Vital Collaborations

The interdisciplinary field of biomechanics has found a natural home at Yale

From Waste to Energy

Yale engineers discover real benefits by utilizing a synthetic solution

Expanding the SEAS Network

The new Yale Institute for Network Science connects SEAS to a variety of researchers

2013-2014

YALE ENGINEERING

Yale

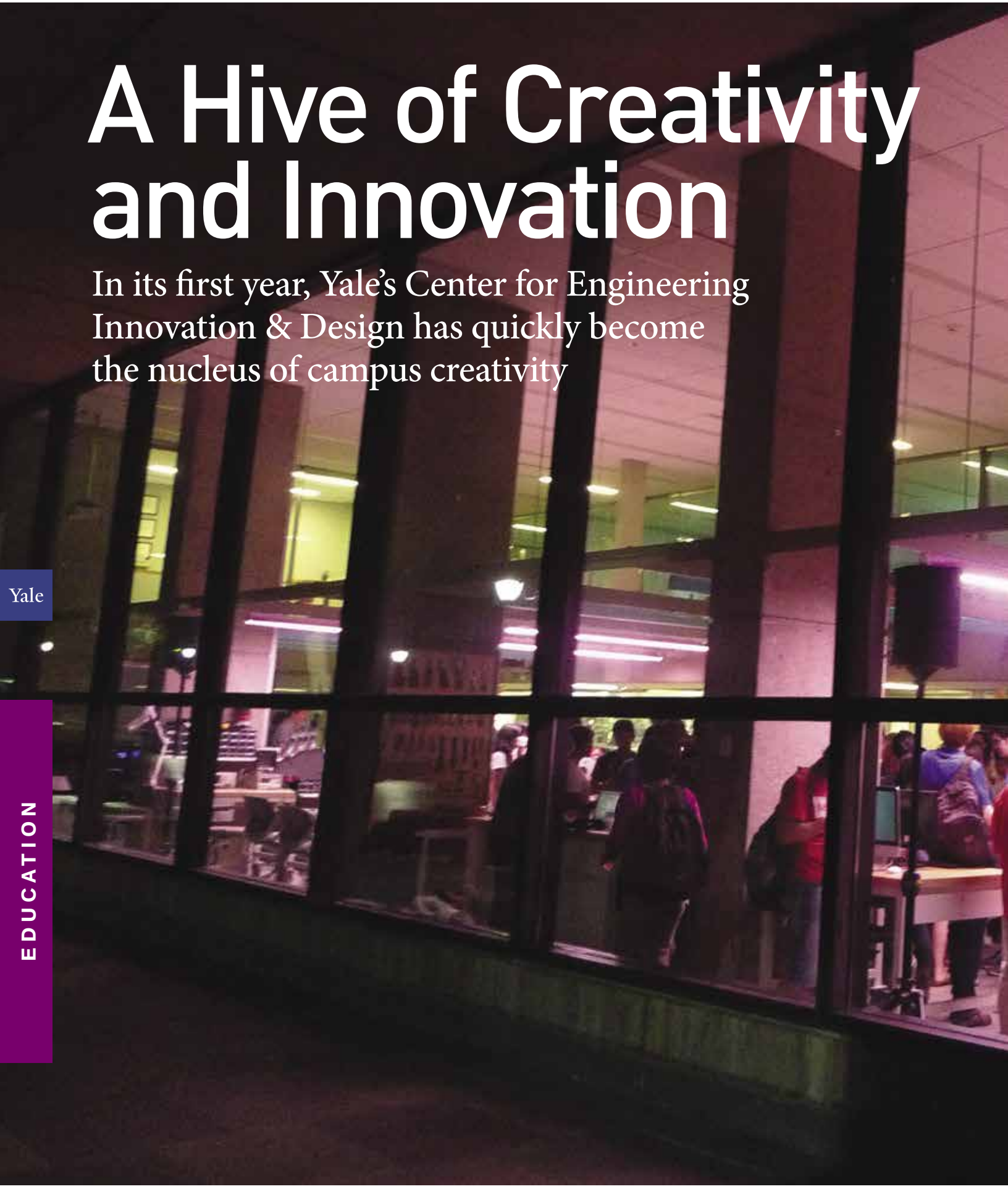
LED'ing the Way

The digital canvas is just one of many ways SEAS is engineering connections across campus

The Publication of Yale's School of Engineering & Applied Science

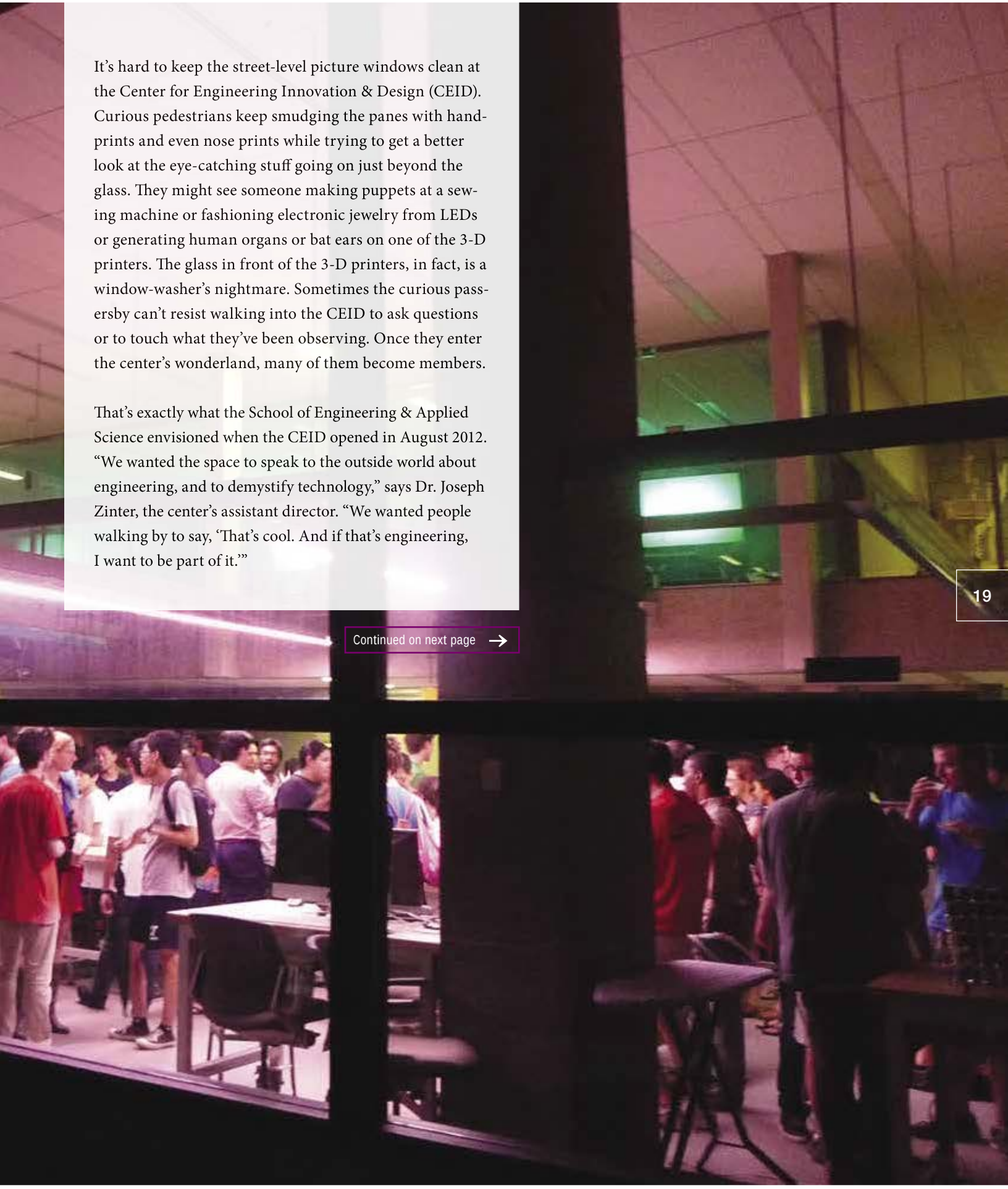
A Hive of Creativity and Innovation

In its first year, Yale's Center for Engineering Innovation & Design has quickly become the nucleus of campus creativity



Yale

EDUCATION



It's hard to keep the street-level picture windows clean at the Center for Engineering Innovation & Design (CEID). Curious pedestrians keep smudging the panes with handprints and even nose prints while trying to get a better look at the eye-catching stuff going on just beyond the glass. They might see someone making puppets at a sewing machine or fashioning electronic jewelry from LEDs or generating human organs or bat ears on one of the 3-D printers. The glass in front of the 3-D printers, in fact, is a window-washer's nightmare. Sometimes the curious passersby can't resist walking into the CEID to ask questions or to touch what they've been observing. Once they enter the center's wonderland, many of them become members.

That's exactly what the School of Engineering & Applied Science envisioned when the CEID opened in August 2012. "We wanted the space to speak to the outside world about engineering, and to demystify technology," says Dr. Joseph Zinter, the center's assistant director. "We wanted people walking by to say, 'That's cool. And if that's engineering, I want to be part of it.'"

Continued on next page →

"That's cool. And if that's engineering, I want to be part of it."

Yale

EDUCATION

In just one year, more than 1,200 people from the Yale community joined the center after completing an entertaining 45-minute orientation and a brief quiz. The meteoric rate of growth surprised everyone.

"It suggests that a space like this really needed to exist," says Ellen Su, one of the center's two full-time design fellows. She graduated from Yale last spring with a degree in art. How did she end up in an engineering center? In exactly the way that the CEID's leadership envisioned. She got interested in the power of design to solve practical problems, but couldn't find much at Yale to help her explore this interest, so she started a Design for America club to promote design thinking and education. Then the CEID opened. "I joined and started using so many resources here," she says, becoming the sort of student Zinter calls "a super-user." Before long she was one of the center's Undergraduate Design Aides, and after graduation she stayed to become an employee.

Her story exemplifies a couple of the CEID's aims: to be a bridge to the broader Yale community and a catalyst for interdisciplinary creativity. It's working splendidly. The CEID's leadership is pleased not only by the unexpectedly high number of members, but by the range of their affiliations at Yale: they come from over 50 undergrad majors and every professional school, including Drama, Medicine, Public Health, and Divinity. Fewer than half – 45 percent – are so-called STEM majors (science, technology, engineering, math). Thirty percent are majoring in social sciences and humanities, and the largest single contingent of members comes from the School of Management (SOM).

"Before the CEID," says Zinter, "SOM wasn't exactly banging on engineering's door." Now there's a space that allows these disciplines to collaborate and investigate mutual interests in innovation and practical solutions. Last spring, for instance, students from SOM, anthropology, graphic arts, and other majors took Zinter's engineering class, Appropriate Technology for the Developing World, at the center. All contributed their skills and perspectives to the class project: to devise practical ways to turn cassava, a staple food for a billion people, from a simple survival crop into products that could generate income for the poor farmers who grow it.

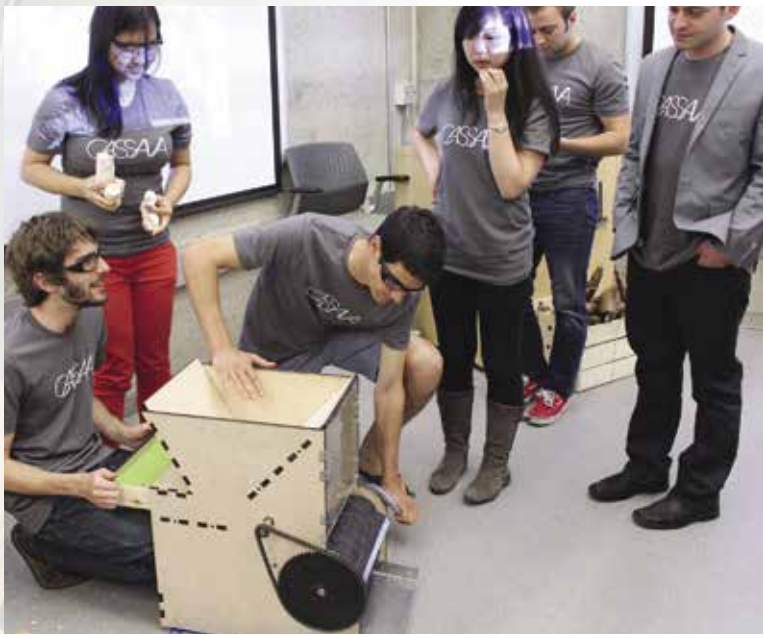
One of Zinter's favorite examples of how the center can be what he calls "a discipline-agnostic space" was last year's

Tree House project. An architecture student named Griffin Collier had long wanted to build a super-duper tree house. Supporters on Kickstarter pledged $10,500, which took care of material expenses, but an undertaking this complicated required many sorts of expertise, an array of machinery and design software, and a place to brainstorm and store materials.

The CEID became the perfect headquarters for more than 50 students, faculty, and staff, including architects, forest managers, and engineers with varying skills (design, prototyping, machining, structure, software, safety). The building materials – including thousands of pounds of aluminum – were stored on the center's floor before being cut, drilled, milled, and finished in the center's various shops. Then came the construction. The tree house now perches in a big oak near campus. The castle in the air imagined by Collier became reality because a space now exists where it could be discussed, designed, and fabricated.

Some people, like Collier, come to the center with a firm idea in mind. Others arrive with vague notions or conceptual fragments, hoping to explore possibilities or find expert guidance on the next steps. "Linking people up is probably the most powerful thing we do," says Zinter.

Continued on next page →



In the past year, for instance, the CEID has functioned as a new bridge between engineering and medicine. The center held an event with the medical school at which physicians pitched ideas and problems to engineers. Some of the ideas, says Yusuf Chauhan, the other full-time design fellow at the CEID, violated the laws of physics, but others led to collaborations with engineers – for instance, a cardiac impeller pump that provides continuous flow of blood to a patient waiting for a new heart. Su and several others are working on a scoliosis brace fitted with sensors that will give parents and doctors better data about how a child is using, or not using, the brace.

Dan Rathbone, a mechanical engineer who will graduate in 2014, was intrigued by the problem presented by Kurt Eric Roberts, an associate professor of surgery. Roberts wanted a noninvasive way to suture hernias. Current practice requires punching four holes through the skin, a painful procedure. Roberts and Rathbone, working at the CEID, developed a way to patch from the inside, using laparoscopy and a new fastening device designed by Rathbone. Roberts is now talking to potential investors. "It wouldn't have happened without the CEID," says Rathbone, another super-user.

One day not long after the CEID opened, Zinter noticed someone with a Yale hospital badge working at a 3-D printer station. Zinter asked him the center's most popular question: What are you working on? "I'm printing some pulmonary vasculature," said the man. "Cool," said Zinter, sensing an opportunity for new links. "Let's talk."

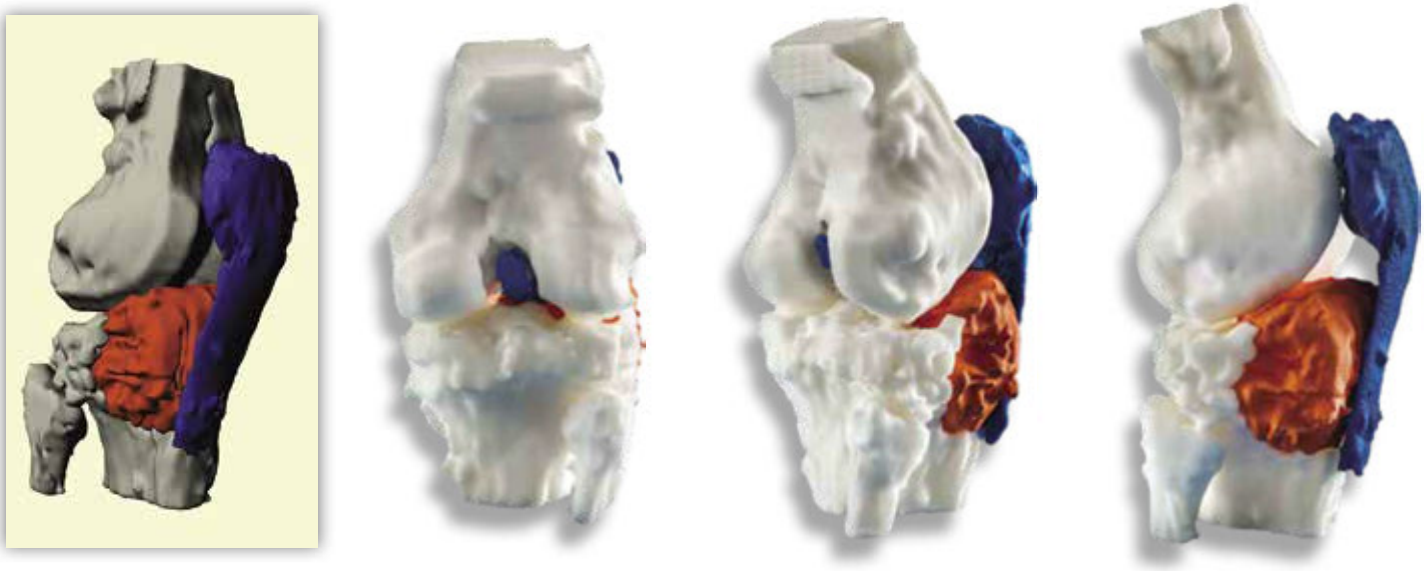
His name was Mark Michalski, a fourth-year radiology resident. Michalski's idea was to use the center's 3-D printers to turn sectional images from patients' MRIs into exact physical models that could help surgeons plan their procedures. He tested his theory this past summer with help from Zinter, Chauhan, and Dr. Dieter Lindskog, an orthopedic surgeon at Yale. Lindskog needed to remove a large tumor from a patient's knee. It was a complicated operation because of all the knee's parts – tibia, fibula, femur, tendon, patella, plus the tumor. Michalski did an MRI and gave the images to Zinter and Chauhan, who used software to turn them into instructions for a 3-D printer. After studying an exact three-dimensional copy of his patient's condition, Lindskog was able to plan his surgical approach more precisely. A 3-D model made at the CEID has also been used to plan prostate surgery.

The models may be helpful for educating patients as well. A surgeon can use one to show a patient exactly what's wrong and what the procedure will be. Similarly, consider the cancer patients who quit chemotherapy because the accompanying nausea seems worse than the disease; showing such patients 3-D models that illustrate how treatment is shrinking their tumors might encourage them to stay the course.

"Who knows where the medical applications for 3-D printing could go?" says Zinter. The center's printers and other high-tech engineering equipment give doctors the means to explore ideas by making them physical.

Another bridge to the medical school is "Medical Device Design & Innovation," an engineering course taught at the center by Zinter and Richard Fan, a Ph.D. in biomedical engineering and a postdoctoral associate in Yale's Department of Urology. The class goal is to design solutions to real medical problems. Zinter and Fan reviewed over 20 physician proposals. Four projects were chosen for development: a novel transport system for harvested organs; a tool that can accurately detect and count a patient's epileptic seizures; a small semi-robot to do surgeries on the base of the

Continued on next page →

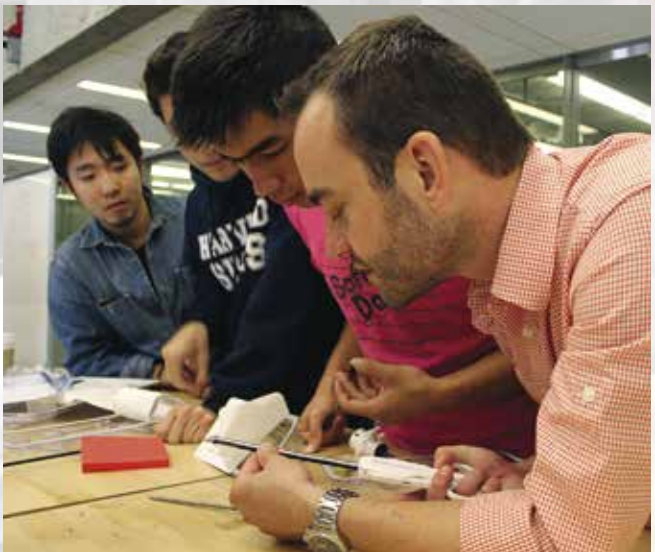


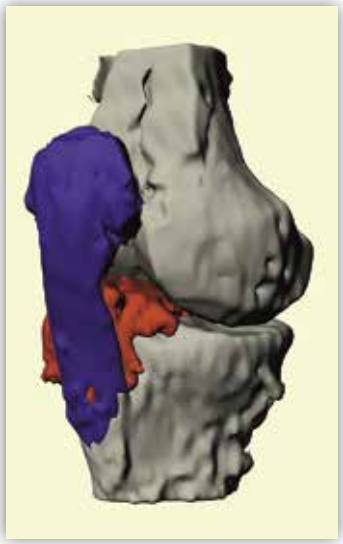
tongue; and a low-cost, subcutaneous drug delivery system. The students and physicians will collaborate throughout the design process, linking engineering and medicine through the common denominator of innovation.

The CEID's space itself was carefully designed to foster exploration and innovation. "If you build it, they might come," says Zinter, "but if you *design* it well, they'll come back." It's no accident, he explains, that the center's most eye-catching equipment, such as the 3-D printers, are located near the windows. Nor is it accidental that when newcomers walk into the center, the first creation-station they encounter is stocked with user-friendly supplies such as glue guns, Styrofoam balls, and pipe cleaners. The tool nook, like all the others, is laid out to be aesthetically pleasing and easy to "read." Most of the supplies and equipment are free for members to use, 24/7, though some of it requires training.

The idea behind all this is to lower the barriers, including fear of technology, for people who want to create things. Before the CEID, the barriers were high. "Our science and technology students are Yale's greatest untapped resource," says Eric Dufresne, associate professor of mechanical engineering & materials science, physics, and cell biology, and director of the CEID, "but there weren't many places for them to pursue their own creative agendas. They usually were confined to the research agendas of the faculty."

Rathbone, the mechanical engineering student, remembers arriving at Yale several years ago eager to "build stuff." But he couldn't find a place where that was easy





Renderings and 3-D printed lightweight, plastic 1:1 scale model of the knee – including the femur, fibula, tibia, ACL, patella (blue), tendon, and the tumor (orange)

to do. A couple of labs and workshops were scattered around campus, mostly in basements, mostly reserved for engineering classes. Tinkering, experimenting, "building stuff," creativity – these basics of engineering were essentially frustrated. "Now we have this gorgeous building," says Rathbone.

Jan Kolmas, another mechanical engineering student who will graduate in 2014, tells a similar story. He came to Yale hoping to become an aerospace engineer, but since Yale didn't offer that major, he took matters into his own hands by starting the Yale Aerospace Club. They began building high-altitude balloons. "But it was very difficult," he says, "because it was hard to get into the machine shop and use the tools. We couldn't do more complicated projects."

The CEID changed all that. "Everything we need is here," says Kolmas. "The tools, the machine shop, the electronics, the meeting rooms." The club has graduated to making unmanned aerial vehicles and is also attracting new members.

Multiplicity of uses was also part of the plan for the CEID. "You can study, socialize, take classes, design projects, or hold meetings here," says Dufresne. "Most of the activity is conceived by students. It's a community built around science and technology." The CEID's schedule brims with club meetings, career talks, tech talks, and student-run workshops on a wide range of topics: software design, chocolate molds, 3-D printing, engine tear-downs, the physics of bubbles.

When smart curious people gather in an engaging space where everyone's work is visible, and where the inevitable question is "What are you working on?" the prospects for creativity and innovation go way up. "That happens all the time," says Kolmas, "with my projects and other people's projects. It has broadened my horizons."

"That happens especially with things totally unconnected to my own work," says Rathbone. "I have no interest in microfluidics, but when the device is dismantled and lying there on the table, it suddenly seems a lot more interesting." A mechanical engineer who knows something about microfluidics has a better chance of envisioning something new that draws from both, especially if there's a space that makes it easy to explore and test ideas through iteration after iteration.

"Yale is doing something really special with the CEID," says Zinter. "It represents a change in pedagogy, with cross-disciplinary learning and design thinking that extend far beyond engineering into how to view problem-solving in the real world, not just problems in the back of a textbook. Because of the CEID, Yale engineers will be different from engineers coming out of other places, with more depth, breadth, and purpose."

*Steve Kemper wrote **Code Name Ginger**, about Dean Kamen and the invention of the Segway. His most recent book is **A Labyrinth of Kingdoms: 10,000 Miles Through Islamic Africa**.*

School of Engineering & Applied Science, Yale University, Dunham Laboratory, Room 222, 10 Hillhouse Avenue
U.S. Mail: P.O. Box 208267, New Haven, CT 06520–8267, Phone 203.432.4200