Yale

From Projects to Products

Students learn the process of launching a business, from conception to market

Back in 2018, a team of students in the Yale Center for Engineering Innovation and Design (CEID) demonstrated a prototype of a device that guided exercisers in performing perfect squats and push-ups. A few years and many iterations later, that device has made its way around the continent for real-world testing. And soon, it could be at your own gym.

That device and a contactless microscope designed specifically for museums are just the first endeavors of Projects2Products (P2P), an undergraduate student program that gives hands-on experience in turning student projects into commercial products.

The program is supported by the CEID, the Tsai Center for Innovative Thinking at Yale (Tsai CITY), and the SEAS Greenberg Engineering Teaching Concourse (GETC). Besides sharing the ingenuity of Yale's students well beyond campus, P2P gives students a chance to work on all angles of entrepreneurship — product design, manufacturing, and marketing.

In designing the program, Deputy Dean Vincent Wilczynski said he had President Peter Salovey's concept of Yale's "Innovation Corridor" in mind — that is, the combined forces of the CEID, Tsai CITY, and GETC, and its promise "to enhance our city's reputation as a center for technology and innovation."

"This is a program that comes from the community of Yale — Yale Athletics, Yale students, and Yale Engineering — to create a learning environment for students to experience an idea in the full-scale development of a commercial product, which includes manufacturing and engineering," Wilczynski said. The program has been working with leaders in Yale's Cooperative Research and General Counsel offices on trademarking and other details.

The Bulldog RepBox™, a device to assist workouts, and the Hover, a microscope that users operate without touching are well underway in the P2P process. Also in the early stages is a balancing board to help medical professionals assess the recovery process of brain injury patients. The scope and aims of each project are flexible. The RepBox could eventually be a consumer project, for instance, while the Hover may be limited to museums and other institutions.

Clare Leinweber, executive director of Tsai CITY, said P2P is a great example of the kind of collaboration at which Yale excels.

"I was so glad when Vince reached out to talk with me about his idea for the Projects2Products initiative," Leinweber said. "It lends itself well to the kind of collaboration that CEID and Tsai CITY seek with each other, and which students value. I'm looking forward to the next steps, and exploring new ideas."

The Bulldog RepBox™

The RepBox provides users with a high-tech assist with push-ups, sit-ups, squats, and other workout staples. These exercises have been around for centuries, but there's still no exact way to make sure you're doing them the right way. With the RepBox, though, everyone from average gym rats to pro athletes can perform them with complete consistency.

The RepBox project originated in the course Engineering Innovation & Design (ENAS 118) in 2018, when students worked with Thomas Newman, then Yale's director of sports performance and innovation, on designing a device to help users perform squats properly and consistently. A key component of the design is its time-of-flight sensor, which measures the distance between the athlete's body and the floor. The RepBox uses this continually monitored signal to alert an athlete when the proper exercise height has been obtained.

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With the basic concept and prototype worked out in ENAS 118, the device then went to CEID Design Aides, who designed a printed circuit board to house the electronics and honed the overall design. Led by former CEID Fellow Antonio Medina '19, the team at the CEID developed a design process to manufacture the devices using the CEID's fabrication and assembly equipment. This phase also involved making the device more user-friendly, refining how it feels and sounds, and making it more durable. A major goal was making sure that it fit in well with a gym or physical therapy environment.

"We wanted to give it a little more of an ergonomic feel, making it a size that's comfortable and portable, but not so small that you can lose it," said Medina, now a graduate student in design at Stanford University.

Also important was creating an interface — including buttons, display, and sounds – that are familiar and easy to use. Even simple things, like adding rubber feet to keep it from slipping around on the gym floor, go a long way toward making the device market-ready.

"It's a great lesson in how long things take to refine things and understand what the client or consumer would really want," Medina said.

With some tweaking, such as figuring out the best way to fit the device's electronics, the team was able to streamline the manufacturing process, which paid off in a smaller and less expensive RepBox. The original design was brick-sized, weighed a couple pounds, and cost about $100 to make. The CEID team's 3D printed iteration weighs less than a pound and now costs $40-$50. It's even outfitted with a sleek logo designed by Jacob Payne, a member of the student team, who majors in architecture. So far, they've made about 50 of the devices which have been deployed for market testing.

They're now working with a manufacturing company in China founded by SEAS alum Gordon McCambridge '16 to explore mass-producing the device.

Above: *The RepBox brings science and consistency to workouts and can be used by pro athletes and casual exercisers.* Below: *Creating iterations allowed the group to refine and perfect the product to meet the needs of consumers.the Rep Box iterations.*

Right: *The RepBox provides users with a digital assistant to aid with push-ups, sit-ups, squats, and other workout staples.*

"They have a lot of experience with this kind of thing, especially small enclosed electronic devices," Medina said. "So it's right up their alley to take a look at our design and see if they can refine it a little further."

Tsai CITY Innovation Fellow Matt Gira is heading up the marketing aspect of the project. Gira recognized the device's potential as soon as he saw it.

"The big question I had right away was, 'What's the price point?' — all the typical business questions," he said. "The entrepreneur in me came out really quickly — price point, market, where do we start? I had a billion questions that came through."

To get some impartial, non-Yale feedback, they've sent the devices to numerous university trainers, physical therapists, and strength coaches. These include University of Florida, the University of Kansas, and Notre Dame. The Municipal Police Training Committee (MPTC) in Massachusetts is also evaluating the device. Newman visited MPTC on one of the days they were incorporating the RepBox into their training regimen.

"They used it for push-ups, and it was bullet-proof. It was great," Newman said.

With a lot of innovations, new ways to use them become apparent once they're out in the real world. That's been the case with the RepBox. Though originally designed for squats, testers used it to also standardize their push-ups and sit-ups. Coaches at the University of Kansas even used it to verify depth of motion for basketball shots. As part of the market research component of P2P, the original and more specific name of "SquatBox" has been altered to the wider-encompassing "RepBox."

The feedback they've gotten so far includes some helpful suggestions, like making the audio signal louder and adding a repetition counter. They've also gotten a lot of rave reviews, which doesn't surprise Newman. It's the era of the tech-savvy athlete, but judging push-ups and squats has long been very subjective and based on very inexact methods. The RepBox brings science and consistency to these exercises.

"It is really accurate and it's really reliable," Newman said. "It's really cool, and it solves a problem. It's an example of something that's a testament to practical design and product development."

The Hover

The Hover, the second major P2P effort, is a contactless microscope that's being tested for use in museums, and potentially wider uses. The first clients for the Hover are the Yale Peabody Museum of Natural History and the Smithsonian Institute — both of whom have worked with the CEID on previous projects. The Hover project began in the 2020 fall semester in ENAS 118, when the student team of Alexa Loste '24, Mikiala Ng '24, Avery Long '24, and Erick Marroquin '24 were tasked with developing a microscope that can be operated without the user touching it.

David Heiser, director of student programs at the Peabody, told the team that he was looking for a microscope that could be used by

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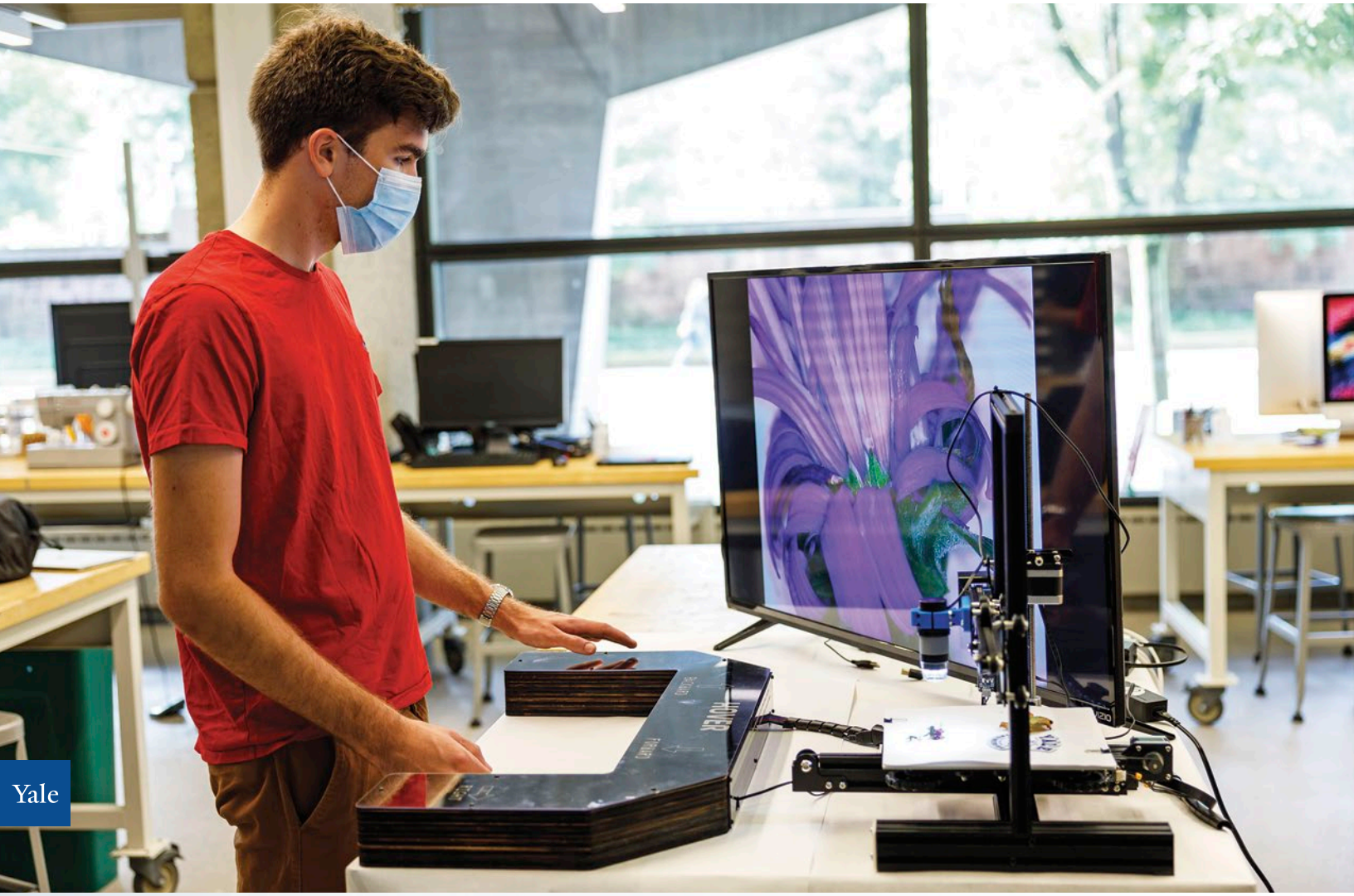


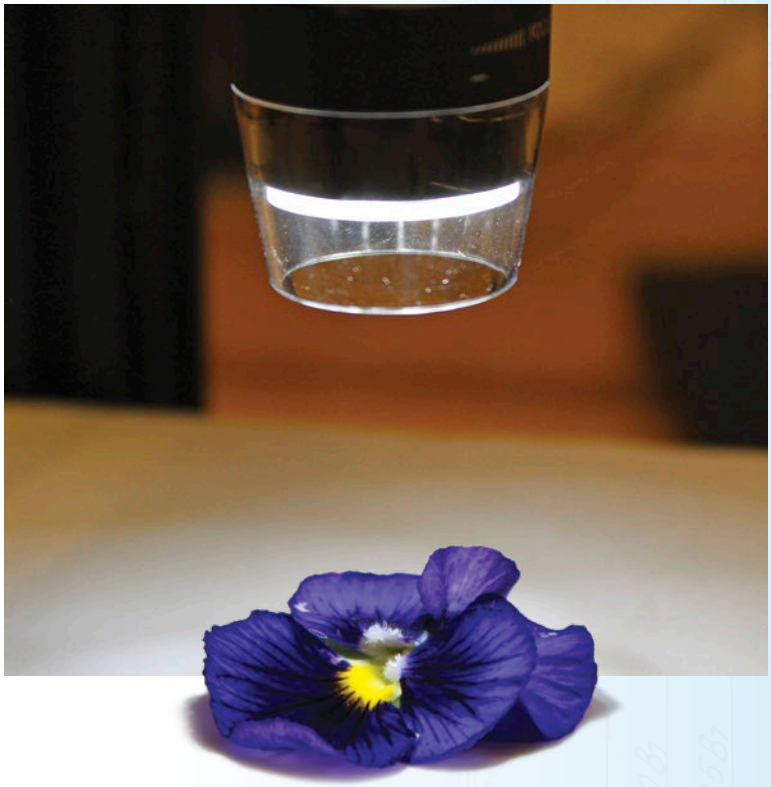
Above: *Ted Wayland '24 utilizes the Hover to zoom in on an item by placing his hand over the device's sensors. The group is exploring ways to implement the Hover at Yale's Peabody Museum of Natural History and the Smithsonian Institute.*

visitors to the museum that wouldn't spread germs, be durable, easy to use, and educational. By end of the semester, the team had developed a working prototype, which went through a second iteration process at the CEID with students and staff honing the device. Officials at the Smithsonian Institute were also brought onto the project, and they offered their own suggestions and goals for how a contactless microscope could enhance exhibits at several Smithsonian museums.

For the third phase of the project, students Lily Dorstewitz '24 and Kayla Morgan '24 took on the job of further advancing the microscope as part of the 2021 CEID Summer Fellows program. Taking the feedback from the Smithsonian and Peabody officials, they developed a sleek device that they dubbed the Hover. Encased in a damage-resistant acrylic surface, the Hover allows users to operate the microscope by holding their hands over different sensors. Depending on where the hands are placed, the microscope lens can go up, down, left and right, as well as diagonally. Hold your hand up high, and the lens travels slowly to its destination. Lower your hand, and it speeds up — but it never gets too fast for novice users to operate or too difficult for people with physical disabilities.

The team demonstrated the device for both the Peabody and the Smithsonian at the end of the program. It was a hit.

"This is really exciting, to see what's possible — It's really clever to repurpose the guts of a 3D printer to get the 3-dimensional motion of the scope — I just think this has real potential, not just for the Peabody, but potential for the field," Heiser said. "This is something other museums and science centers would be very interested in."



Left / Right: *Items such as a flower petal become much more vibrant when displayed on the large, connected screen.*

Heiser added that a number of features in particular impressed him. For instance, the large stage of the microscope means that visitors won't have to ask museum workers to switch out samples for examination.

"With this nice big stage, which is different from the limited stage of a traditional microscope, you could have seven or eight things on it and then people could literally move the stage all around and see each one of those things."

As a bonus, the team also outfitted the Hover with a game in which users can test their prowess with the device by zooming in on specified items. It also has a large monitor that allows others, who aren't using the microscope, to also see what's being examined in vibrant, high-definition detail.

"I see this as something for public discovery and for the examination of things — it's great for that," Heiser said. "With it connected to a screen, it becomes an exhibit, so that others in the room standing by the person see the same thing. It becomes sort of a social thing."

Smithsonian officials were also impressed.

"There's a lot of practical uses that we could make of this, and it's just another tool that we can use when we're trying to come up with mechanical interactives to be used in a really engaging way for working with visitors in different museums," said John Powell, a developer of exhibits for the Smithsonian. "We could use it in a variety of museums."

One idea, he said, is that it could potentially be used in the Smithsonian American Art Museum, which has a conservation lab open to the public.

"They're trying to reinterpret it to give more direction for visitors, so with something like this, you can imagine zooming in on an artwork and being able to see the tiny details that conservators have to repair or restore when they're working on a painting or some other artwork," Powell said. "From that, to science museums to air and space, there's so many different applications that we can use it for."

Juanita Wichienkuer, chief of design for the Smithsonian, suggested that the Hover could allow visitors a new way to look at rare artifacts. Because they're so valuable, the museum can't allow visitors to touch these artifacts, but simply keeping them encased in glass creates a certain distance between the exhibit and the visitor. The Hover could help them resolve this conflict.

"But letting them scan it in this way might be more engaging than just having detailed shots of it that are already done for you," she said. "We're always looking for ways to engage people in a way that's not just reading another text panel."