the institute

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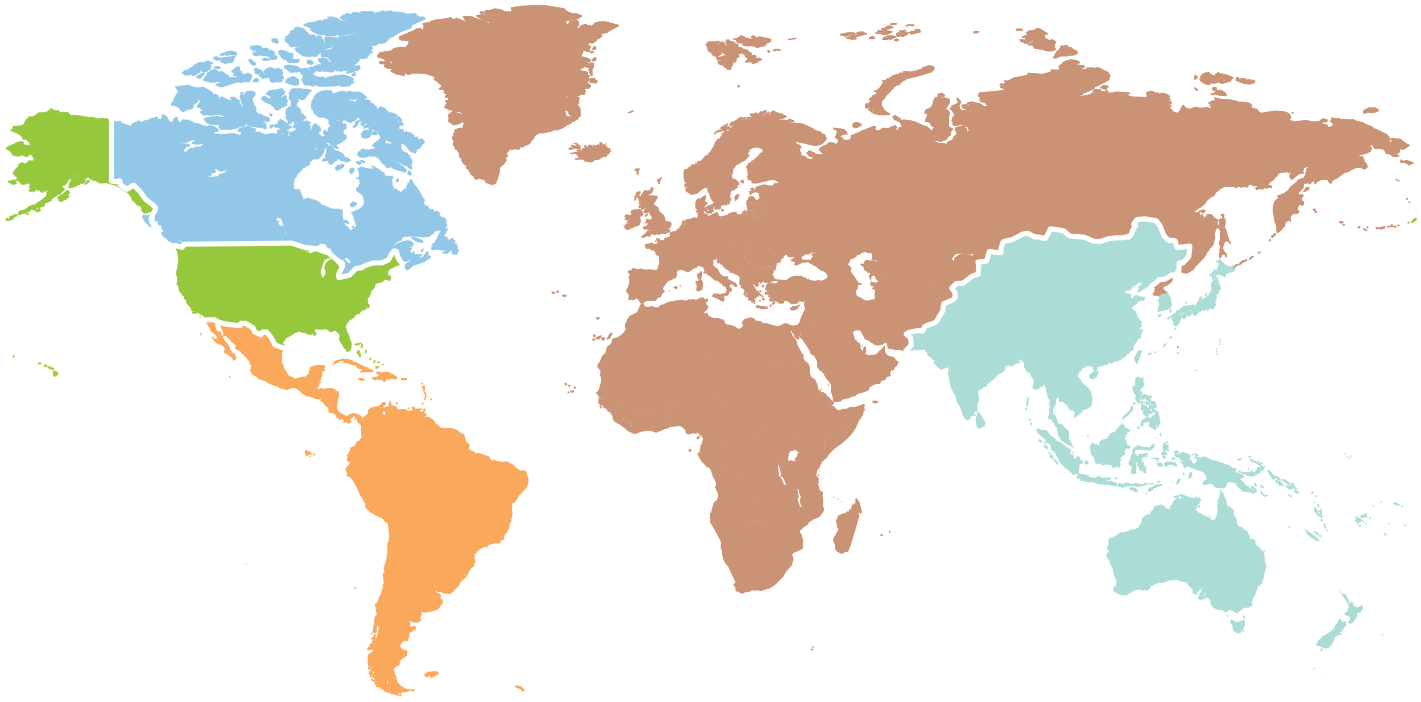
The MAKER MOVEMENT

IEEE



REGION NEWS

REGION 1 NORTHEASTERN UNITED STATES

■ Chapter of IEEE–Eta Kappa Nu (IEEE-HKN), the organization's honor society, formed at **Wentworth Institute of Technology, Boston**.

■ Student branch at **New Jersey Institute of Technology, Newark,** forms IEEE Robotics and Automation Society chapter.

■ Student branch at **New York City College of Technology** forms IEEE Robotics and Automation Society chapter.

REGION 2 EASTERN UNITED STATES

■ **Philadelphia Section** forms IEEE Solid-State Circuits Society chapter.

REGION 3 SOUTHEASTERN UNITED STATES

■ Student branch at **Kennesaw State University, Georgia,** forms IEEE Robotics and Automation Society chapter.

■ **Charlotte (N.C.) Section** forms IEEE Young Professionals (YP) affinity group.

■ Chapter of IEEE-HKN formed at **East Carolina University, Greenville, N.C.**

REGION 4 CENTRAL UNITED STATES

■ **Northeast Michigan Section** forms IEEE Industry Applications Society chapter.

■ Student branch at **Wayne State University, Detroit,** forms IEEE Power & Energy Society chapter.

REGION 5 SOUTHWESTERN UNITED STATES

■ **Denver Section** forms IEEE Life Member (LM) affinity group.

■ **Dallas Section** forms IEEE Power Electronics Society chapter.

■ **Fort Worth (Texas) Section** forms IEEE Power & Energy Society chapter.

■ Student branch at **Texas Tech University, Lubbock,** forms IEEE Women in Engineering (WIE) affinity group.

REGION 6 WESTERN UNITED STATES

■ **Fort Huachuca (Ariz.) Section** forms IEEE YP affinity group.

■ **Oakland–East Bay (Calif.) Section** forms IEEE YP affinity group.

■ **San Fernando Valley (Calif.) Section** forms IEEE Solid-State Circuits Society chapter.

■ **Hawaii Section** forms IEEE YP affinity group.

REGION 7 CANADA

■ **Kitchener-Waterloo Section** forms IEEE Sensors Council chapter.

■ **New Brunswick Section** forms IEEE WIE affinity group.

■ Student branch at **McGill University, Montreal**, forms IEEE WIE affinity group.

REGION 8 EUROPE, MIDDLE EAST, AND AFRICA

■ **Algeria Section** forms IEEE WIE and YP affinity groups.

■ Student branch at **Zewail City of Science and Technology, 6th of October City, Egypt,** forms WIE affinity group.

■ Chapter of IEEE-HKN formed at **Politecnico di Torino, Italy.**

■ Student branch formed at **Nazarbayev University, Astana, Kazakhstan.**

■ **Kenya Section** forms IEEE Communications Society chapter.

■ **Latvia Section** forms IEEE WIE affinity group.

■ **Malta Section** forms IEEE WIE affinity group.

■ Student branch formed at **University of Hassan II, Casablanca, Morocco.**

■ **Romania Section** forms IEEE YP affinity group.

■ Chapter of IEEE-HKN formed at **University of KwaZulu-Natal, Durban, South Africa.**

■ Student branch at **Bozok University, Yozgat, Turkey,** forms IEEE WIE affinity group.

REGION 9 LATIN AMERICA

■ **Argentina Section** forms IEEE Photonics Society chapter.

■ **Bahia (Brazil) Section** forms IEEE WIE affinity group.

■ Student branch at **Universidade Federal de Campina Grande, Brazil,** forms IEEE Antennas and Propagation Society chapter.

■ Student branch at **Escuela Tecnológica Instituto Técnico Central**, **Bogotá,** forms IEEE Robotics and Automation Society chapter.

■ Student branch at **University of Costa Rica, San José,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch formed at **Universidad Estatal Península de Santa Elena, Ecuador.**

■ Student branch formed at **Universidad Mesoamericana, Guatemala City.**

■ Student branch at **Universidad Tecnológica de Honduras, San Pedro Sula,** forms IEEE WIE affinity group.

■ **Mexico Section** forms IEEE YP affinity group.

■ Student branch at **Instituto Tecnológico Superior de Xalapa, Mexico,** forms IEEE WIE affinity group.

REGION 10 ASIA AND PACIFIC

■ **Northern Australia Section** forms IEEE YP affinity group.

■ Chapter of IEEE-HKN formed at **University of Queensland, Brisbane, Australia.**

■ Student branches formed in **Dhaka, Bangladesh,** at **Green University** and **Jagannath University.**

■ **Wuhan (China) Section** forms IEEE Industry Applications Society chapter.

■ **Delhi Section** forms IEEE LM affinity group.

■ **Sendai (Japan) Section** forms IEEE WIE affinity group.

■ Student branch formed at **Aoyama Gakuin University, Shibuya, Japan.**

■ Student branch at **Universiti Putra Malaysia, Selangor,** forms IEEE Power & Energy Society chapter.

■ Student branch at **Fatima Jinnah Women University, Rawalpindi, Pakistan,** forms IEEE Computer Society chapter.

COVER: HUSEYIN YAPICI

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Celebrate IEEE Day on 3 October

MEMBERS AROUND THE WORLD are organizing events to mark IEEE Day, on 3 October. The day commemorates the anniversary of the meeting in Philadelphia in 1884 when members of the American Institute of Electrical Engineers, one of IEEE's predecessor societies, gathered for the first time to share technical ideas.

More than 500 celebrations took place on last year's IEEE Day under the theme of leveraging technology for a better tomorrow. Included were technical talks, humanitarian projects, and field trips. Visit the IEEE Day website (http://www.ieeeday.org) to add your event to the world map and to see what other groups are planning.

Contests will be held for the best photos and videos taken at IEEE Day celebrations. To learn more about contest rules and prizes, visit the website.

As part of the celebration, IEEE is offering a US $30 discount on dues for new members who join between 1 and 17 October. (The offer does not apply to student or graduate student memberships.) To receive the discount, new members should enter the promo code IEEEDAY17 at http://www.ieee.org/join.

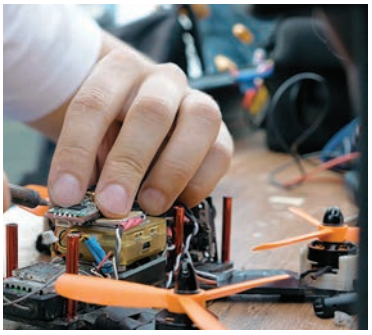
—Amanda Davis

This photo of the IEEE student branch at Hashemite University, in Jordan, won first prize in the 2016 IEEE Day photo contest.

INSIDE

ONLINE

TECH HISTORY TIMELINES
In celebration of its 40th anniversary year, *The Institute* is presenting a series of timelines highlighting technologies that have advanced significantly during the past four decades. Visit http://theinstitute.ieee.org/40anniversary to see the ones we've published so far.



Calling All Makers!

IF YOU'VE BEEN TINKERING with a tech project that could have applications in the real world, here's your chance to show off your work: The IEEE Maker Project contest is open to anyone 18 years or older.

Makers can submit their entry to the IEEE Transmitter website (http://transmitter.ieee.org/makerproject). Project categories include health and safety, education, entertainment, and transportation. A panel of judges will rate the projects based on three criteria: originality, innovation, and benefit to humanity. The deadline to submit entries is 17 October.

Finalists in each category receive an Amazon gift card worth US $50 in their local currency, and their projects will be featured on IEEE Transmitter. The grand-prize winner will receive a $500 Amazon gift card and an hour-long mentoring session with an IEEE member.

Contestants are encouraged to share their projects on social media using the hashtag #IEEEMakerProject.

—A.D.

Proposed Changes to IEEE Code of Ethics

THE IEEE BOARD OF DIRECTORS at its meeting of 25 June approved the following resolutions:

"RESOLVED that, in accordance with the IEEE Policies, Section 7.8, the publisher of *THE INSTITUTE* is instructed to include in both its August 2017 online version and its September 2017 print edition, copies of the proposed changes to the IEEE Code of Ethics presented to this meeting, with a request for comment thereon; and

FURTHER RESOLVED that all IEEE Major Boards shall have the opportunity to discuss such changes to the IEEE Code of Ethics prior to final action by the Board of Directors; and

FURTHER RESOLVED that this Board shall engage in final consideration of such changes to the IEEE Code of Ethics at its November 2017 meeting."

The following is the IEEE Code of Ethics, marked to show the proposed changes and is hereby published for comment in accordance with Section 7.8 of the IEEE Policies:

"We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members, and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, **in keeping with principles of ethical design and systemic sustainability,** and to ~~disclose~~ promptly **disclose** factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of **the capabilities of** technology~~;~~ **by individuals and by society as a whole, and** its ~~appropriate application, and potential consequences~~ **applications and societal implications, including outcomes attributable to autonomous systems;**
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics."

Comments on the foregoing changes should be directed to IEEE Director Kate Duncan at kduncan@ieee.org and/or IEEE Ad Hoc Committee on Ethics Programs Chair Greg Adamson at g.adamson@ieee.org, on or before 30 October.

Three Vie for President-Elect



IEEE LIFE FELLOW José M. F. Moura [above, left] was successful in getting nominated by petition as a candidate for 2018 president-elect. His name appears on this year's ballot along with the two board-nominated candidates, Fellow Vincenzo Piuri [center] and Life Fellow Jacek M. Zurada.

Members can access their ballot electronically on the IEEE annual election Web page (http://www.ieee.org/elections) or can return their printed ballot using the postage-paid business-reply envelope in the ballot package. Balloting ends on 2 October at noon CDT USA/17:00 UTC.

—A.D.

Calendar of Events

SEPTEMBER

10–13
International Conference on Mobile Brain-Body Imaging and the Neuroscience of Art, Innovation, and Creativity, Valencia, Spain

16–17
Region 7 executive committee meeting, Montreal

23–24
World Maker Faire, New York City

OCTOBER

2
Last day that marked annual election ballots can be accepted by IEEE

16–19
IEEE International Conference on Intelligent Transportation Systems, Yokohama, Japan

NOVEMBER

6–8
IEEE Conference on Network Function Virtualization and Software Defined Networks, Berlin

8–9
IEEE International Conference on Rebooting Computing, Washington, D.C.

15–20
IEEE Meeting Series, Phoenix

30 November–3 December
IEEE Women in Engineering Forum East, Baltimore

CLOCKWISE FROM BOTTOM LEFT: ISTOCKPHOTO (4); JACEK M. ZURADA; VINCENZO PIURI; JOSE M.F. MOURA

The MAKER ISSUE

WHETHER YOU GREW UP tinkering with radios or cars or built gadgets from scratch, your hobbies might have inspired you to become an engineer. That same sentiment is now spreading far and wide in what's called *the maker movement*. People of all ages are picking up soldering irons for the first time, and some could be inspired to become engineers, too.

In this special report, *The Institute* takes a look at IEEE's involvement in the movement [right]. IEEE volunteers are setting up booths at some of the world's largest maker fairs, which attract tens of thousands of people.

The 3D printer helped usher in the maker movement, and its capabilities have evolved impressively. We feature a bioprinter being used in classrooms so students can print living organisms for experiments [p. 8].

And the Gigabot 3D printer from the startup re:3D is making it affordable to produce large objects, like airplane parts and flooring tiles [p. 19].

We also showcase several members' projects, including an android named Ken, a robotic Rubik's cube solver, and 3D-printed prosthetic hands [pp. 10–12].

To help turn your big idea into reality, Alon Hillel-Tuch, cofounder of crowdfunding website RocketHub, shares his tips on how to raise money by crowdfunding [p. 13].

Should your idea turn into a product, you'll need to protect your intellectual property, and InnovationQ Plus can help with that [p. 17]. This IEEE resource combines more than 4 million articles, standards, and conference proceedings in the IEEE Xplore Digital Library with 90 million patents from 20 organizations around the world.

We also profile IEEE Senior Member Samir Chatterjee [p. 18], who founded the Idea Lab at Claremont Graduate University, in California. Chatterjee, an adjunct professor at the nearby University of Southern California's Iovine and Young Academy, is transforming classrooms at the two schools with the makerspace concept: equipping students with tools to solve problems and to help them turn their concepts into prototypes and even profitable ventures.

In her president's column, Karen Bartleson discusses how the IEEE Foundation's programs bring the promise of technology, and the knowledge of how to apply it, to improve the world [p. 14].

Visit theinstitute.ieee.org for our latest content. To send us your comments on what you've read in this issue, email the editors: institute@ieee.org.

—Monica Rozenfeld, associate editor

IEEE Joins

DIY tech projects are turning people of all ages and backgrounds into tinkerers

BY MONICA ROZENFELD

ELECTRONIC COMPONENTS ARE now more affordable than ever—expanding possibilities for do-it-yourself projects and perhaps providing the impetus behind a new generation of tinkerers around the globe. Not all new DIYers who are dreaming up ideas for novel devices and bringing them to life have technical backgrounds. In fact, some are not yet in high school.

They can be found working away at so-called makerspaces, typically located in libraries, schools, and community centers. The facilities provide tinkerers with 3D printers, laser cutters, soldering irons, and other tools. Prototypes and finished projects are often displayed at maker events and science competitions.

Last year more than 1.4 million people participated in or visited Maker Faires around the world—double the number from 2014, according to Maker Media, which has been organizing the fairs for 11 years. More than 190 events were held last year in 38 countries. Companies and other organizations sponsor booths. IEEE has sponsored booths as well in recent years, and is part of the maker movement.

The grassroots movement encourages tinkerers to design, build, and demonstrate their projects while learning from one another. People with varying degrees of technical expertise are involved, from novices to engineers.

"The movement is about our desire to understand the world around us and manipulate things to make new products or use existing ones in new ways," says IEEE Senior Member Tom Coughlin, past director of IEEE Region 6 and chair of the IEEE public visibility committee, which aims to increase people's awareness of IEEE and its members. He and several IEEE volunteers led activities at the organization's booth during the Maker Faire Bay Area event, held this year from 19 to 21 May in San Mateo, Calif.

"*The maker movement* is essentially a modern term to describe something that has been around ever since humans started using stones as tools," Coughlin says.

The movement is more than just a few fairs each year. It is a way to inspire the next generation of technologists year-round, Coughlin says. For example, the IEEE Maker Project [p. 5] inspires tinkerers to come up with inventions in areas that include health care, entertainment, and transportation. IEEE Educational Activities awards a US $500 grant to an IEEE group in each region that holds a maker event. And IEEE has developed an informal partnership with Maker Media to support one another's efforts in maker activities.

ENDLESS POSSIBILITIES

At Maker Faire events last year, booths organized by high-tech companies, schools, and other organizations offered activities that taught visitors how to solder and use a 3D printer. They also covered how to incorporate chips, sensors, and other electronics into their projects, as well as how to code. IEEE members were there to help.

One was Life Senior Member Charles Rubenstein. He has organized the IEEE booth for the past six years at the annual World Maker Faire, scheduled this year for 23 and 24 September in New York City. He notes that the movement goes above and beyond a traditional science fair, because students don't merely research a project and make a poster about it; they actually build a model of their idea.

CLOCKWISE FROM LEFT: HUSEYIN YAPICI; CHARLES RUBENSTEIN; MAKER MEDIA

the Maker Movement

At the 2016 World Maker Faire, in New York City, IEEE held a "Learn to Solder" workshop [above]. Senior Member Grant Imahara [left], spokesman for Mouser Electronics and former cast member of the MythBusters *TV series, gave a keynote speech at the event. He talked about his projects before the maker movement began and how building gadgets today is much easier thanks to the maker community.*

"They can build an autonomous drone, for example, with GPS and a webcam to track where it flies and where it will land and program it to send the information back to their laptops," Rubenstein says.

He hopes to get more members involved, especially from IEEE Women in Engineering and IEEE Young Professionals. Such volunteers can serve as role models to the tens of thousands of students who attend.

During one World Maker Faire, members of the IEEE student branch at Rutgers University in New Brunswick, N.J., showed off their DIY robot at the IEEE booth. The students asked visitors to draw a meandering line on a big piece of paper. A hand-size wheeled robot then followed the line, as light-detecting sensors distinguished the contrast between the drawn line and the paper's lighter background. It was one way to engage kids who came by the booth, and teach them about robotics, Rubenstein notes.

Another hands-on project at last year's event, sponsored by the Institute of Engineering and Technology, taught visitors to build an LED flashlight. Kits included two batteries and light-emitting diodes, and were designed so that participants—including a few 5-year-olds—didn't need to solder anything to put them together.

For Rubenstein, who teaches an introductory electronics course for non-engineering majors at Pratt Institute, in New York City, the beauty of maker events is that participants don't have to know why a technology works. If they just know how to assemble the components, they can design and build their own projects.

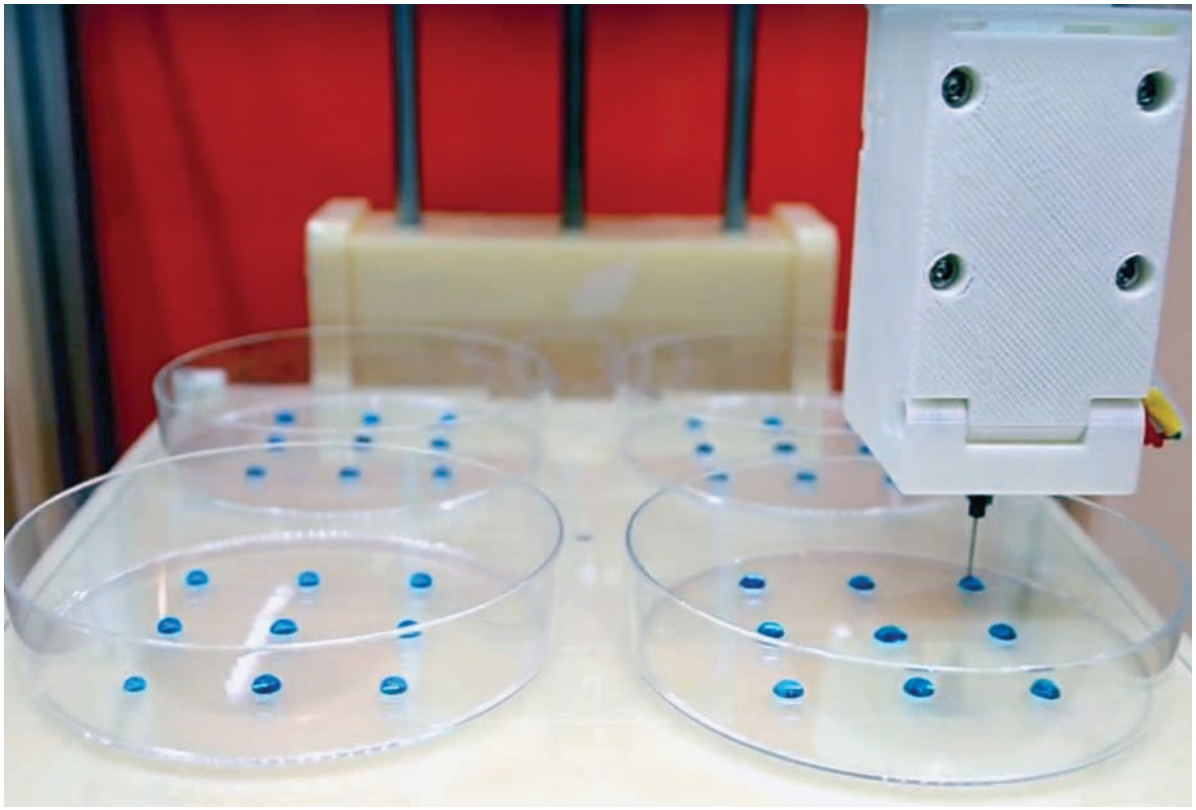
HOME-GROWN FAIRS

In a few parts of the world where Maker Media has not held maker fairs, IEEE volunteers have organized their own. For example, more than 800 people attended the two-day IEEE Digital Maker Expo in May in Miri, Malaysia, hosted by the IEEE student branch at Curtin University.

This month IEEE volunteers in India are holding their second annual Project Competition and Maker Faire at the Vardhaman College of Engineering, in Hyderabad. More than 350 people are expected to attend, according to IEEE Senior Member Ramalatha Marimuthu, chair of the event.

A number of the devices shown last year tried to improve the quality of life for those with disabilities, Marimuthu says. Projects included eyeglasses that rely on facial-recognition software to help the visually impaired identify people they know, as well as an "intelligent" walking stick to assist users with their balance. Several of the makers from last year's event are working to bring their projects to market, Marimuthu adds.

Such projects are the reasons why Coughlin says he became part of the maker movement. "I believe the ingenuity of individual makers will help solve some of the world's biggest problems," he says. "And that's why IEEE must be part of this movement." ◆



The r3bEL 3D printer can print algae, bacteria, and even plant or animal cells. It can arrange identical cultures in precise positions on petri dishes [left] or in various 3D shapes [below].

Print Your Own Live Organisms

A 3D-printing company lets students experiment with bacteria and cells BY IVAN BERGER

AT FIRST GLANCE, the r3bEL bioprinter from SE3D looks like any other 3D printer. It has the same basic design and a movable nozzle to deposit materials layer by layer. But instead of laying down, say, plastics, r3bEL prints living organisms: algae, bacteria, and even plant or animal cells.

SE3D, a three-year-old company in Santa Clara, Calif., sells its bioprinters to high schools and universities for science projects and experiments. The technology is not new; it's already used in life sciences fields such as biotech and biomedicine. But the company's founder, Maya Lim, says she felt it was important to give students access to such tools so they could engage hands-on with biology. Lim spoke about her venture in April at an IEEE Women in Engineering International Leadership Conference virtual event on disruptive technologies.

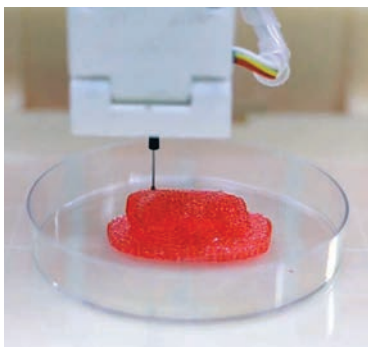
The company has brought its printers to classrooms, thanks in part to a grant of nearly US $900,000 from the U.S. National Science Foundation. A r3bEL is roughly the size of a traditional 3D printer—35 centimeters wide by 35 cm long by 38 cm high—and sells for about $4,000. Schools can order custom kits that include algae, bacteria, and cells—the printing materials—as well as a curriculum with lab experiments for students to learn about topics including biotechnology and tissue engineering.

HOW IT WORKS

With the r3bEL, students can print bacteria in a petri dish to test antibiotics, for example, based on lesson plans in SE3D's curriculum. The printer keeps the bacteria in a precise volume of encapsulated gel, unlike current school experiments that grow bacteria on agar plates. Students can print hundreds of identical cultures in precise positions on the dish—useful for repeating experiments on the same organisms to observe how they react to different stimuli.

Like other 3D printers, the r3bEL relies on computer-aided design (CAD) software. With the software, students can print complex biological structures by combining the living organisms, and they can precisely replicate the same structure as many times as they need to. One experiment involves exposing the same algae cultures to different light wavelengths and intensities to determine how the exposures affect photosynthesis.

The focus of the curriculum is for students to understand how cells grow and respond in different environments. Students design simple experiments to prompt changes in cell behavior.



STUDENT PROJECTS

Students can go beyond the curriculum to develop their own projects, according to Lim.

For example, in California, a pair of students from high schools in San Jose and Fremont teamed up for a project at the Synopsys Alameda County Science and Engineering Fair in the biochemistry, microbiology, and molecular biology category. Their project used the bioprinter to mimic the formation of biofilms, which are coatings generated by bacterial colonies to protect themselves from drugs and other organisms. The project, which compared the effects of different antimicrobial solutions, could provide insight into antibiotics resistance. The students' project won first place.

At Conrad Weiser High School, in Robesonia, Pa., a student is using the bioprinter to explore possible uses of bioglass—a flexible glass that cells can grow on—for repairing torn ligaments in humans. Another student is applying the printer to study new ways to diagnose celiac disease. At Winchester Thurston School, in Pittsburgh, a student is using the printer to experiment with drug delivery using dye molecules in varying concentrations as a stand-in for actual drugs.

To help raise money for schools that cannot afford the printers, the company is launching a campaign on the crowdfunding platform Indiegogo.

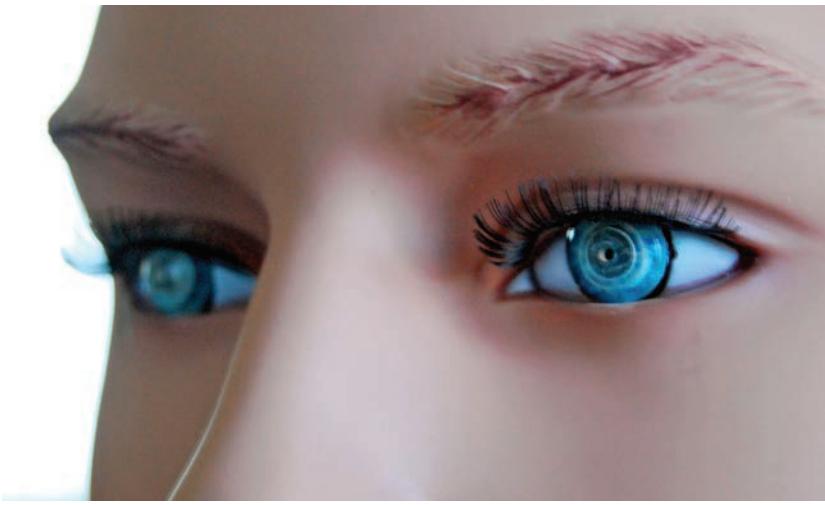
Educational institutions aren't the only ones interested in the bioprinter. Makerspaces are too. Found at public libraries and community centers, makerspaces encourage people to dream up ideas and see them through. The spaces often are equipped with 3D printers, so perhaps it's natural that some of them would be interested in the bioprinters as well.

The potential for bioprinting is endless, Lim says. "The holy grail is that one day we'll print organs," she says, adding, "We need to prepare students for more advanced laboratory work and skills that are relevant to their future careers." ◆

SE3D (2)

IEEE Members Are Makers Too

BY **AMANDA DAVIS**



WITH CREATIVITY at the heart of engineering, it's no surprise that IEEE members have embraced the maker movement. *The Institute* interviewed several who are working on DIY projects in their spare time—and they're not doing it just for fun.

Two members are demonstrating their handiwork in hopes of getting kids interested in robotics. And IEEE student members and volunteers in Turkey are using 3D printers to make plastic hands. One student branch is creating free prostheses for children, and another is working on a remote-controlled device to help perform dangerous tasks such as bomb disposal.

CONVERSATIONS WITH KEN

One way to turn kids on to robotics is by letting them speak to an actual robot. Enter Ken: an interactive humanoid built by IEEE Senior Member Grayson Randall and volunteers in the IEEE Eastern North Carolina Section. They began building Ken in early 2015 and received a US $36,430 grant to continue their work later that year from the IEEE Foundation, the organization's philanthropic arm.

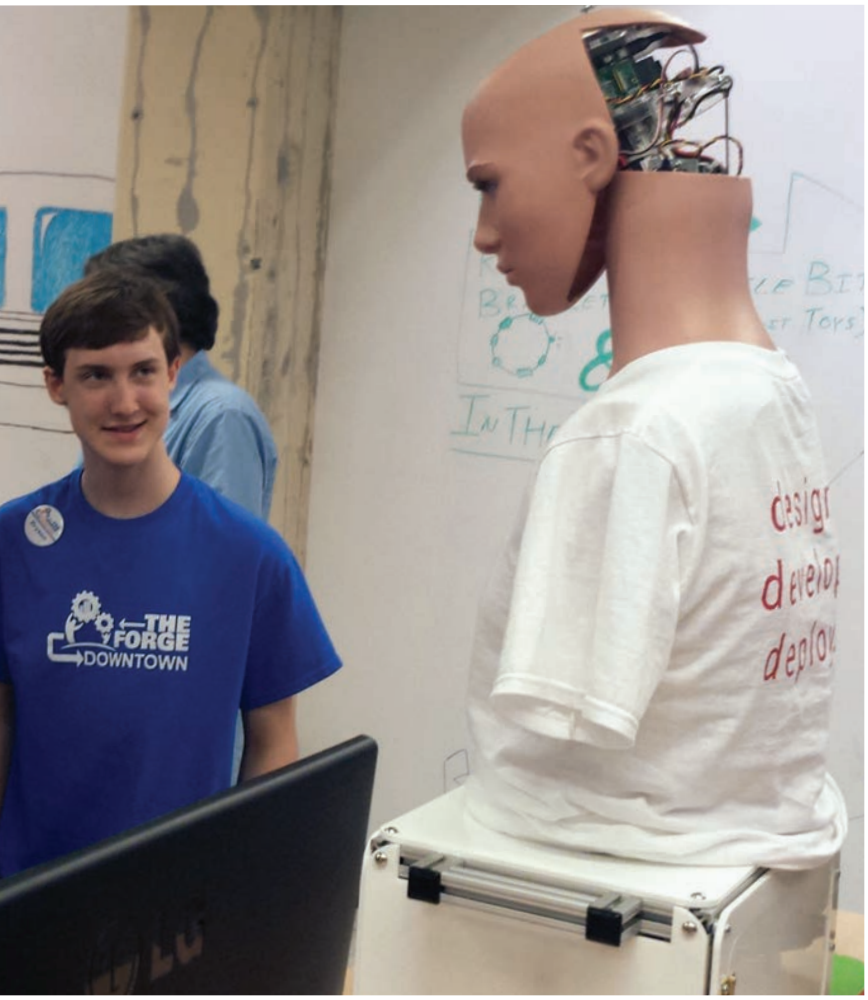
Randall is vice president and CTO of Ascot Technologies, a software company in Cary, N.C. He was 2015 chair of the section and originally pitched the idea of building a humanoid as a section project.

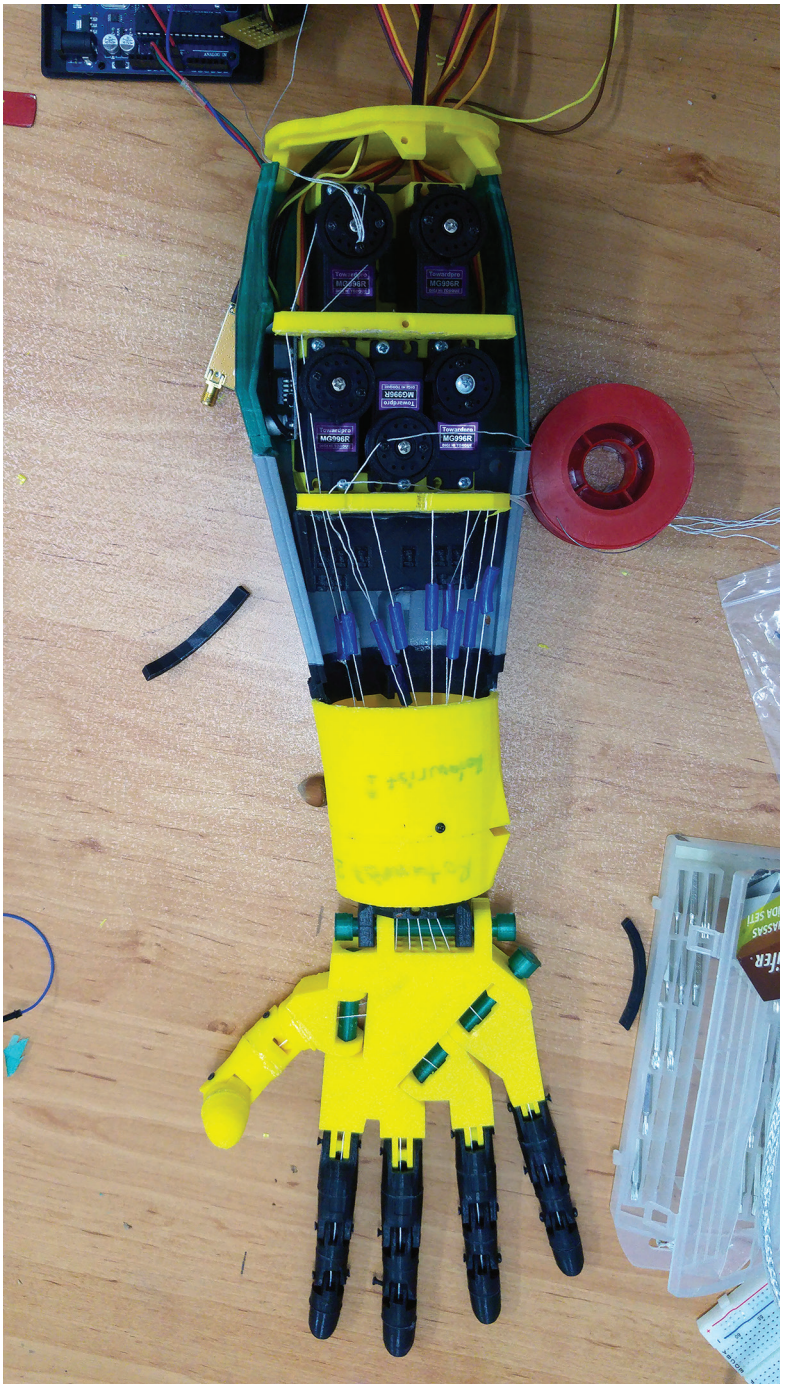
"From the beginning, the initiative received tremendous support," he says. Several section volunteers as well as students from nearby universities met once a week for a year to develop the robot. IEEE also partnered with the Forge Initiative, a nonprofit in Cary that holds STEAM (science, technology, engineering, art, and math) programs for preuniversity students.

For their talking robot, the IEEE volunteers started with a mannequin's head and torso. They embedded its eyes with thumbnail-size video cameras feeding data to a Raspberry Pi computer. The computer runs a program that can recognize faces from the real-time video feed. When Ken detects a face, it turns its head in the direction of the person. The volunteers are experimenting with a pair of wired microphones mounted near Ken's ears that can detect where someone's voice is coming from.

When someone speaks to Ken, the computer runs Google's speech-recognition program to translate the words to text. The program then forms a text-based response, which Ken speaks via a text-to-speech synthesizer.

Through their partnership with the Forge, the IEEE volunteers have been demonstrating Ken to the general public, including students in kindergarten through fifth grade. "We sit Ken down on the floor so the kids can actually walk up and be at eye level with him," Randall says. "Kids respond very quickly."





CLOCKWISE FROM TOP LEFT: PELIN PULAU; GRAYSON RANDALL; HÜSEYIN YAPICI; KIKO MCDONALD

In North Carolina, IEEE volunteers are working with members of the Forge Initiative, a nonprofit, to develop Ken [above], a humanoid that can hold conversations. Ken's eyes [left] contain thumbnail-size video cameras that feed data to a Raspberry Pi computer. IEEE student members at Koç University, in Istanbul, are building 3D-printed prosthetic hands for children [far left]. Elsewhere in Turkey, student members at Dokuz Eylül University, Izmir, are working on a 3D-printed robotic hand [right] that can be controlled remotely.

So how good a conversationalist is Ken? "He can speak on a lot of topics," Randall says. The robot, for example, can discuss how it was developed, and can answer questions about IEEE and the Forge. Ken knows a lot about movies, TV shows, celebrities, and other topics of general interest, according to Randall.

"But sometimes the discussion gets a little silly," Randall notes, "because Ken's responses can be unpredictable."

No matter how the conversations go, people of all ages seem to get a kick out of Ken, Randall says. And the humanoid project hasn't benefited only young children. Volunteers held weekly workshops last year for middle school, high school, and university students. Mentors from IEEE and the Forge described how they built the humanoid and helped students construct four bots based on Ken's design. Participants learned basic concepts of software, artificial intelligence, mechanical and electrical systems, 3D printing, soldering, and circuit design and construction. So far, they've helped demonstrate the original Ken to more than 6,000 people in the community.

HELPING HANDS

The IEEE student branch at Koç University, in Istanbul, is building 3D-printed prosthetic hands for children. [A volunteer holds an example of one in the photo at far left.] Koç is one of several universities supporting the Robohand Turkey Association (RTA), a nonprofit in Istanbul that works with children who are missing hands or have other limb deformities due to birth defects, disease, or accidents. The IEEE Turkey Social Responsibility Project group is coordinating the partnership. RTA works with children directly, and IEEE volunteers build the prosthetics. The end result is free, custom prosthetics for children who need them.

Cost is an important factor. As children grow, they must be fitted with a new prosthesis almost every year,

On display at the 2016 World Maker Faire, in New York City, was a Rubik's cube–solving robot [above] built by IEEE Senior Member Gim Soon Wan and his 10-year-old son, Anthony [neither is pictured]. Some attendees tried to solve the classic puzzle game before the robot could.

according to IEEE Student Member Pelin Pulcu, the IEEE Turkey Section social responsibility projects coordinator. Similar prosthetic hands can cost thousands of US dollars.

The Robohand prosthetic is made of lightweight plastic. Straps wrap around a child's forearm to hold the prosthesis in place. The hand has moveable fingers that can grasp and hold objects. There are different ways to control the hand, depending on the patient's disability.

Robohand is an open-source project, so volunteers can download designs, instructions, and other resources. Essentially, anyone who has materials, time, and engineering skills can build one. Once a hand is completed, the students deliver it to a child who needs it. The prosthetic is then customized to meet her measurements and needs.

Six members of the IEEE student branch at Dokuz Eyul University, Izmir—Huseyin Yapici, Fatih Ceken, Ilhan Berke Agan, Emre Fikri Baltaci, Mertcan Akin, and Meltem Sag—are working on a robotic hand [see photo on p. 11] that is attached to a wrist joint and arm piece and can be controlled remotely. Their invention, the RobotEI, was featured in the April issue of *Popular Science* magazine's Turkey edition. The team also placed third in this year's Izmir Robotics League Competition, organized by the IEEE student branch at the Izmir Institute of Technology.

Their 3D-printed hand and forearm are made of plastic parts. The parts are printed at the university's technology development zone, DEPARK. Students assemble the joints by tying the parts together with threads of plastic and nylon. The threads connect to a system of servomotors attached to gears inside the forearm. The motors turn the gears, which tug on the threads, enabling the fingers and wrist to move.

The hand is controlled remotely by a glove embedded with sensors on each finger. The sensors are wired to an Arduino Nano computer board about the size of a postage stamp. The board processes the movements and transmits signals wirelessly to a control circuit on the robotic hand. The control circuit is wired to the motors and moves them based on the movements of the human hand in the glove. If the person wearing the glove waves his index finger up and down, for example, the robotic hand will make the same movements nearly simultaneously.

The glove can control the hand from up to 20 meters away, and the team is incorporating Wi-Fi antennas to transmit the signals over longer distances. That would be especially important if the arm is one day attached to, say, a bomb-disposal robot—a situation in which humans would need to maintain a safe distance. But for now, the system is still a prototype.

RUBIK'S CUBE SOLVER

IEEE Senior Member Gim Soon Wan says he believes the best way to get kids hooked on engineering is to encourage them to build their own projects. It worked for his three children. Two years ago he and his son, Anthony—age 8 at the time—started building a robot that could solve a Rubik's cube. To complete the cube's puzzle, the player must manipulate its blocks so that the stickers on each face are only one color.

The pair used a Lego Mindstorms kit, which has hardware and software for creating custom, programmable robots. The cube solver was originally designed by David Gilday, a Lego enthusiast from Cambridge, England. (You can download instructions for building it and other projects at mindcuber.com.) Although the instructions are freely available, there are different ways to customize the robot, Wan says.

Wan's Rubik's cube–solving robot has an open container at its center in which the cube is placed. Infrared sensors detect the cube in the container. Next, a robotic arm flips the cube around to reveal different sides to the sensors, which scan each sticker to determine its color. Once the robot knows the color of all 54 stickers and their locations, an algorithm calculates the steps it will take to solve the puzzle. After all the steps are worked out, the robot manipulates the cube to do just that.

Wan and Anthony, now 10, as well as Wan's 12- and 13-year-old daughters, Alyssa and Stephanie, all like to build Lego projects. Anthony gravitates toward mechanical problems, while his sisters enjoy programming, Wan says. The family has demonstrated the Rubik's cube solver at several events including local STEAM fairs and IEEE Region 1 student branch conferences. They got a chance last September to show off the project at the World Maker Faire, in New York City, where IEEE-USA sponsors a booth.

"Children and their parents were excited to see that a Lego robot could actually solve a Rubik's cube," Wan says. "Some of the students at the fair even tried to compete with the robot to see who could solve it first"—and a few indeed beat the robot.

Wan mentors children in his town of Windham, N.H., where he hosts free robotics workshops each weekend at his home. Fifteen to 20 kids attend each week, he says. They build robots from Mindstorms kits and learn basic coding concepts to program different types including four-legged robots that crawl, four-wheeled robots that mimic construction vehicles, and two-legged robots that walk and dance. Every week Wan gives the children a different challenge. After about two hours of instruction on basic mechanical engineering and coding concepts to complete a task, they have 90 minutes to build a bot that can do that job.

"It's important for students as well as engineers to engage in DIY projects so they can learn from their own mistakes," Wan says. "This will give them valuable skills they will not get from textbooks." ◆

GIM SOON WAN

ISTOCKPHOTO

Crowdfunding Your DIY Project

Six tips for a successful launch

BY MONICA ROZENFELD

IF YOU WANT to take your side project to the next level, you'll likely need a little help from your friends, and perhaps a whole lot of strangers. Crowdfunding sites, like Indiegogo and Kickstarter, encourage people to contribute money to help inventors realize their ideas, whether it be for completing a humanoid science tutor or a game console for pets.

"One of the hardest things to get people to do is open their wallets," says Alon Hillel-Tuch. He helped create one of the first crowdfunding sites, RocketHub, in 2009. He has given talks on TEDx and was interviewed by *Make:* magazine on how tinkerers can use such sites to raise funds. When people do back a project, he adds, it's because they believe in the idea, want to be part of a community that supports the innovation, and would like to own the final product.

But with tens of thousands of projects on crowdfunding sites to choose from, how can yours stand out from the pack? Hillel-Tuch, who sold RocketHub in 2015 for US $15 million, offers six tips on how IEEE members can launch a successful crowdfunding campaign.

TELL YOUR STORY

The first thing you must do to set up your crowdfunding campaign is to explain what your project is about. But don't just lay out the facts, as many engineers will do, Hillel-Tuch says. Potential funders have many projects to choose from, so you must ensure that yours stands out.

"Get to the core of why you're pursuing the endeavor," he says, whether in your written description or a video you produce. "You have to pull on their emotional strings in a sincere and authentic way." Tell them why you're excited about your project and why you want to share it with them.

IEEE members have a leg up in terms of getting strangers to trust them, he says. He is familiar with the organization because his father, Bruce Tuch, helped develop the IEEE 802.11 standard. IEEE members have the experience to see their projects through, Hillel-Tuch says—which might encourage people to fund one of their endeavors over a similar one being developed by, say, a hobbyist.

SET A FUNDING GOAL

People contribute, on average, US $75. If you want to raise $150,000, the math is simple: You'll need 2,000 people to back your idea. If you have that kind of network, or the ability to grow that large a community, that's fantastic. But if you do not, break apart your project, Hillel-Tuch advises. If, for example, you need $40,000 to build your prototype, set that as a milestone. Once you reach that goal, it further encourages people to back your project.

Many crowdfunding sites release funds only when the goal has been reached—which is why it's important to be practical and not overly ambitious. You could wind up with no cash at all.

If you decide at some point to pursue funding from venture capitalists, realize that many of them likely will want to see that you've had a successful crowdfunding campaign. That shows you can work well in a team, because you couldn't have done it alone. It also might show that you pay attention to feedback, can craft a story about your product, and have the stamina to keep pushing when times are tough.

ASK FOR HELP

Most successful campaigns have a team behind them, Hillel-Tuch notes. You might need help making a promotional video or growing a social media following to let people know about your campaign. That's a lot of work for one person, he says.

You also need feedback, whether it's about the product itself or tips on how to better describe it. Feedback can help you home in on your audience. You might have thought your product was for teenagers, but then you notice that your friends and family are interested in it for reasons you hadn't considered. By understanding who your audience is and how the product is useful to them, you're able to describe how your project can add value to their lives.

"If your campaign is set up well," Hillel-Tuch says, "people will spread the word about your project to their networks and create a buzz factor."

OFFER REWARDS

Giving your backers a little something extra for funding your project can encourage them to support your idea or invest more than they would have otherwise. For example, offer the first 100 investors the chance to purchase the finished product before it hits the market. Or send a T-shirt to those who give at least $50.

KEEP INVESTORS IN THE KNOW

Stay in constant contact with your backers. Update them on the status of your project by email, social media, or other means, Hillel-Tuch advises. They'll want to know if there are delays, and why. They also will want to know about features you've added, price changes, the expected launch date, and where they can buy the finished product. If you don't keep them in the loop, they'll feel neglected.

STAY COMMITTED

Starting a campaign can be really exciting, Hillel-Tuch says. Some projects might even attract news and social media attention once they're posted on crowdfunding sites. But when the money slows down, it can be disheartening, he says. "Some crowdfunders feel they've lost support. This is exactly when you need to keep pushing," he continues.

That might mean reaching out to more people through social media or participating in live events in nearby cities.

"Your crowdfunding campaign will only move forward if you move it forward," Hillel-Tuch says. Those who stick it out often find that interest picks up again, and that's when they reach their funding goals. ◆

Get to the core of why you're pursuing the endeavor

Building the Foundation for a Better World

It takes IEEE members who want to get involved

KAREN BARTLESON IEEE PRESIDENT AND CEO

OUR WORLD, despite myriad advances in technology during the past century, still needs to be changed for the better. Too many people do not have access to clean water, reliable energy, the Internet, or health care. Not everyone has the opportunity to achieve his or her full potential through access to education.

I believe that one of the most important applications of technology is to improve people's lives. For those in underserved regions of the world, technology can save lives, alleviate suffering, and maintain human dignity. Technological innovation is the principal driver for improvements in quality of life and economic prosperity. Technology professionals are central to this innovation. Every day, IEEE members around the world are working to advance technology to benefit those whose need is greatest.

For example, in May I had the privilege to spend several weeks in Africa representing IEEE. It was one of the most inspiring and unforgettable opportunities of my professional career. IEEE is working with several organizations to provide educational support and technical development to the engineering profession throughout Africa.

In addition, across the continent, top African officials from government, industry, and academia are committed to encouraging women and girls to participate in information and communication technology (ICT) fields. And it is not just talk—they are putting programs in place and funding them. I think this is an impressive example of the support needed worldwide to build the pipeline of technologists, particularly female, for the future.

Through this type of collaboration, students and underserved communities around the world are able to benefit from technology as we work together to solve important problems and provide solutions to such life-altering issues as clean water, reliable energy, food production, health care, and education. Students, young professionals, and underserved communities are key to IEEE's future and a focus of our strategic objectives in building the next generation of members. In addition, these groups are among those who benefit the most from IEEE Foundation programs.

The IEEE Foundation works to raise funds to invest in IEEE programs that bring the promise of technology, and the knowledge of how to apply it, to improve the world. The Foundation supports educational and humanitarian programs around the globe, particularly through its priority initiatives: the IEEE Smart Village, Engineering Projects in Community Service in IEEE (EPICS in IEEE), the IEEE Power & Energy (PES) Society Scholarship Plus Initiative, and IEEE REACH (Raising Engineering Awareness Through the Conduit of History).

EPICS in IEEE, for example, matches IEEE members and student members with high school students to work in collaboration with community-based organizations on engineering-related projects. With a recent EPICS in IEEE grant, IEEE student members from Beijing Jiaotong University, along with preuniversity students from local schools, built desks and chairs that can easily be adjusted to the height of children in primary grades. The premise was that furniture built to take into account the distance between a student's eyes and the top of her desk will encourage good posture. In turn, this can help reduce myopia, scoliosis, and other conditions. Properly sized furniture can also help lessen fatigue, while encouraging learning and information retention.

The PES Scholarship Plus Initiative has provided financial support as well as work experience to more than 700 undergraduate electrical engineering students from Canada, India, Puerto Rico, and the United States. The initiative is helping to attract highly qualified engineering students to the power industry. These students will one day develop new green technologies, build the smart grid, and change the way the world generates and utilizes power.

IEEE members around the world are working to advance technology to benefit those whose need is greatest

The IEEE Foundation has embarked on an exciting path forward, launching the Realizing the Full Potential of IEEE campaign. This comprehensive campaign aims to raise US $30 million by IEEE Day 2020 to sustain and grow existing IEEE programs, expand the reach of the Foundation's philanthropy, and open new doors for both the Foundation and IEEE. This ambitious initiative was developed by IEEE Fellow Leah Jamieson, who served as the 2007 IEEE president and president of the IEEE Foundation from 2012 to 2016. The IEEE Foundation board of directors, led by IEEE Foundation president John Treichler, a Life Fellow, along with the Foundation's professional staff, will lead the charge.

Members' involvement with and support of IEEE and the IEEE Foundation are critical to efforts to advance our profession, the work of IEEE, and the endeavors of engineering professionals worldwide. As engineers and scientists, we have the opportunity every day to engage in projects to change our world for the better.

Technology can overcome tough challenges. It always has. And at no other point in recorded history have we had more possibilities before us to apply our skills and abilities to address problems facing humanity. The initiatives you choose to work on can span the breadth of humanity. The technologies used to address these issues can be as diverse as the engineering and scientific branches in which our members excel.

I encourage all of our members to be engaged, be involved, and be part of the drive toward fulfilling our mission of advancing technology for the benefit of humanity.

Please share your thoughts with me at president@ieee.org. ◆

TJ KLEIN

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Sparking Conversation

Several blog entries on our website led to lively discussions in their comments section. To join the debate, visit http://theinstitute.ieee.org/sept17responses.

DOES HAVING A LICENSE MAKE YOU AN ENGINEER?

In Oregon, consultant Mats Järlström started researching traffic-signal timing intervals after his wife was caught running a red light by a traffic camera in 2013. His calculations suggest that at certain intersections, the timing of yellow lights isn't long enough.

Järlström, who has a bachelor's degree in engineering from Sweden but not a state-issued engineering license, tests audio products and repairs, upgrades, and calibrates test instruments. He discussed his theory with "60 Minutes," a local TV station, a sheriff, and a leading authority on traffic-light technology. He was invited to address the Institute of Transportation Engineers.

The Oregon Board of Examiners for Engineering and Land Surveying said that without an engineering license from the state, Järlström broke the law each time he critiqued the traffic-light system and identified himself as an engineer in correspondence.

After paying a US $500 fine, he filed a civil rights lawsuit against the licensing board, accusing it of violating his First Amendment rights. He says the Constitution allows him to criticize the camera formula and to call himself—accurately, in his view—an engineer. On 14 June, the board admitted that its "interpretation violated Mr. Järlström's rights under the First Amendment."

I am a licensed professional engineer (P.E.), and I think this fine is outrageous. Unless the Oregon board is incompetent, then it knows what it is doing is without basis and malevolent—intended to silence the thoughtful public. A P.E. stamp on a drawing makes a guarantee about the work. Expressing an opinion is not the same as making a guarantee.

—Falstaff77

Non-engineers make comments all the time about traffic signals, and they should, of course, be able to. The question in this case is whether an unlicensed engineer without expertise in this area should be able to publicly challenge an engineering design by proposing an alternative design that he validates on the basis of his unrelated engineering training. There is some line that the Oregon board thought was being crossed.

—R. Denney

I am a retired registered engineer, and I cannot believe Järlström was fined for doing what any competent person could do without a license. I say he should take this to the highest court he can reach. I hope a civic-minded legal organization, like the American Civil Liberties Union, is volunteering to represent him.

—Ivan Ash

According to the definition Oregon law gives, he misrepresented himself. *Engineer*, *professional engineer*, or *registered professional engineer* means an individual who is registered in this state and holds a valid certificate to practice engineering in Oregon. That's the definition used by the board—so when he wrote to that board, he should have respected its definitions.

—Ben Voigt

As a professional engineer myself, I would say that Järlström is clearly within his rights to refer to himself as an engineer, particularly since he possesses a degree in engineering. The matter hinges, however, on the laws of the state of Oregon. If the laws there are so overreaching as to prevent someone such as Järlström from identifying himself this way, I'd say a change of the law is in order.

—captvolt

After Järlström wrote letters identifying himself as an engineer, he was told to not use the term *engineer* to refer to himself and not to engage in engineering. He persisted several times and was eventually fined. This goes beyond simply saying the light was too short or speaking up about something. It looks like the board gave him several chances to stop referring to himself as an engineer before it issued a fine. Initially, I thought the fine was a ridiculous overreach. Now I'm not so sure.

—Gary Burrell

Because he provided his testimony voluntarily and was not paid for it, he should be allowed to do so as a matter of free speech as protected by the First Amendment of the U.S. Constitution. Stating that he is an engineer is common practice for anyone with an engineering degree. Oregon should counter his arguments with facts, data, and calculations of its own—not with a heavy-handed fine.

—Rich R.

INSTITUTE FOR JUSTICE

Mats Järlström, a consultant, critiqued his local traffic-light system and was fined by the Oregon Board of Examiners for Engineering and Land Surveying for calling himself an engineer in correspondence.

Sparking Conversation

continued

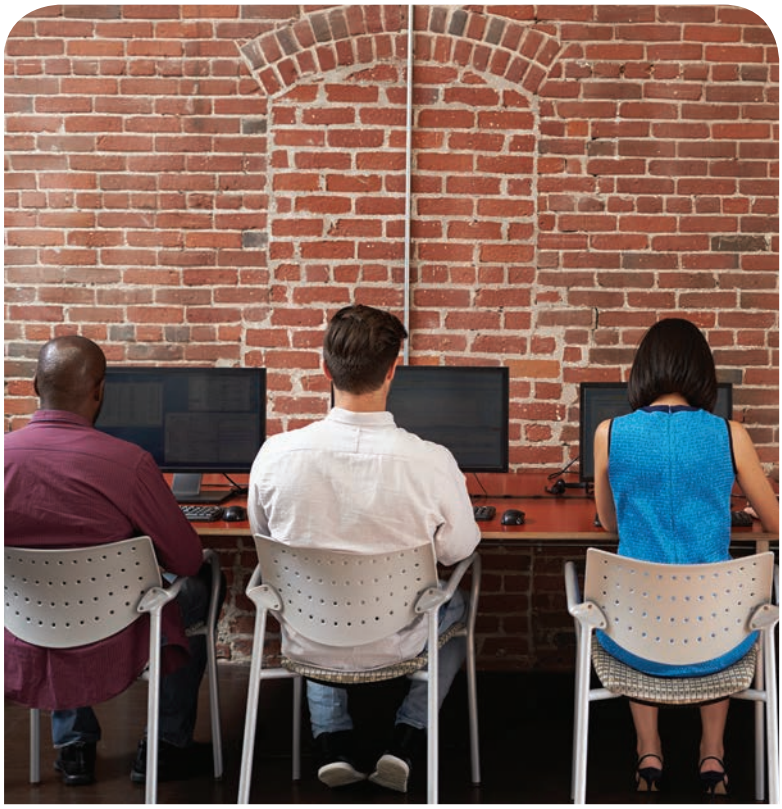
REWIRING YOUR BRAIN TO GET AHEAD IN YOUR CAREER

When a coworker or boss makes a remark that implies you're not good enough, smart enough, or educated enough to get that raise or be part of a team, what do you tell yourself? That's the question posed by Nectar Consulting CEO Michele Molitor, who was a presenter at the IEEE Women in Engineering International Leadership Conference, held in May in San Jose, Calif. Her Atlanta-based company helps women develop leadership skills.

When Molitor heard unkind words at a previous job, it kept chipping away at her self-confidence, and ultimately her performance, she said, leading her employer to fire her. Trying to recover from that experience was challenging, and she came to realize that self-criticism is as hurtful as what others might say. She noticed she wasn't the only woman experiencing what she calls LCS *(lost-confidence syndrome), especially in the tech field.*

Lost-confidence syndrome, or "toxic boss syndrome," can affect anyone, not just women. I have left or almost left jobs I liked because of these issues. In one case I did leave, and in the other, the company fired the problematic supervisor. These experiences taught me two things: First, during the interview process, get a feel for the leadership style of the person you will be working for. There are indicators that will show up either with that person or with the potential coworkers that interview you. Second, if you are experiencing problems with a superior or coworker, other people probably are too. So if you do your best, there is a decent shot that when the smoke clears, you will be fine.

—Tom Barbeau



MILLENNIALS CONCERNED AUTOMATION WILL REDUCE THEIR JOB PROSPECTS

Workers born after 1982 say they do believe automation will bring positive changes such as increased productivity in the workplace; however, they're concerned it will come at the expense of their jobs. That's according to the Deloitte Millennial Survey, which asked 8,000 college-educated young professionals from 30 countries about job security.

The survey also asked the participants how they thought automation, artificial intelligence, and robotics would impact the workplace. The results showed they are hopeful yet cautious.

The threshold for disruption might be lower than predicted, because many people are likely already in jobs that take much longer for a human to do than an AI system. This is just the same old ethical debate scientists have so far failed to solve. Why should engineers be any more successful in solving it?

—Asterion Daedalus

U.S. government policies on jobs, education, and technology are at least 50 years behind emerging automation technologies. Unless jobs are created and performed that "look like work," you won't be getting any attention in regard to policies that may help you or your company. Examples of jobs that look like work include physical labor, retail, data entry, and oil drilling. Of course, these are all legitimate and necessary forms of work, but most can be automated pretty easily.

However, the newer forms of labor meant to replace them, including scientific and medical research, artistic and creative pursuits, social work, and counseling—all with low levels of potential automation—are often looked upon as a waste of time because the economic return is less immediate and obvious.

—pjgeneva

DO YOU THINK THE H-1B VISA CAP IS STUPID?

The controversial but popular U.S. H-1B work visa program, meant to attract skilled foreign labor, is undergoing review by federal agencies. Each year the H-1B program allows a maximum of 85,000 noncitizens to work in the country for up to six years. Some observers say they are concerned that the program is being used to replace U.S. workers with cheaper labor.

Former Google CEO Eric Schmidt—now executive chairman of Alphabet, Google's parent company—disagrees with putting a cap on the number of H-1B visa holders. During a Q&A session held in May at MIT's Computer Science and Artificial Intelligence Lab, Schmidt said any limits on the program make it more difficult for U.S. companies to remain competitive. He said the cap is the "single stupidest policy" in the entire American system. The United States should be attracting skilled workers, he says, adding that the H-1B policy restricts U.S. companies from having a fair chance of recruiting them.

Of course Schmidt is against it. If the supply of H-1B engineers were reduced, he'd have to increase wages—which would affect his company's profits. With engineers who would work for lower wages than teams based in the United States, his company would make more money. What's not to like?

—Simon Jones

For the past 15 years, IEEE-USA has been the leading voice in Washington, D.C., fighting for H-1B visa reform. In 2013, for example, big tech companies including Google spent US $53 million in Washington trying to get an increase in H-1B visas. They failed, in large part because of the work done by IEEE-USA and IEEE members.

Today, IEEE-USA is fighting to get real reforms made to the H-1B program that would make it much harder, if not impossible, for companies to use the visa to replace American workers with H-1B workers. If implemented, these reforms would save between 40,000 and 50,000 jobs each year, many in technology fields. At the same time, IEEE-USA is working to make it easier for international students who earn advanced STEM degrees in the United States to become American citizens through the green-card process. Highly skilled workers strengthen our economy. H-1B visas don't.

—Russ Harrison, IEEE-USA director of government relations

I have a master's degree in software engineering, and I am a development team leader in the financial software industry. I am also an IEEE member. If I had a work visa I would get hired immediately and would be a taxpayer in the United States with a US $120,000 salary. However, I am a French citizen. I've been told that no one will wait several months to sort out the visa paperwork and let me immigrate, especially because of the "zillions" of H-1B workers readily available for cheaper temp work.

Companies in the United States should recruit long-term workers, not temps, to keep people with real knowledge of the product for more than two years.

—John Gallet

ISTOCKPHOTO (2)

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Need Info on Patents? Try IEEE's InnovationQ Plus

The database gives subscribers access to all IEEE Xplore documents BY KATHY PRETZ

RANDI KLETT

FILING FOR A patent is a complex but important process that can protect your intellectual property. You have to do research to ensure your idea is unique and determine whether the same or a similar patent already exists. The work can be time-consuming if the sources you need to reference are in different databases or websites.

To help speed the process, IEEE partnered last year with IP.com, an intellectual property software and services company in Fairport, N.Y., to launch InnovationQ Plus (http://innovationqplus.ieee.org).

The InnovationQ Plus database includes critical patent and non-patent literature for IP research. It's also the only one that contains the more than 4 million articles, standards, and conference proceedings in the IEEE Xplore Digital Library.

It indexes the full text of the IEEE documents, not just abstracts and bibliographies. Searching the full text is important because IEEE is cited by top patenting organizations three times more often than material from any other publisher, making the material critical prior art—evidence that your invention is not a novel idea.

What's more, there's also IP.com's own proprietary database of non-patent literature along with a database of 90 million patents and related information from 20 authorities around the world. They include the European Patent Office, the U.S. Patent and Trademark Office, and the World Intellectual Property Organization, with new authorities added frequently. All patents from Brazil, Sweden, Switzerland, and Taiwan were added recently.

"InnovationQ Plus is the most comprehensive patent search and analytics product on the market," says Angela Trilli, associate director for IEEE analytics products. "It can provide a full picture of the technology landscape, so you can make critical decisions on R&D and IP and how to get the most return on your innovation investments."

But InnovationQ Plus offers more than just determining patentability, Trilli says. Its tools can help uncover areas where opportunities for innovation exist, or can analyze what technologies a competitor is working on.

Here are some of the product's other features.

INSIGHTFUL INFORMATION

The InnovationQ Plus search engine is powered by IP.com's neural network machine-learning technology. The system matches queries based on meaning rather than keywords—which reduces the time it takes to find information. In the query bar, users can type descriptive phrases, sentences, or full paragraphs, or paste wording from a patent application. The search engine then sifts through the database to find the most relevant documents.

"Patent landscaping" is another feature. This analytics tool can look at a company's portfolio of patents, as well as those of its competitors, to deliver insights into a company's approach to technology and business.

"Looking at the patent landscape can help you decide whether to develop a technology, sell a patent, or perhaps partner with another company through licensing," Trilli says.

The analysis could even help you determine, for example, whether to continue to pay maintenance fees to keep a patent active, to abandon a patent, or to sell it. Or the program could identify when it makes sense to license patent rights to another organization as a way to develop revenue. In such cases, the patent holder retains ownership of the invention and receives royalty payments on future sales of the product. There's a big market for licensing technology, Trilli says.

You also could view a semantic map, a graphical model that helps analyze the landscape of existing patents to identify where new products or features are needed. The map also can show which technologies competitors are patenting—which could provide insight into a company's business plans or an entire industry.

InnovationQ Plus is available as a subscription for engineers and patent professionals at companies, universities, and other organizations.

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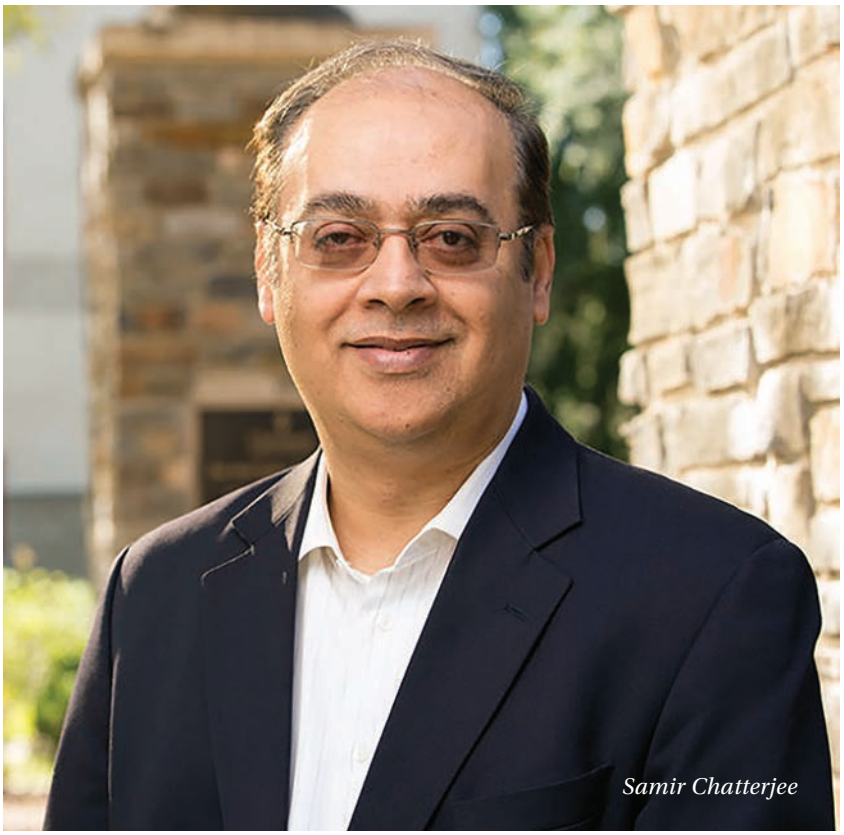
PROFILE

Bringing the Maker Philosophy to Universities

Samir Chatterjee is helping students launch innovative products and startups

BY **MONICA ROZENFELD**



Samir Chatterjee

IEEE SENIOR Member Samir Chatterjee is transforming what education looks like at two universities in the Los Angeles area. His teaching model is based on the makerspace concept of building things to solve problems. He wants to equip students with the tools they need to do just that, and help them turn concepts into prototypes and even profitable ventures.

Chatterjee is an adjunct professor of innovation and design at the University of Southern California's Iovine and Young Academy (IYA). In the makerspace there, he has undergraduate students with backgrounds in areas such as music, graphic design, and computer science working together.

The academy, a four-year undergraduate program, was founded in 2014 and is named after Jimmy Iovine, a founder of Interscope Records, and rapper and entrepreneur Andre "Dr. Dre" Young. Together they created the headphone company Beats, which was acquired by Apple. The money from the acquisition helped to provide funding to establish the school.

Chatterjee's other venue is the Innovation Design and Empowerment Applications (IDEA) Lab, which he founded at Claremont Graduate University in 2002. Ph.D. students there collaborate on projects designed to improve quality of life. They work on their projects for the three or four years it takes them to complete their program. Students have access to devices and materials not often found in traditional classrooms, such as 3D printers and rapid visualization software tools used to sketch out concepts on a computer.

"The students love to learn by doing," Chatterjee says. "The skills they're developing in these makerspaces are valuable in the marketplace today, and give the students an edge over their competition."

In this interview, Chatterjee discusses some of the successful projects that have emerged from the two labs.

Tell us about IYA and what it offers students.

The academy is designed to teach critical thinking and innovation. It's focused on three areas: art and design, engineering and computer science, and business and venture management. The school draws on the talents of faculty and visiting industry leaders to empower the next generation of innovators with the potential to disrupt industries.

Faculty members work with students to bring design thinking and business innovation principles to their projects. The students at IYA meet at a makerspace fondly called *the garage* because it's outfitted with a host of technical tools. They have the means at their disposal to come up with creative designs for their projects and see them through to working models.

What is your role at the academy?

I joined in January, and my main role is to get students involved with the school's R&D activities. I also help develop the curriculum, which is a blend of courses on software, business innovation, and engineering. And I work with the students on their capstone projects in a class called the Garage Experience. Student teams incorporating different disciplines select real-world problems to take on, come up with solutions, design a prototype, and then test it.

One such project is CancerBase. Students developed a software program that helps cancer patients monitor the progress of the disease and learn about treatment options from data collected about other patients. It was one of several projects featured at the White House's Cancer Moonshot summit, held in October. Established last year under the Obama administration, the national Cancer Moonshot project is a US $1 billion initiative to accelerate the development of new methods and treatments that will help eliminate cancer. CancerBase received funding from the National Institutes of Health.

Another project is Mira Labs, a startup launched in 2015 by several of the academy's students. It is developing augmented-reality smartglasses that will sell for less than $30. The venture will be receiving an early-stage $1.5 million investment later this year. The startup's advisory board includes Atari founder Nolan Bushnell as well as a developer of the Google Cardboard virtual reality glasses and the lead developer at Beats.

What led you to launch the IDEA Lab, and what would you like it to accomplish?

My ultimate goal is to make the lab an incubator of breakthrough ideas and startups launched by students. More than 30 R&D projects have been completed so far, and nearly 10 more are underway. One project that came out of the program is DCL Health, a technology startup pioneering the use of artificial-intelligence and sensor technologies to remotely monitor patients with chronic diseases including diabetes and heart conditions. Its remote monitoring software can assist patients with heart failure to manage their recovery at home.

What lessons can other schools learn from your labs?

Perseverance is needed to successfully launch such makerspaces at universities. At Claremont, I built the IDEA Lab from the ground up in 2002 with a grant from the National Science Foundation. Each successful project brought another and attracted donors and sponsors. Today we're in a position to be leaders in this new model for education. Twenty Ph.D. students have graduated from the lab.

Not every student is right for this environment. It takes a certain type of person, specifically those who are risk-takers and have the passion to solve a big problem. Such labs provide them with the ingredients for their projects to succeed. ◆

SAMIR CHATTERJEE/CLAREMONT GRADUATE UNIVERSITY

3D Printer Manufacturer Helps Customers See the Big Picture

Gigabot turns out large-scale items BY **KATHY PRETZ**

THREE-DIMENSIONAL printers are no longer just for hobbyists. Architects, designers, machinists, and toymakers are using them. But for some, traditional 3D printers are too small. And for others, the large industrial ones are too expensive, sometimes costing hundreds of thousands of US dollars.

IEEE Member Samantha Snabes' startup, re:3D, in Austin, Texas, is changing that. Re:3D makes the Gigabot, an industrial-strength printer whose smallest model produces objects as big as 212,000 cubic centimeters—about 30 times bigger than what leading desktop 3D printers produce. Gigabots have printed parts for airplanes, drones, and prosthetics.

Gigabots vary in size and price. The smallest, Gigabot 3+, can turn out items that are 59 cm by 60 cm by 60 cm. It costs US $8,550 and is sold as a kit. The company's largest fully assembled printer is the XLT 3+, which sells for $16,995 and prints items that are 59 cm by 76 cm by 90 cm.

Gigabots print with common thermoform plastics that melt at 320 °C.

"The printer is an affordable industrial tool for helping to solve problems locally," Snabes says. "Our users often create their own designs using a wide variety of tools including scanners to capture details and free downloadable files for printing designs."

Snabes refers to re:3D as a for-profit social enterprise. It's committed to giving a percentage of its earnings to social-impact organizations. For every 100 printers sold, the company donates one to a group that needs the machine to benefit its community.

During re:3D's annual GigaPrize contest, individuals and groups worldwide submit videos describing how they could use a 3D printer to make a difference. The winner is selected by judges and online votes. Good Works Studio, a social enterprise in Houston, received a Gigabot to print insulated floors for emergency shelters [see photo below, left]. The 2014 recipients were the Human Needs Project of San Rafael, Calif., and its partner, the Tunapanda Institute of Nairobi, Kenya, for a machine to print children's shoes as well as to print fittings for PVC pipes bringing potable water to a Nairobi neighborhood.

Steve Adler, the mayor of Austin, Texas, and re:3D cofounder Samantha Snabes with a Gigabot 3D printer. The company recently donated one to Good Works Studio, a social enterprise in Houston, so it could print insulated floors, like the one at left, for emergency shelters.

FROM TOP: RE:3D; GOOD WORKS STUDIO

COLLEAGUES WITH A MISSION

Snabes launched the company in 2013. She and her cofounders, IEEE Member Matthew Fiedler and Ernie Prado, had been working for NASA's Johnson Space Center, in Houston. She was the deputy strategist for the center's Space Life Sciences Directorate and Human Health and Performance Center.

Snabes and Fiedler had volunteered with Engineers Without Borders–NASA Johnson Space Center for more than three years in Nicaragua and Rwanda, where they witnessed challenges faced by underserved communities.

"Unemployment was so high, and everyone depended on expensive imported goods," Snabes says. "Yet the people we met were innovative and creative. We felt they should be able to create their own solutions to the problems they faced if only they could afford the right tools."

At the time, the maker movement and 3D printers were becoming popular. It didn't take long to come up with the idea for an inexpensive printer that was larger than the popular MakerBot desktop models.

"We found that $10,000 was the most that NGOs and small- and medium-size organizations could spend for an industrial tool," Snabes says. To afford the printer, some organizations hold fund-raisers or apply for grants. Re:3D offers a 10 percent discount to schools, nonprofits, and makerspaces.

To help finance a printer it had yet to design, re:3D applied for funding from Start-Up Chile, which in 2013 provided $40,000, equity-free, to start the company. The only catch was the company had to be located in Santiago. Snabes quit her job and moved there to set up an office while Fiedler continued at NASA and in his spare time built the prototype of what would become the Gigabot. After two months, he unveiled the Gigabot at Start-Up Chile's SXSW booth, in Austin, where the two launched a Kickstarter campaign. After the show, Fiedler flew the machine to Santiago. Re:3D continued working on Gigabot and ultimately came up with an open-source industrial 3D printer that was relatively easy to ship, assemble, and use.

There was a glitch, however. "We learned early on that manufacturing and shipping the machines from Chile was complicated and expensive," Snabes says. "To keep the price of Gigabot low, we decided to return to the United States and do most of the manufacturing and fabrication in-house." By buying many parts from U.S. suppliers, they avoided duty and shipping costs they might have incurred in Chile.

Development of Gigabot 1.0 was supported through that 2013 Kickstarter campaign, whose goal was to raise another $40,000. They reached that threshold in a little more than a day and ultimately raised $250,000. Since then, the company has raised about $300,000 more through a second Kickstarter campaign, accelerator funding, and pitch grants.

Re:3D set up its Austin headquarters in 2015, after establishing a manufacturing facility in Houston. It's across the street from the Johnson Space Center, where a number of the startup's 20 employees once worked.

"Several companies in Texas have Gigabots, and their application is creating additional jobs," Snabes says. Gigabots can now be found in 53 countries, she says.

EXPANSION PLANS

Snabes ultimately wants to eliminate the need to source the filament and instead use pelletized thermoform plastics and shredded reclaimed plastic waste. She's on a "plastic garbage hunt," as she calls it.

"We could order recycled plastic pellets online," she says, "but we'd prefer to experiment with ways for companies and organizations to use their own waste."

With so much research ahead, re:3D is hiring. It's looking for machinists, software engineers, and service technicians. ◆

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