGE INTO AN
OPPORTUNITY.

CMU'S IRIS ROVER: A HEARTBEAT IN SPACE, A LEGACY ON EARTH

ALEXANDER JOHNSON

Shortly after the January 8, 2024 liftoff of United Launch Alliance's Vulcan Centaur rocket with their rover on board, Carnegie Mellon University's Iris team, consisting of about 30 students and a handful of staff, filed into their rental house in Florida.

CMU's Iris rover sits secured to the Peregrine Lunar Lander inside a clean room at Astrobotic's headquarters before leaving Pittsburgh for Florida.

The Iris team watches the liftoff of United Launch Alliance's Vulcan Centaur rocket from Cape Canaveral's Space Launch Complex, carrying the Iris rover among its payload.

Hours after rousing speeches from team leadership, hopeful messages and the perfect launch, they learned that Iris, the lunar rover built by 300 students from across CMU's seven colleges, wouldn't make it to the Moon. An anomaly in Astrobotic's Peregrine lander, to which Iris was bolted, would prevent a soft landing on the lunar surface.

Rather than find themselves discouraged, the students immediately jumped into action. They transformed their rental home into an impromptu command center and decided to make the most of any time remaining in Iris' journey. Team members extended their stays in Florida, booking hotels or staying with relatives as events unfolded.

"Our team wanted to figure out what we could do to better science, or any technical capabilities of our rover," said Nikolai Stefanov, the mission control lead for Iris. "Basically, it boiled down to a bunch of all-nighters in a vacation home."

The living room, kitchen, dining room and patio all became workstations where the crowd broke into their respective teams. An air mattress was inflated and propped up vertically to form a wall, cordoning off areas to maximize focus and privacy. A couch became a favored spot for sleep-deprived team leadership, who needed to be a shout or the shake of a shoulder away from handling any challenges. Smartphone hotspots became a way to preserve bandwidth and ensure redundancy.

"It was a blessing in disguise, having everyone working together all in the same house," said Carmyn Talento, the representation team lead for Iris, who organized media events and made the project available to all possible audiences. "When you needed somebody's expertise or opinion, all you had to do is go poke someone, go wake someone up. Everyone was always willing and eager to put their efforts toward something."

> " IT WAS A BLESSING IN DISGUISE, HAVING EVERYONE WORKING TOGETHER ALL IN THE SAME HOUSE. "
> — Carmyn Talento, representation team lead for Iris

Iris wouldn't be a rover in the traditional sense, but it was still a space-faring object that was actively making history. The team dropped everything to make sure that it continued to do so.

When the team was able to retrieve information and check the status of Iris' systems from hundreds of thousands of miles away, they knew that it was a success story unlike any other: a heartbeat in space. It was proof that years of hypothesizing, building and testing had worked — even in the face of uncertainty.

"There was an eruption of cheering," Talento said, "a new wave of hope."

NOT DEAD YET

The 2.2-kilogram rover, powered by a custom single board computer, was the first of its kind to survive a launch and a zero-gravity environment. Printed directly on the board were the names of dozens of engineers who contributed to the rover's journey. Its primary systems, tucked within a shoebox-sized carbon fiber chassis, performed well as the rover endured extreme temperatures and high levels of radiation. Even through lapses in signal and changes in objective, Iris persevered.

> " THE TEAM WORKED AROUND THE CLOCK — THERE'S NO TIME OF DAY IN SPACE. "   — Carmyn Talento

As the mission continued, so did the issues. The team faced several interruptions on the ground. Planned communications outages meant that they were unable to check its systems for excruciating periods of time. A tornado warning sent the team into a frenzy. A fire alarm went off. At one point, a mix-up between a thermostat and the house's security system brought the police to their rental. Still, none of it stopped them from their new goal of receiving data and testing systems as Iris soared through space.

"The team worked around the clock — there's no time of day in space," Talento said. "There's no a.m. or p.m. You either have signal, or you don't have signal. We work with what we've got, and as students, we're going to want to work."

By the time Peregrine started to swing back toward Earth, Iris became much more than an engineering project. For the students, it became a symbol of resilience and a

Members of the Iris team worked around the clock to respond as new challenges arose.

[RED] YAMCS (b'irisyamcs') ->
WIRED [14B]: Hello, Earth!
YAMCS (b'irisyamcs') ->
[53B]: Transitioning from

Image of Iris' wheels taken in space by Astrobotic (edited by Oleg Sapunkov, the Iris Thermal Lead).

I am not dead yet!

Instagram meme posted by Iris team

testament to their ability to pivot on the fly. A few short days after the initial launch, the Iris team posted a meme on Instagram depicting the rover as a Monty Python character, declaring defiantly, "I am not dead yet!"

They followed by sharing that they had achieved two-way communication with the rover in space, receiving a message in real time from Iris: a cheerful, "Hello, Earth!"

As Peregrine continued its egg-shaped orbit around the planet, the team brainstormed ways to make the most of its battery life and remote capabilities.

(Left) Raewyn Duvall, Iris program manager, and (right) Connor Colombo, chief engineer, at work in Florida.

ONLY THE BEGINNING

Iris returned to Earth's atmosphere above the remote south Pacific Ocean on Jan. 18, and disintegrated upon reentry. While Iris' journey didn't go as planned, the students succeeded in building a piece of space-faring technology that has made it farther from Earth and closer to the Moon than any student-built rover has to date.
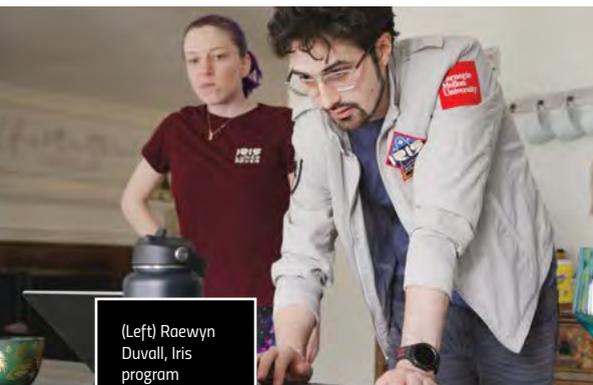
"Ultimately it comes down to having a team that works well together, is confident and throws ideas out, however crazy they might be," Talento said. "Speak your mind, and someone will take it, someone will run with it, and together we'll figure it out."

There are currently no plans for an "Iris 2." However, the technology and action behind Iris lays substantial groundwork for future space, robotics and engineering endeavors at Carnegie Mellon. Raewyn Duvall, the Iris program manager and a rover executive director, noted that the team's work has already made a substantial impact on space and robotics work at CMU.

"A lot of lessons learned have already gone into projects like MoonRanger," said Duvall, who was previously at NASA. In one instance, before delivering Iris to Astrobotic, an opening needed to be made on the rover to access difficult-to-reach internal electronics so that software updates could be made after delivery. This inspired an approach to incorporate more direct access points into the designs of future projects. "The question of, 'How do you future proof?' is something most students don't think of. Building it into the procedures future projects will use is a really big thing."

> " SPEAK YOUR MIND, AND SOMEONE WILL TAKE IT, SOMEONE WILL RUN WITH IT, AND TOGETHER WE'LL FIGURE IT OUT. "
> — Carmyn Talento

BUT PERHAPS MORE IMPORTANTLY, IRIS AND ITS STUDENT TEAM HAVE ESTABLISHED A LEGACY OF TEAMWORK AND INCLUSION.

"One of the goals of Iris at a fundamental and broad level is to open up space to more people," Talento said. "If we've learned anything from this, it's that that's a good idea and needs to happen sooner rather than later."

International contributions to the project meant that the team was able to bring in perspectives that seldom make their way into other institutions in the industry. "We were fully a university project, so were able to work with international students who would not otherwise be able to due to proprietary issues," Duvall said.

Additionally, the Iris team comprises individuals from a wide range of academic backgrounds, ethnicities, cultures, sexual orientations and gender identities to form a welcoming environment. "They have become such a family," Duvall said.

"Especially after being stuck in a house together," Talento added. "We have the annoying younger brother trope, the strange cousin ... the separated dad who comes back for all of the cool events," Duvall added jokingly. "There are all of those roles."

The experience allowed the current students, many of whom are members of Gen Z, to form relationships that will likely last a lifetime while setting records and achieving scientific marvels.

"Iris' legacy is to open up space to students, to young people, to enthusiasts, to dreamers," Talento said. ■

Bringing Responsible Thinking to AI

SHERI HALL

Translating language with nuance might be one of Mona Diab's superpowers, especially when it comes to incorporating cultural differences into language technologies. But it's not her only superpower.

Beyond deciphering language, Diab, the director of the Language Technologies Institute (LTI), strives to translate what she has learned in six and a half years working in industry at both Meta and Amazon to train the next generation of AI scientists and impart the integrity that will lead to the responsible development and use of artificial intelligence. Diab endeavors to translate the technical aspects of these new tools into concepts that regulators and the public can better understand.

"I believe our field has an obligation in the ways we interact with society," said Diab. "How do we build technologies that take into account people and cultures? And how do we develop the next generation of scientists, and instill in them the right values?"

Diab has coined the term "responsible thinking" as an important tenet of computer science training; as valuable and as critical, she believes, and as computational thinking. For Diab, responsible thinking means that the architects of new technologies must address broader societal issues such as privacy, culture, security, and diversity and inclusion.

Her drive to influence the next generation of technology architects inspired Diab to leave the private sector for SCS.

"Out in the real world, we have gaps we need to fill, specifically talent gaps when it comes to developing AI," she said. "But how do we do it in the right way? I came here because I want to help fill that gap the right way, and CMU is the number one place in the world for AI."

Building a bridge between technology and society

Born to Muslim Egyptian parents, Diab spent the first eight years of her life in England. She began learning Arabic in school at eight years old, and practiced by reading the Quran.

> "I'm very passionate about women being able to be and do anything they want."
>
> — Mona Diab
> — منى دياب

> **" Diversity and inclusion of ideas, cultures and people is the only way to unlock untapped potential leading to eventual growth. "**
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"When we moved back to Egypt," she said, "I was treated differently because Arabic was not my native language. But I was also a geek, so I was acing all of the Arabic exams."

From a young age, her parents emphasized the Islamic tenet of seeking knowledge. "The Quran is very clear that we should pursue knowledge wherever it is in the world," she said. "It's something a lot of people don't realize."

This principle is what inspired Diab to pursue higher education, specifically the intersection of technology and language.

"My perception of Islam is that it is very logical," Diab said. "The whole scientific method — how you investigate a problem empirically — originated with Islam. For me, this notion of language and how it shapes thought is rooted in the Quran."

When Diab wanted to study in America, it was the Islamic principle of seeking knowledge that propelled her parents to give their blessing, even though her extended family disapproved.

Diab's education reflects her twin passions for computers and society. "I'm focused on the balance between humans and technology," she explained. "I am very analytical, but I've always been interested in the humanities as well."

Diab holds degrees in computer science and Egyptology, machine learning and computational linguistics. She's spent portions of her career in both academia and industry, which led her to appreciate the human and social consequences of AI.

"When this opportunity came about [to lead the LTI], it was a big deal for me," she said. "In industry, you can have a small impact on developing new talent. In academia, it's scaled up."

Translating cultures

Diab's global experiences give her special insights into how to address cultural issues in large language models and teach students to build nuance into generative AI tools.

For starters, when building a model that generates language, it is important to consider what information is available to guide the model. "The internet is not a good reflection of every society and culture," Diab said. "It really depends on how much internet penetration you have in a specific community and what demographics are represented."

In a current study, Diab's research team is using surveys to compare how cultural trends in Egypt and the U.S. are reproduced on the internet and how they influence generative AI tools.

"For example, how important is it to take care of the elderly in your society?" she said. "In Arab society, this would be deemed as very important. In Western cultures, it would have a different value. Having these differences represented in technology is important."

But information about the cultural norms in Egypt may not be as widely available on the internet, and therefore may not be accurately represented in generative AI models. "An AI model may mislead you in understanding a cultural value because the information is misconstrued on the internet," Diab said.

In addition, language and translation are important components of how models translate cultural values. "So, we have to build systems that ask these questions in a smarter way, using a framework rooted in anthropological sciences," she said.

Regulatory translation

Diab has begun work to bridge the divide between computer scientists and government regulators. The ultimate goal is an automatic regulatory compliance system that helps technology architects anticipate regulations and build compliant generative AI models.

"We want to make sure this new system doesn't add to the burden of building models, but makes it easier for people to be responsible and governed in the right way," said Diab. "We want to ensure the highest scientific integrity standards by anticipating and helping to shape regulations."

Such a system would help foster better relationships between government regulators and technology builders, Diab said.

Consider the example of advertisements for online gambling on social media platforms. Many governments across the globe regulate who can see these ads. For example, regulations restrict U.S. platforms from showing them to people under age 18.

"This creates a complicated scenario because there is also a privacy aspect to social media accounts, so often the demographic information can't be identified," Diab said. "Companies find all sorts of loopholes to follow these types of regulations in practice, but it's time consuming. Currently, you have legal and policy people getting together with technology people to implement this manually.

"The technology I am proposing could assist with this problem by distilling a lot of information, beyond what a single human could do," Diab explained.

In addition to aggregating data, Diab envisions a system that would foster better communication between regulators and technology experts using chatbots and assistive communication technologies.

"It would essentially create an interface between the technology architects and the legal and policy people," she said. Diab envisions the system would include features that translate technical language and concepts into explanations that policymakers can better understand.

"If they could have more fruitful conversations, they could have better compliance with the regulations, and together they would be able to create better regulations," she said.

Championing Female Scientists

Beyond working to bridge divides between academia and industry, technology and culture, and regulators and scientists, Diab is pursuing another goal: elevating the role of women in science.

"I'm very passionate about women being able to be and do anything they want," she said.

Diab recalls when she first began attending academic and technology conferences in the U.S. "Most of my formative years were in Egypt," she said. "There are protocols that women wear dresses and makeup. In the U.S., I would dress up to go to a banquet at a conference and people almost looked down on me."

These stereotypes of female scientists in Western cultures drive some women away from STEM fields, Diab said.

"In the U.S., female scientists are represented in the media as being nerdy or geeky — not feminine," she said. "A lot of girls who have potential in the sciences step out of that realm because of this perception. You should be able to decide to look however you want. And women should not be considered less smart or able just because we are feminine."

To cope with this issue in her own life, Diab has connected with six other female scientists who are leaders in their fields. They formed a group called "The Fashionistas," and they meet regularly to discuss the difficulties of being a female leader in science.

Diab has also created a broader group on Facebook called Global Women in NLP (Natural Language Processing) — with more than 500 members.

"It's meant to be a safe space for women to vent, get advice and propel their positions," she said. "We also have a lot of conversations around sponsorships, mentorships, publications, how domestic issues can interfere with work — you name it."

Supporting women interested in building large language systems is one more way that Diab hopes to influence the next generation of AI scientists. Diab truly believes that diversity and inclusion are critical for the sustainability of the field.

"Diversity and inclusion of ideas, cultures and people is the only way to unlock untapped potential leading to eventual growth," she said. "I'm learning so much every single day. I truly believe that responsible thinking with diversity and inclusion as a core tenet is going to be the next frontier in our field, and I want to use it to train the next generation of scientists."

It all comes down to bridging the gaps between the technology industry and academia, and between AI architects and regulators — forms of translation that truly highlight Diab's superpowers. ∎

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TRICIA MILLER KLAPHEKE

SHAPING AI POLICY

SCS Faculty Advise Government Officials on Benefits, Threats and Regulations Required for Ethical AI Implementation

The executive order on artificial intelligence that President Joseph Biden announced in October of 2023 followed years of conversation between policymakers and academics on how AI can be used responsibly. Though not an entirely new phenomenon, faculty from across CMU have since provided expertise and a sense that AI can help policymakers in specific circumstances.

SCS Dean **Martial Hebert** said the revolution around AI reminds him of the digital revolution, except that advances are coming much more rapidly. As with many political issues, the reaction to that is often binary: some leaders fear that AI is evil and could lead to increasingly dangerous outcomes, while others feel AI is a force for good that can solve many problems. The reality, SCS faculty agree, lies somewhere in the middle.

Martial Hebert,
Dean of SCS

While it is important for experts advising government officials to have a deep understanding of both technical details and public policy surrounding AI issues, sending a consistent message to government entities will help coordinate efforts across individual circumstances. Hebert identified three priorities for the government in crafting policy: training people to use AI, researching potential new uses for AI, and establishing frameworks to make AI trustworthy. Explaining the nuances of each of those priorities can be difficult.

Carnegie Mellon and SCS are uniquely positioned to advise U.S. government officials at the federal, state and local levels on such policies. In addition to having expertise in AI, SCS faculty collaborate broadly across the university, working closely with faculty from the Heinz College of Information Systems and Public Policy, the Dietrich College of Humanities and Social Sciences, and the Tepper School of Business, as well as from other universities across the country, to give recommendations that consider each question from every angle.

ADVISING FROM THE BEGINNING

Every time AI has had a potentially big impact, **Tom Mitchell,** Founders University Professor in Computer Science, has been there to advise government officials. He first briefed federal officials about AI in the early 1990s when he spoke to the Information Sciences and Technology (ISAT) committee within the Defense Advanced Research Projects Agency (DARPA), the Department of Defense's funding agency for research. As a member of ISAT, Mitchell spoke about where technology was heading and where ISAT might want to invest its resources. Since then, he has traveled to Washington frequently, briefing officials from different government branches and agencies about how they should be taking advantage of AI, as well as how it should be regulated.

In the late '90s Mitchell joined the National Academies of Science (NAS) Computer Science and Telecommunications Board. Following the attacks of September 11, 2001, he participated in and chaired NAS' Workshop on Information Fusion and Counter-Terrorism, briefing the workshop on the use of AI in counterterrorism. Soon after, he testified before a congressional committee on how AI could be used to help the Veterans Administration process medical claims.

Tom Mitchell, Founders University Professor in Computer Science

> "All of the interactions I've had with government people have made me more optimistic about our government function than what I read in the newspapers," he said.

In 2023 Mitchell attended multiple private meetings with members of Congress and spoke publicly to Senate Republican staffers about large language models. With a nonpartisan think tank called the Special Competitive Studies Project, Mitchell chairs a task force that will give government officials recommendations on generative AI, advising how the U.S. can remain competitive with other countries as officials learn how to use the technology ethically. Mitchell also works with the U.S. National Academies on a congressionally-mandated study on AI and the future of work. Both will be published in 2024.

Mitchell said three broad principles should be followed as they design the government response: most regulations should target the application of AI, not AI at large; a small percentage of regulations should target general purpose AI tools such as Chat GPT; and ultimately, no matter how diligent they are in anticipating potential issues, some will come up that can't be anticipated, and an organization will need to be in place to address those.

Tom Mitchell (left), meets with Rep. Susie Lee (NV-03) to discuss the latest advancements, research, opportunities and challenges surrounding AI. Also meeting: members of CMU's Block Center Responsible AI leadership team: Hoda Heidari (center front) expert in AI ethics, fairness and accountability and Ramayya Krishnan (right front) faculty director of the Block Center. Not pictured but attending: Rayid Ghani, expert in AI, policy and social impact.

AI HELPING HUMANS MAKE GOOD DECISIONS

Aarti Singh, professor in MDL and director of AI-SDM

Aarti Singh, professor in the Machine Learning Department, briefed members of Congress and their staff for the first time in September 2023 when the NSF brought together the leaders of all 25 AI research institutes it is funding to Capitol Hill to raise awareness of how AI can positively impact society. Singh is the co-director of the AI Institute for Societal Decision Making (AI-SDM), which opened at Carnegie Mellon in June 2023 thanks to a $20 million, five-year grant from the National Science Foundation.

Researchers from an array of disciplines and institutions collaborate at AI-SDM to advance AI and use it to better inform decisions people make. The institute focuses on two specifics: as a matter of public health, the researchers are looking at ways AI can help identify patients at high risk for certain pregnancy complications early on and ways to engage them with health services.

In the area of emergency management, AI-SDM explores ways to use autonomous robots and drones to go places too dangerous for humans. Getting into these areas supplies emergency managers with more informed data to make critical decisions. These challenges are ideal for academics to explore, since they are not the kind of projects that profitability-driven companies have shown interest in.

Singh has continued to answer questions from Congressional staff following the September event.

> "My takeaway was that people talk a lot about what AI can do, both positively and negatively, so that leads to both the hype and the fear of it," said Singh, "but what people talk less about is what AI cannot do and that's so important to convey."

Singh will continue to engage with policymakers and the other AI research institutes. NSF hopes to host another showcase for the AI institutes on Capitol Hill, and Carnegie Mellon will host the annual summit for the AI institutes in October 2024.

ENCOURAGING SMART GOVERNMENT ACQUISITION

One of the primary ways the federal government can influence how artificial intelligence evolves, even while it moves slowly to establish regulations and laws, is through its acquisition of technology. As one of the largest buyers in the market, government agencies can encourage ethical, effective technology to be developed by buying from companies that produce it well. Once that technology is built for the government, it can more easily be adapted for private buyers.

In September **Rayid Ghani**, distinguished career professor in the Machine Learning Department and the Heinz College of Information Systems and Public Policy, testified before the Senate Homeland Security and Governmental Affairs Committee on Acquisition and Procurement.

Rayid Ghani, distinguished career professor in the Machine Learning Department and the Heinz College of Information Systems and Public Policy

Rayid Ghani (left) testifying before the Senate Homeland Security and Governmental Affairs Committee on Acquisition and Procurement.

"Too often, organizations go on the market to buy AI without completely understanding, defining and scoping the concrete problem they want to tackle, without assessing whether AI should even be part of the solution, and without including individuals and communities that will be affected," Ghani wrote in his testimony. "AI systems are neither applicable for all problems facing government agencies, nor are they one-size-fits-all. By starting with the concrete problem at hand, and understanding how it's being tackled today, an effective, collaborative and inclusive scoping process can help determine the requirements that the AI system needs to fulfill."

Ghani has testified before Congressional committees before and often works with government staff at the local, state and federal levels as they look for technology solutions. He said that each time he has testified before a committee that starts a conversation, it continues as staffers work to understand the nuances of potential policies.

Going forward, Ghani said he sees three avenues where CMU faculty can help government in interesting and impactful ways. The first: helping local governments figure out how to use AI to allocate resources, making sure that the government's services and supplies are reaching the people who need them. The second: helping regulatory agencies determine how to use AI responsibly in their efforts to audit companies in their jurisdiction and enforce the law. The third: to continue supporting the National Institute of Standards and Technology, an office within the U.S. Department of Commerce, as it develops broader guidelines that make up the AI Risk Management Framework.

SUPPORTING WORKERS

Jodi Forlizzi, the Herbert A. Simon Professor in Computer Science and the Human-Computer Interaction Institute, is deeply involved with the AFL-CIO's Technology Institute. As AI continues to reshape the responsibilities of frontline workers, Forlizzi and her HCII collaborators, faculty member Sarah Fox and Ph.D. student Franchesca Spektor, work with the union to think about how these workers can be part of developing technology that makes their jobs easier, not harder.

In October 2023, Forlizzi spoke to the AI Insight Forum on AI Innovation, hosted by two senators from each party. Senate Majority Leader Chuck Schumer (N.Y.) and Senator Martin Heinrich (N.M.) represented the Democrats and Senator Mike Rounds (S.D.) and Todd Young (Ind.) represented the Republicans.

Forlizzi built on the previous closed-door briefings she had delivered to members of Congress, emphasizing the involvement of workers in the design, development and deployment processes of AI to ensure workers' expertise is reflected in the AI systems created. At the forum, Forlizzi cited housekeepers at hotels as an example.

"For housekeepers, algorithmic managers (AMs) increase work, increase job requirements and decrease worker autonomy," she wrote in her testimony. "Instead of letting housekeepers clean rooms in the order that makes the most sense to them based on their ability to complete their room quotas with a minimum of wear and tear on their bodies, AMs send them back and forth and up and down in hallways and elevators, while they push 200- to 300-pound carts. We have heard again and again from housekeepers that the AM 'wastes my time.' AMs increase wear on the worker by assigning several check-out rooms, which require heavy cleaning, back-to-back, as opposed to alternating them with the lighter physical requirements of rooms in which only sheets and towels need changing. Housekeeping is also an entry-level job that traditionally did not require technology skills or even fluent English. This, combined with typical connectivity issues, has altered the job of the housekeeper greatly, with little to no increased training or increased compensation."

Along with UNITE HERE, an AFL-CIO member that is the largest hospitality union in the U.S., Forlizzi will lead a research team, a hospitality training center and a software company that provides algorithmic management solutions for the hospitality industry in 2024. Funded by the NSF, the collaborators will develop recommendations to prepare workers for the future.

Forlizzi, who earned her master's degree in interaction design and her Ph.D. in design in human-computer interaction, both from Carnegie Mellon, said those groundbreaking experiences inform the way she works and advises officials on issues that are developing now.

Jodi Forlizzi, Herbert A. Simon Professor in Computer Science and the Human-Computer Interaction Institute

"We were some of the first people doing the kinds of design work that we're doing today. Our program was really new. In some ways we were making it up as we went and creating new knowledge, so it taught me to be comfortable with uncertainty," Forlizzi recalled. "You're making a lot of judgments as a designer and a researcher to try to improve the state of the world, and that's something I'm still doing."

Of course, many more CMU AI experts have given their testimony to government officials at all levels, including the United Nations, and will continue to do so as AI policy develops. At a time when the technologies advance at a dizzying pace, the U.S. government continues to look to CMU for expertise not only to understand the advances in AI and the guardrails needed to keep people safe, but also how to best implement AI ethically and with fairness for all. ■

AARON AUPPERLEE

Carnegie Mellon University and Play Included® Bring LEGO® Brick Based Interventions

to the **U.S.**

Carnegie Mellon University
Center for Transformational Play

PL A Y INCLUDED

Brick by brick, Carnegie Mellon University is building a new way to transform children's social and emotional learning in schools and community organizations throughout Pittsburgh and, eventually, across the country.

CMU has announced its partnership with a U.K. social enterprise, Play Included®, to officially launch Project Baseplate, a scalable platform for deploying LEGO® brick based activities to children across the United States. The university's pioneering Center for Transformational Play (CTP), which focuses on the research and development of transformational games, will lead the first two Project Baseplate initiatives: launching the Brick-by-Brick® program, an internationally acclaimed LEGO® brick based therapy in the United States; and conducting a research study on the potential for Brick Clubs to foster economic connectedness through cross-class friendships.

"We're excited to be working with an organization that shares our values and priorities: creating playful experiences that change people's lives," said Jessica Hammer, CTP director and the Thomas and Lydia Moran Associate Professor of Learning Sciences in CMU's Human-Computer Interaction Institute in the School of Computer Science and the Entertainment Technology Center (ETC).

The CTP is the first U.S. training partner for the Brick-by-Brick® program. Creation of the CMU training hub is supported by the Leonard Gelfand Center for Service Learning and Outreach, which works with staff, students and faculty at CMU and within the community to improve educational outcomes for K–12 students through educator professional development. The partnership will enable CMU to train education professionals to deliver the program in their own schools and community settings to support children's development and personal well-being.

Project Baseplate will also investigate how Brick Clubs, set up through partnerships with community organizations, can enable cross-class friendships by bringing together children from different backgrounds. Cross-class friendships can dramatically impact children's lives. Recent research on economic mobility and connectedness suggests having strong social networks across socioeconomic status is associated with upward income mobility. At Brick Clubs, trained facilitators guide children in Brick-by-Brick® program activities, including collaborative building techniques that strengthen both skills and confidence. Led by the CTP, a multi-organizational team of researchers will first study the types of social connections enabled by current Brick Clubs. The researchers will then design research-backed

Dragon's Den after school program participants take part in weekly Brick Club activities

"Brick Buds" after-school program participants put the finishing touches on their LEGO Space Mining creations

Members of Brick Club at Dragon's Den build collaboratively under the supervision of their facilitator CMU ETC K-12 Network Coordinator and Play Included Brick Club facilitator Anthony Palyszeski (center)

interventions to help kids form meaningful relationships with children from different socioeconomic backgrounds.

The project will include area K-12 schools and community institutions such as the Children's Museum of Pittsburgh and Dragon's Den, a nonprofit providing transformative learning environments in Homestead, just outside Pittsburgh. Hammer will lead the research project in collaboration with Kody Manke-Miller, an assistant professor of teaching in the Dietrich College of Humanities and Social Sciences' Psychology Department and the college's director of research on diversity and inclusion; and Judith Uchidiuno, an assistant professor in the Georgia Institute of Technology's School of Interactive Computing. This research is funded by the Richard King Mellon Foundation.

The Brick-by-Brick® program, developed with support from the LEGO Foundation, is an evidence-based, child-led approach that draws on the latest research in neurodiversity and learning through play. The neurodiversity-affirming

program offers children positive, meaningful social experiences in a playful and accepting environment. Through collaborative play, children have fun and make friends, and develop their communication skills, confidence, and social and emotional well-being.

"We are thrilled to be partnering with the prestigious Carnegie Mellon University to launch our Brick-by-Brick® program training pathway in the U.S. Just like the Center for Transformational Play, we firmly believe that play is fundamental for children's development. Not only does it support their social and emotional well-being, it improves their cognitive and physical

development. Most importantly, play is an opportunity for children to enjoy meaningful social experiences together — something many children missed out on during the recent pandemic," said Gina Gómez de la Cuesta, founder and director of Play Included.

"The Center for Transformational Play team is hugely enthusiastic and passionate about giving children access to playful experiences, and our partnership will give educational professionals the opportunity to learn how to support the social and emotional well-being of children using the most up-to-date version of LEGO® brick based therapy," Gómez de la Cuesta continued.

Western Pennsylvania educators and community partners; representatives from Play Included: Director Gina Gomez de la Cuesta, Head of Partnerships Benjamin Huaman, and Head of Operations Sarah Lee

Over the past few weeks, the university has trained 27 school-based and out-of-school program educators in the Brick-by-Brick® program methodology, and 16 active sites across Pittsburgh have already implemented the program with more than 170 local children. The Brick-by-Brick® program is supported by funding from the Benedum Foundation, The Grable Foundation and David L. and Noelle C. Conover of Matt's Maker Space.

"We are excited to bring the Brick-by-Brick® program to Pittsburgh and launch Brick Clubs in our region," said John Balash, head of partnerships at the

CTP and director of educational engagement in the ETC. "In fact, we have already seen the benefits of the program through a pilot we ran with students around Pittsburgh."

The CTP ran a Brick-by-Brick® program pilot in 2023 across Intermediate Unit 1, covering schools in Fayette, Greene and Washington counties; the Allegheny Intermediate Unit, covering schools in Allegheny County; Manchester Craftsmen's Guild in Pittsburgh; Dragon's Den in Homestead; ASSEMBLE; Pittsburgh Public Schools; Beaver Area School District's Dutch Ridge Elementary School; and the Matt's Maker Space at Mt. Lebanon's Mellon Middle School. In collaboration with Remake Learning, the CTP looks forward to expanding across the region and amplifying Play Included's work. At CMU, the Simon Initiative and ETC have supported the rollout of regional clubs.

"Having visited some of the creative Brick Clubs in Pittsburgh, it is clear that the Brick-by-Brick program provides a welcoming space that encourages children to be more playful and creative. It's an incredible way for children to engage, interact with one another and build experiences via learning through play," said Andrea Hernández, program specialist at the LEGO Foundation.

Teachers can learn more about the Brick-by-Brick® program on the Play Included website.

There are a number of funded training places available for education professionals in Pennsylvania. To learn more, visit the Project Baseplate website.

NOT ONLY AVAILABLE, BUT ACCESSIBLE

BRINGING CMU CS ACADEMY INTO THE SPANISH LANGUAGE

KAYLA PAPAKIE

Sofía De Jesús, associate program manager, CMU CS Academy

> *When I found CMU CS Academy, for the first time I thought, 'I can teach with this.'*

Sofía De Jesús was teaching in a middle school when she first used CMU CS Academy, a free program that provides computer science curricula and professional development to help middle and high school instructors teach programming skills.

"As a teacher, I was always looking for resources. I'd used so many of them, but my students and I would get bored, so nothing had stuck," she said. "When I found CMU CS Academy, for the first time I thought, 'I can teach with this.' "

Founded in 2018 by Mark Stehlik and David Kosbie, both University Teaching Professors of Computer Science, CMU CS Academy teaches Python, a text-based programming language that is the most widely taught language at the university level. The online program offers several different curricula, including the flagship course, CS1: Introduction to Programming with Python; a lightweight version of CS1 for middle schoolers; and a college preparatory course that has the option for students to earn CMU credits.

Non-native English speakers can struggle in English-based computer science programs, especially Spanish speakers. A year after its initial launch, Stehlik and Kosbie championed the need for a Spanish version of the program and began piloting the translation work with CMU undergraduate students.

> *Availability and accessibility are not the same, and they're not interchangeable.*
> — Sofía De Jesús

The CMU CS Academy team

Simultaneously, De Jesús reached out to inquire about translation plans after completing her CS1 Level 1 and Trainer certifications.

"I loved it so much that at some point I ended up sending an email saying, 'Hey, if you ever think about translating, just let me know,'" recalled De Jesús, who has volunteered her time to translate other materials. Elated to hear that translation was already underway, she joined the CMU CS Academy team full time in July of 2021 as associate program manager.

About 15 percent of U.S. residents are native Spanish speakers, and that percentage has grown 40 percent year-over-year since 2009. Educational programs celebrate when they enroll these diverse students, yet there are still barriers to learning after getting in the door.

"Availability and accessibility are not the same, and they're not interchangeable," De Jesús said. "If a course is available, but it is not in your language, the process for learning is different. It can be taxing and even physically exhausting. Having resources in Spanish makes a massive difference."

The Spanish translation team includes School of Computer Science students and students from other programs, many of whom come from different Latin American countries, including Argentina, Cuba, Mexico, Puerto Rico and Colombia. De Jesús also works with foundations and Ministries of Education in Latin America and districts in the United States to help support teachers using the curriculum.

"Having a group from so many different backgrounds is a really cool way to tackle a translation project. All of their knowledge and experiences kind of bleed into that translation," De Jesús said.

Team Testimonial:

"Having gone to school in heavily Hispanic communities, I feel like having access to a Spanish program that allowed for a wider range of people to learn about coding and its impact on the world would have provided more options and opened the eyes of many students to a career they might have not considered before. I hope that our work allows for more people to join the amazing, ever-growing world of computer science. There are so many careers possible through that area of study or interest that, at least to me it seems that way, it can fit for anyone and everyone."

— José Raúl Anaya Meléndez, Spanish Translation Team Member

Daniela Hernandez, a senior AI major in SCS and head TA for the Spanish team

Daniela Hernandez, a senior artificial intelligence major in SCS and one of the students on the project, says the experience has been fun and eye-opening to the challenges of translation.

"Choosing translations sometimes posed a challenge due to the diversity of our team members, each having different words for certain things," Hernandez explained. "Deciding on universally understood terms and representations proved difficult."

The word for the color brown, for example, in many Spanish-speaking countries is "marrón." But in Cuba, they often use "carmelita" instead, as a reference to the color of the habits worn by the nuns and monks in the Orden de las Carmelitas. Considering these regional nuances, the team had to do their best to standardize the translations, making clear notes on the intended meaning for each word to prevent confusion or inconsistencies. Each translation also underwent an editorial process to ensure correctness. It was a huge undertaking, consisting of translating not only the courses and code, but also any supporting material and services, including documentation, virtual assistance and in-person training.

"A crucial aspect of expanding the curricula involves teaching the material to Spanish-speaking teachers so that they can teach their students," said Hernandez, who is currently the head TA for the Spanish team. "I've had the opportunity to collaborate with teachers from Puerto Rico, Mexico, Colombia, Chile and Ecuador, among other countries."

> A crucial aspect of expanding the curricula involves teaching the material to Spanish-speaking teachers so that they can teach their students.

The team also had to be cognizant of the different user modalities. While both the teacher and student could be using the program in Spanish, there are also many cases where a teacher uses the program in Spanish while the student uses it in English, or vice versa. The team had to ensure a seamless teacher-student experience no matter which language was toggled on either end.

"The way we've done the translation is flexible enough for people to use it and have all the resources regardless of which version they're in," said De Jesús.

More than 370,000 students in total have used CMU CS Academy, and there have been over 56,000 classrooms created. On any given day, there are nearly 50,000 students and 2,100 teachers using the program. The top countries for users in Spanish are Colombia, Ecuador, Puerto Rico and Mexico. They are also rolling out the program in Chile.

While the CS1 curriculum translation has been completed, the team views it more as a work in progress.

"Overall, translations are an ongoing process," said Hernandez. "We continually enhance, rearrange and modify the content as needed, striving to make the material as clear as possible."

The next planned curriculum translation is College Programming and Computer Science, the college preparatory course that provides optional CMU credits. And although she will not be an official member of the CMU CS Academy team once she graduates in May, Hernandez hopes to stay involved.

"I plan to stay connected and contribute in any way possible," she said. "Witnessing the remarkable projects our students complete with the knowledge they've gained from the course is truly inspiring. Knowing I played a small role in providing them with this content makes me proud to be part of such an amazing team." ∎

Rachel Wilson, a senior computer science major, said her involvement with CMU CS Academy's Translation Team has sparked her interest in a research project. Wilson, who is also a Hispanic studies minor, does not come from any particular dialect of Spanish. Rather, she learned the language in school.

While working with CMU CS Academy in the spring of her first year as a member of the Outreach Team, Wilson heard about the translation project and became interested from afar. "I wanted the opportunity to practice Spanish, but I did not yet have the confidence to say, 'Yes, I can translate,'" she said. After expressing interest in shadowing the translation team, Wilson was thrown in almost immediately. By summer, she was working to convert both the code and content into Spanish.

Rachel Wilson, a senior CS major, Hispanic studies minor and CMU CS Academy translation team member

Wilson returned for a second summer with CMU CS Academy feeling much more confident in her language and translation abilities. That summer, she led professional development trainings and taught code completely in Spanish.

"That was probably the most fun I've ever had because the teachers were so eager to learn and they loved the support we provided," she said. "It really makes you feel like a superstar."

Wilson, who will be staying at CMU after graduation to complete the Fifth Year Scholars program, says the experience opened her eyes to the ways in which computer science, teaching and Spanish could all be combined. "It was the perfect intersection of my interests, and it has been a huge inspiration for my Fifth Year Scholars project. I want to investigate the effects of learning code in a person's native language."

SCS PROFESSOR PENS PROBABILITY TEXTBOOK

Mor Harchol-Balter, the Bruce J. Nelson Professor of Computer Science has completed her book "Introduction to Probability for Computing" published by Cambridge University Press.

As mentioned on the book's website, the book gives an introduction to probability as it is used in computer science theory and practice, drawing on applications and current research developments as motivation and context.

The textbook is available broadly for colleges to use in their curriculum and will be used in SCS' Probability and Computing course. ■

Harchol-Balter issued this statement:

For anyone who took Probability and Computing (often referred to as "PnC") at CMU, the long-awaited textbook for the class is finally here: Introduction to Probability for Computing. The book is dedicated to the students of CMU's School of Computer Science, whom I've loved teaching for the past 24 years. It is written in classic PnC style, as a list of Questions and Answers. The book is also full of pictures referencing CMU, including Carnival festivities, Buggy, the Three Rivers of Pittsburgh, the States of Love, and more. Some of you might even find your name in there. Enjoy the memories as you refresh your probability!

Thank you all for encouraging me to finish this.

— Mor Harchol-Balter
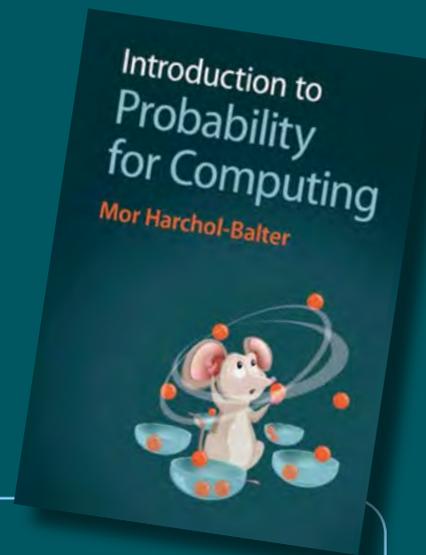
BEHRING FOUNDATION SUPPORTS UNDERGRADS FROM BRAZIL IN TECH

The Behring Foundation, a Brazilian-based family organization focused on empowering talented youth and promoting social development, has established a scholarship to support international students pursuing tech-related undergraduate degrees at Carnegie Mellon University.

The Behring Scholarship provides funding for two students per year with permanent residential addresses in Brazil who are enrolled in SCS or the Department of Electrical and Computer Engineering (ECE) in the College of Engineering. The scholarship is intended to cover the full cost of attendance for up to five years, including tuition, fees, room, board, books, supplies and more.

"From the start of the Behring Foundation, we wanted to educate talented Brazilians in technology and expose them to the best opportunities possible in the field," said Lucas Giannini, executive director of the Behring Foundation. "When establishing our scholarships and fellowships, we were looking for world-class academic opportunities — leading institutions in computer science and artificial intelligence — where we could do so. Carnegie Mellon clearly stood out."

The foundation's gift is the first of its kind at CMU, helping to fill a financial aid gap for international undergraduates who may not have as much access to funding opportunities as domestic students.

In addition to financial support, CMU's Behring Scholars will benefit from access to networking opportunities and meetings, like an annual summit to catalyze their education and career.

"Education is only one piece of the puzzle in terms of developing a thriving, productive ecosystem for technology in our community," Giannini said. "We also bring our scholars together with like-minded individuals who believe in technology as a key lever for social change."

To date, the foundation has pledged $1.37 million to support the Behring Scholarship. Two ECE students received the inaugural funding in fall of 2023, and the foundation's continued support will fund two more students in the next academic year.

"We want to support the best technologists, and we feel that putting them in a unique, thriving community that surrounds and immerses them in technology is the best way to do that," Giannini said. "That's what we've found here at Carnegie Mellon." ■

JOSHUA QUICKSALL

Jim Herbsleb to Step Down as Head of SD3

During his tenure as director of CMU's Institute for Software Research, now the Software and Societal Systems Department (SD3), Jim Herbsleb has been the architect of transformative change and enduring progress. Under his leadership since 2019, Jim has navigated the department through a significant rebranding, not just in name but in spirit, ushering in a period of remarkable growth and expansion. His adept handling of the department's transition through the COVID-19 pandemic showcased exceptional leadership, ensuring that the strong sense of community in SD3 not only endured, but thrived in the face of unprecedented challenges. Jim's foresight and dedication were pivotal in the successful return to on-campus work, demonstrating his unwavering commitment to the well-being and professional development of his team.

Among Jim's most notable accomplishments are the substantial increase in the faculty roster. His work has not only elevated the department's standing within the academic community but has also significantly enriched the collaborative and educational experience for faculty and students alike.

As Jim prepares to refocus on his groundbreaking research in software engineering and collaboration, we look forward to the continued impact of his work on how geographically disperse teams achieve synergy. Jim leaves behind a legacy of leadership that has indelibly shaped the department for the better, embodying the spirit of innovation and community that defines Carnegie Mellon.

We extend our heartfelt gratitude for Jim's years of dedicated service. His visionary leadership and profound contributions have set a lofty standard for those who follow. As he embarks on the next phase of his professional journey, we offer our best wishes for continued success and discovery. ∎

ADAM KOHLHAAS

Roni Rosenfeld to Step Down as Head of Machine Learning

After nearly five years as head of the Machine Learning Department in the School of Computer Science, Roni Rosenfeld announced that he will be stepping down. Beginning in 2018, Rosenfeld's tenure has been marked by significant growth and achievements, including the doubling in size of the core faculty, the expansion and streamlining of the master's program, and the navigation through challenges posed by space constraints within the department.

With Rosenfeld's leadership, the Machine Learning Department navigated its way through unprecedented challenges brought about by the COVID-19 pandemic. During this time, his work as head of CMU's Delphi Research Group contributed to the national response to the pandemic through COVIDCast, a nationally adopted tracking and forecasting tool. Despite this additional workload, as well as myriad uncertainties regarding the future, Rosenfeld managed to steer the department through this difficult time and helped to reestablish a strong sense of community among its members.

Moving forward, Rosenfeld will be continuing his groundbreaking work in developing epidemiological tracking and forecasting with the Delphi Research Group.

As the Machine Learning Department looks forward, with the recent accelerated developments in machine learning and artificial intelligence, Rosenfeld's invaluable contributions leave behind a legacy of excellence that will continue to shape the department's future endeavors. ∎

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PARTNERSHIP CREATES GROWTH OPPORTUNITIES FOR STUDENTS AND RESEARCHERS

A "unicorn company" is a term used to describe private startups worth $1 billion. The Unicorn Factory Lisboa acts as a hub for these companies and recently forged a new partnership with Carnegie Mellon University Portugal, a main driver in the Portuguese tech sector.

In October 2023, the International Technologies Institute (ITI) became the first research institution to partner with the Unicorn Factory. ITI President and CMU Portugal National Director, Nuno Nunes, said the university is one of the most competitive in Europe.

Despite being a medium-sized European country, Portugal has positioned itself as a leader in creating these highly innovative companies, Nunes noted.

"There are many projects and partnerships that benefited from a wide network of CMU Portugal talent and many leaders that, one way or another, contributed back to the country as academic leaders, entrepreneurs or by sharing their experiences with younger researchers," explained Nunes.

To highlight the varied diversity of the companies, he pointed to companies like **Mambu**, which started as a student project. Students researched micro-finance in Africa, and Mambu quickly became a leader in cloud banking. Another company, **Feedazi**, started as machine learning for various sectors and landed their skillset on financial fraud detection. For each of these ventures, Nunes believes location is primarily responsible for their success.

"While many of these global companies have headquarters in the U.S. or other financial markets, they share the Portuguese DNA," said Nunes.

Nunes notes that their partnership with the municipality of Lisbon and Fundação Santander Portugal Fund allows them to take advantage of local initiatives, making it seamless for startups to scale up through the Unicorn Factory.

Carlos Moedas (center), the mayor of Lisbon, sits in front of a computer screen, surrounded by a group intrigued with the technology

"Some of the Unicorn companies said it was very hard to find people with experience and skills to manage global digital products," explained Nunes. "With the help and funding of Fundação Santander, we are bringing this to Lisbon in collaboration with several schools and faculty from CMU."

Because the Unicorn Factory is a large driver of economic growth in the region, Nunes said the longevity of the partnership can be measured through the continued projects of researchers and alumni.

"The impact comes after these young, talented researchers create new companies and get jobs in world-class companies or universities," said Nunes, "even if they are not based in Portugal." ◼

Nuno J. Nunes, President of the International Technologies Institute and CMU Portugal National Director, in front of the Unicorn Factory building in Lisbon

Names in the **News**

Faculty members Maria Florina Balcan, Roger B. Dannenberg, Ken Koedinger and Elaine Shi have been recognized as **2023 fellows of the Association for Computing Machinery** (ACM).

Takeo Kanade, a Founders University Professor in the RI, received the **BBVA Foundation Frontiers of Knowledge Award** for decades of pioneering scientific achievements in computer vision and robotic perception.

Bailey Miller, a Ph.D. student in CSD, received an **NVIDIA Graduate Fellowship**.

RI faculty member Chieko Asakawa has been selected as a **National Academy of Inventors fellow**, the highest professional distinction awarded solely to inventors.

The RI's Zakia Hammal was named an **AI Researcher of the Year** at the prestigious Women in AI Awards North America 2023.

MLD Assistant Professor Virginia Smith was selected as a **2023 Samsung AI Researcher of the Year**.

Faculty members Hoda Heidari and Brad Myers recently received professorships. Heidari has been named the **K&L Gates Career Development Professor of Ethics and Computational Technologies**, while Myers was named the **Charles M. Geschke Director of the HCII**.

Researchers from the RI and College of Engineering won the **Best Industrial Robotics Research Paper Award** at the 2023 IEEE International Conference on Intelligent Robots and Systems.

Maarten Sap, an assistant professor in the LTI, received an **Amazon Research Award** for his work on preventing large language models from producing factually incorrect, unethical or toxic content.

SCS graduate students Yiding Jiang and Zhiqing Sun received **2023 Google Ph.D. fellowships**.

Graduate students Lea Albaugh, Bailey Flanigan, Maxwell Jones, Paul Pu Liang and Shih-Lun Wu were named **2024 Siebel Scholars**.

Leila Wehbe and Min Xu, faculty members in MLD and Lane CompBio, respectively, earned **NSF CAREER awards** totaling more than $1 million.
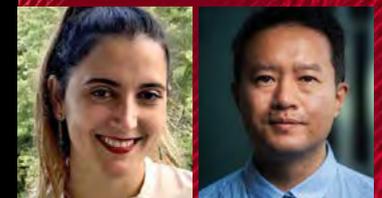
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Stehlik Leaves His Mark

CMU launched its undergraduate computer science degree program in 1989, graduating its first 75 undergrads in 1992. Mark Stehlik advised them all.

Stehlik has advised close to 4,000 students in Pittsburgh and Doha, Qatar, helping them navigate the occasionally rough waters between high school and college graduation. But Mark's dedication doesn't stop there. He has:

- Trained close to a thousand AP Computer Science high school teachers;
- Led C++ summer workshops as part of an NSF-sponsored program that helped equalize the gender balance in computer science at CMU;
- Co-founded CMU CS Academy, which provides free online computer science curricula for high school and middle school classrooms that has been consumed by almost 400,000 students.

We will honor Mark at Spring Carnival in 2025. Make a donation at tinyurl.com/MarkStehlikFund

Mark's SCS legacy is indelible, but his retirement is imminent. **To celebrate his career and his impact SCS has created the Mark Stehlik Endowment for CS Academy.** Donations to the fund will support the initiative to ensure that CS Academy exists in perpetuity.

FOR MORE INFORMATION:

Jenny Belardi, *Chief Advancement Officer*
412-268-8810 ■ jbelardi@andrew.cmu.edu

" Like so many people who passed through SCS during Mark's long tenure, I owe him more than I could ever hope to pay back in one lifetime. I think it's only fitting to honor his impact, to pay forward his endless support for others, by building a fund that will provide ongoing support for his vision of a CS education program accessible to anyone, anywhere. "

— Jonathan Betz (SCS 1999)

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