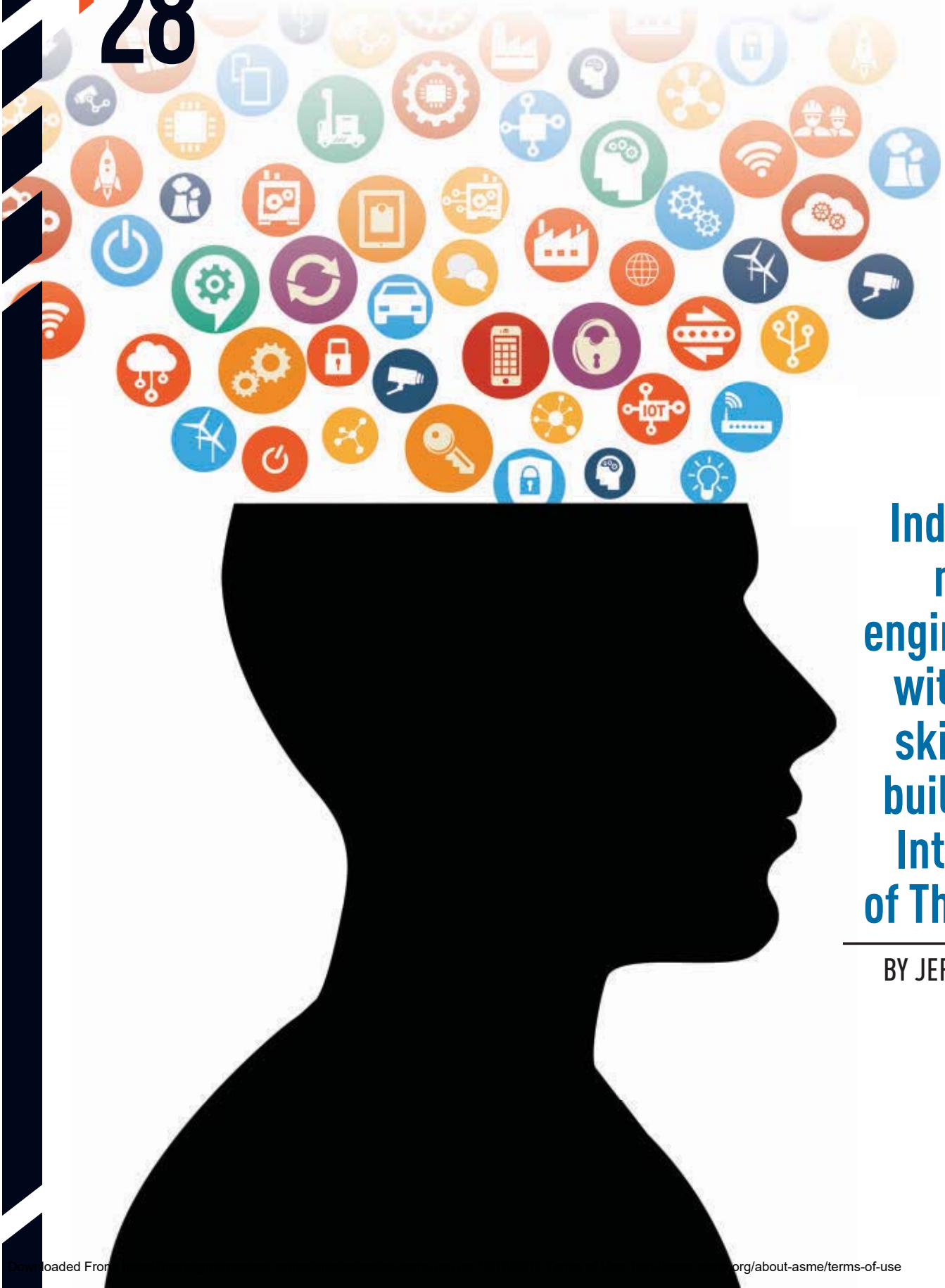

Industry needs engineers with the skills to build the Internet of Things.

BY JEFF O'HEIR

FILLING THE TALENT GAP

Will Caldwell was sure he wanted to be a mechanical engineer. The 20-year-old had spent his childhood in Madison, Wis., building models of spacecraft and futuristic vehicles with whatever he could find around the house. He started a mechanical engineering club at his high school. And when he enrolled in the University of Wisconsin-Madison's School of Engineering three years ago, he hoped to someday design cars.

But along the way, he realized that mechanical engineering skills alone would not get him where he wanted to go. His pals who recently graduated with mechanical engineering degrees had landed jobs that required them to program computers and robots, and to perform other tasks that were related more to the computerized world of the Internet of Things (IoT) than to traditional mechanical engineering.

"I met a lot of people who had figured out what IoT was and wanted to do something real with it," he said. But neither he nor his friends had much opportunity in their mechanical engineering classes to learn about IoT-related technologies and how to apply them to real-world solutions.

In the emerging IoT ecosystem, new technologies like embedded sensors make it possible for just about any type of device, machine, or component to collect data and send and receive information over the Internet. Data analytics and cloud computing then turn that data into something valuable.

Almost every industry is now trying to leverage those technologies to improve business and manufacturing operations, monitor and diagnose how well machines are functioning and forge closer collaboration between humans and machines. This is called the Industrial Internet of Things (IIoT) or Industry 4.0, and companies desperately need a new type of engineer to help them create it.

Until a few years ago, industry expected entry-level mechanical engineers to focus on mechanical engineering. But today almost every job they take on—from designing a medical implant to engineering a turbine jet engine—also requires an IoT-related skill, says Peter Hirst, associate dean of executive education at MIT Sloan School of Management. "IoT is everywhere now," he said. "The job function might not be characterized as IoT, although many of those jobs include some implementation of sensors, data measurements, and connectivity."

Hirst also serves as director of the IoT Talent Consortium, an industry-academic group that develops new ways of training engineers, technicians and others to meet the needs of IoT employers. He's in constant contact with C-level executives from a variety of technology, engineering, and science companies, who say their biggest challenge today is finding the talent to fill IIoT-related jobs.

"It's no longer you and 10 mechanical engineers working on a project, it's you and a designer and a

data scientist and a customer expert," he said. "Those are the kinds of abilities that people historically learned by osmosis and experience over a 10- or 15-year career. Now we're saying we need people to come out of school with those abilities."

But most are not. This has created a gap between the skills that industry needs to develop the technologies, products, and services that make companies profitable and competitive, and the skills that entry-level mechanical engineers typically bring to the table. For these reasons, companies and engineering educators are looking at new ways to train young engineers in the skills needed to bridge the gap.

FINDING A UNICORN

For at least 40 years, mechanical engineering fundamentals have been taught in much the same way. The core classes stuck to the basics every mechanical engineer must know, such as material, fluids, thermodynamics, measurements, and instrumentation. That satisfied industry, and that's what professors on a tenure track had incentives to teach.

While industry has complained over the years about young engineers' lack of job preparation in some areas of technology, most of the skills they needed were closely related to traditional mechanical engineering and could be honed early in a career. Large companies with deep pockets were also able to pick up the slack and teach engineers skills they didn't learn in school. Some still do. GE, for example, looks for candidates with deep knowledge in specific areas and have a commitment for life-long learning, said Stephan Billers, GE's chief manufacturing scientist, who directs a team that develops IoT-related software and hardware to digitize manufacturing processes.

GE also spends billions on ongoing business and technical training initiatives, internship and co-op programs, and online courses. "We hire talent, not skills," Billers said.

But it's difficult for small companies to offer the same opportunities. "Startups don't have the money to burn on training," said Kayla Matheus, a Yale-trained mechanical engineer who invented MOTI, an IoT device designed to help people develop better habits, and founded a San Francisco-based company of the same name to commercialize it.

Many companies, especially those that can't afford to train young employees, expect universities to do a better job teaching mechanical engineering students practical IoT skills. Matheus's startup is no exception. Its namesake product has as much to do with software as hardware. She and her small team develop cloud-based databases, manage firmware, and have created a smart-phone app, and they integrate all these technologies into the device's ecosystem.

Matheus hopes the young engineers who apply to her company will have a working knowledge of

"Startups don't have the money to burn on training"

— Kayla Matheus, a Yale-trained mechanical engineer who invented MOTI (pictured)

these skills their first day on the job. A little marketing, supply chain, and overseas manufacturing experience would also be nice. "We need people who can wear many different hats but who also have focused experience," Matheus said. "We're looking for a unicorn."

REAL-WORLD SKILLS

To prepare for these new jobs, students need a deeper understanding of the cornerstones of IoT, including data analytics, networking, cloud computing, mechatronics (a combination of mechanical, electrical, computer, and controls engineering), automation, and robotics. Young engineers don't need to be crack computer programmers, Hirst and others said, but they need to have enough working knowledge of other specialties to understand what their co-workers or teammates—from designers to data scientists to marketing experts—are actually talking about.

To give them that working knowledge, some companies are taking matters into their own hands.

Siemen's PLM, which sells a suite of software that automates manufacturing processes, donates millions of dollars in IoT-related software, curriculum, and training to more than 3,000 schools, universities and organizations around the world. The company also supports dozens of government, industry, and academic initiatives to provide mechanical and other engineers with the computer-related skills they'll need for IIoT and Industry 4.0 jobs. "More real-world activities will help solve some of those challenges we face," said Dora Smith, Siemens PLM's global director of academic programs.

ASME, for its part, hosts a series of global engineering competitions called the IShow, challenging young engineers to design a marketable product that will have a social impact. Each year, more of those projects include sensors, connectivity, cloud computing, and other IoT-related technologies, said Mahantesh Hiremath, a distinguished engineer at Space Systems Loral, a satellite builder in Palo Alto, and an ASME Fellow.

"All those projects on display are very much in tune with what young mechanical engineers will see in the workplace," he said. ASME also offers national and local professional development courses and seminars on IoT-related components like sensors and big data. It also works with academia to shape STEM curricula from kindergarten through university.

Engineers compete in ASME's IShow India. The international hardware competition features many solutions that include IoT-related technologies. Above is Navyo, a Bluetooth-connected smart glove accompanied by a Mobile App that can guide a blind person turn by turn via vibrations.

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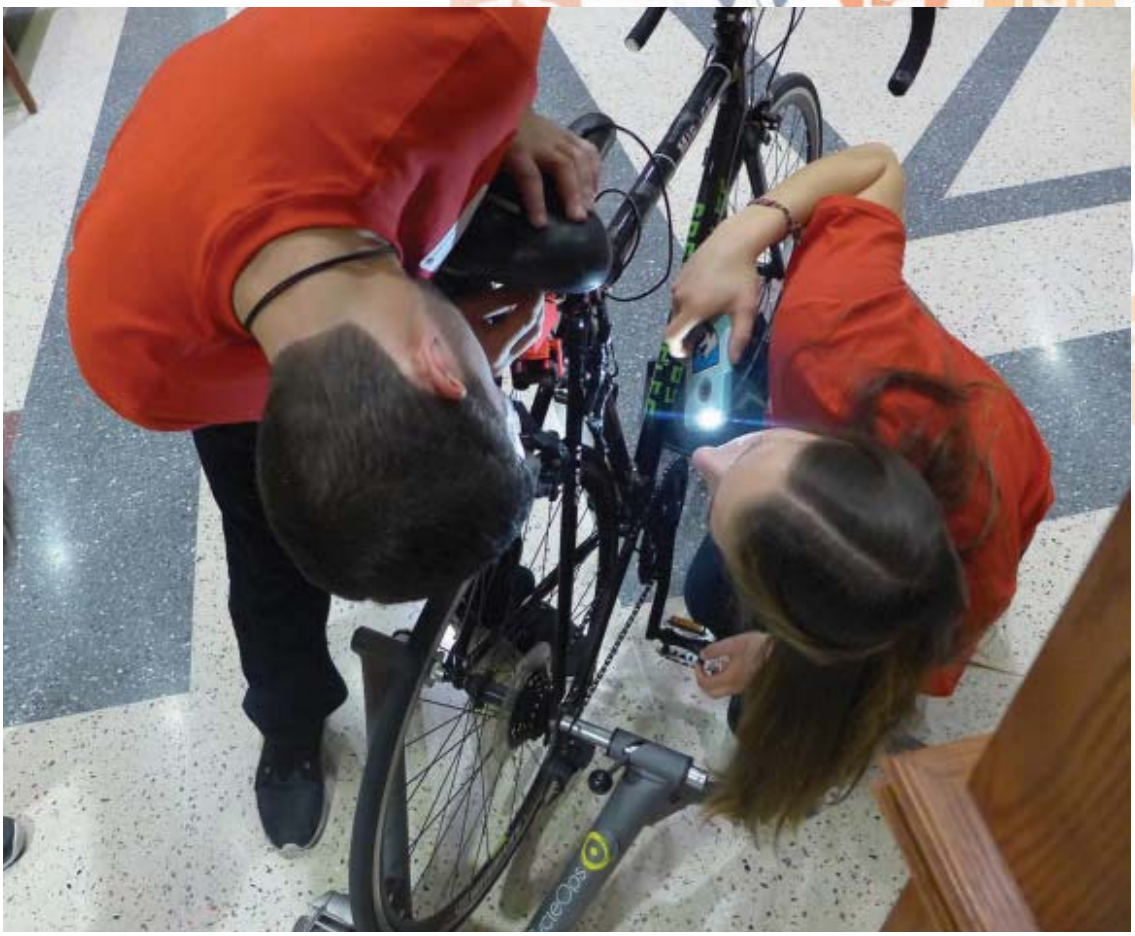
— Mahantesh Hiremath, Space Systems Loral



Will Caldwell and Katie Miller inspect the Safe Cycle, a device they designed to alert a bicycle rider to traffic behind the bike. *Photo: David Tenenbaum/University of Wisconsin-Madison*

THINK DIFFERENT

Training efforts by corporations and organizations can help teach young mechanical engineers how to incorporate IoT technologies on the job. But to properly prepare students for positions created by new IoT technologies, university engineering programs will have to do a better job at contributing, industry and education leaders agree.

Raj Veeramani, a University of Wisconsin-Madison professor in the Industrial and Systems Engineering Department, realized that a few years ago. Since then, he and a handful of other thought leaders have been developing better ways to teach and train young engineers to give them IoT skills.

One of the best is to have students from different majors collaborate on hands-on projects that include IoT components, Veeramani and others say.

"You need to expose [students] to different technologies, designs, disciplines, and business models."

— Professor Karthik Ramani, School of Engineering, Purdue University

For that reason, he and his colleagues launched the IoT Lab two years ago. They saw it as "a tech sandbox" that would bring together students, including those with nonengineering majors, to explore, innovate and engage in problem solving and entrepreneurship with IoT technology.

Veeramani papered the campus with flyers announcing the IoT lab's first informational session, which fell on an incredibly cold January night in 2014. It didn't help that he forgot to mention on the flyer that there'd be free pizza. "I wasn't sure if anyone would show up," he said.

Meanwhile, a handful of other university engineering departments have developed similar initiatives. They're typically set up in partnership with government or industry, which are turning to universities to understand IoT and figure out how to take advantage of the technologies and related business and marketing strategies.

In these programs, students typically pitch an IoT project or build a solution to a problem posed by a company or government agency. The univer-

sity supplies the parts, equipment and guidance the student teams need to complete their projects. The energy, knowledge, and ideas fostered by the environment benefit the corporate or government partners as well. "They bring together a lot of smart people to make the progress you couldn't do alone or with other private companies," said Daryl Erbs, vice president of technology at Manitowoc Foodservices, one of about 25 companies that have joined the IoT Lab's consortium.

Each university adds a few twists to differentiate their program. Karthik Ramani, a professor in the School of Engineering at Purdue University, for example, is developing a set of kits for core mechanical engineering classes with all of the basic components students could use to build an IoT-enabled device related to class topics. He also teaches a popular toy design class where he encourages students to build products and develop business models that fit into the IoT ecosystem. On top of that, Ramani started an IoT product-design contest in his mechanical engineering class.

"If you want to get the best of all worlds, you need expose [students] to different technologies, designs, disciplines, and business models," he said. "That's an interesting concoction that is not found in traditional university settings."

A NEW DIRECTION

Back at the University of Wisconsin-Madison, more than 80 students showed up on that cold winter night for the IoT Lab's open house. Student interest in IoT has blossomed ever since. At a subsequent open house last fall, more than 280 students from a variety of majors showed up. Today, half of the lab's 40 participants are engineers, while the rest are from nonengineering majors, such as computer science and business. About 30 percent are usually women, a much higher percentage than in most engineering-related activities, Veeramani said.

Will Caldwell was one of those participants. His friend—a nutrition major and cycling enthusiast whose friend had been hit by a car—had inspired him to develop a system that would alert bicyclists of a dangerous traffic condition and help them avoid injury. He thought the IoT lab might help him figure out how to go about it. At the open house, Caldwell hit it off with the other students and made a strong pitch to the judges, who accepted his project, which he eventually called Safe Cycle.

The lab, he said, had everything he needed to make his project a reality. "It has the newest, coolest stuff," he said, mentioning an Oculus Rift virtual-reality system; Google Glass; drones; plenty of Arduino boards, Raspberry Pi microcomputers, actuators, motors, and sensors; and a huge RFID container packed with past and present projects to inspire new design and technical ideas.

The University of Wisconsin-Madison IoT Lab is "a tech sandbox" that would bring together engineering and nonengineering students.

During the three months he spent working in the IoT lab, he managed a four-person team that included the nutritionist, along with a mechanical engineering major and an electrical engineering major, both freshman with no project experience. By necessity, each team member did a bit of everything, learning what they needed as they went along. "You ended up doing electrical engineering, computer science, design and marketing," Caldwell said. "I learned so many things in the lab that I couldn't learn in class."

At the end-of–semester open house, Safe Cycle won an award for "Most Potential Impact." And the experience changed Caldwell's career path entirely.

To develop his interest in IoT, he added a computer science major to his mechanical engineering major and tacked on a minor in electrical engineering to build what amounted to a major in mechatronics.

"I was strictly mechanical engineer until the end of last semester. I wanted to build cars," he said. "Now I want to build drones, robots, and other things."

He seems to be on his way. Last summer, Caldwell was hired by a team of UW plant scientists to design and build machines that use connectivity and sensors to capture data on growth patterns of carrot and corn crops. "They were interested in my experience in IoT," he said. "That's what got me the job." ME

JEFF O'HEIR is a contributing writer.