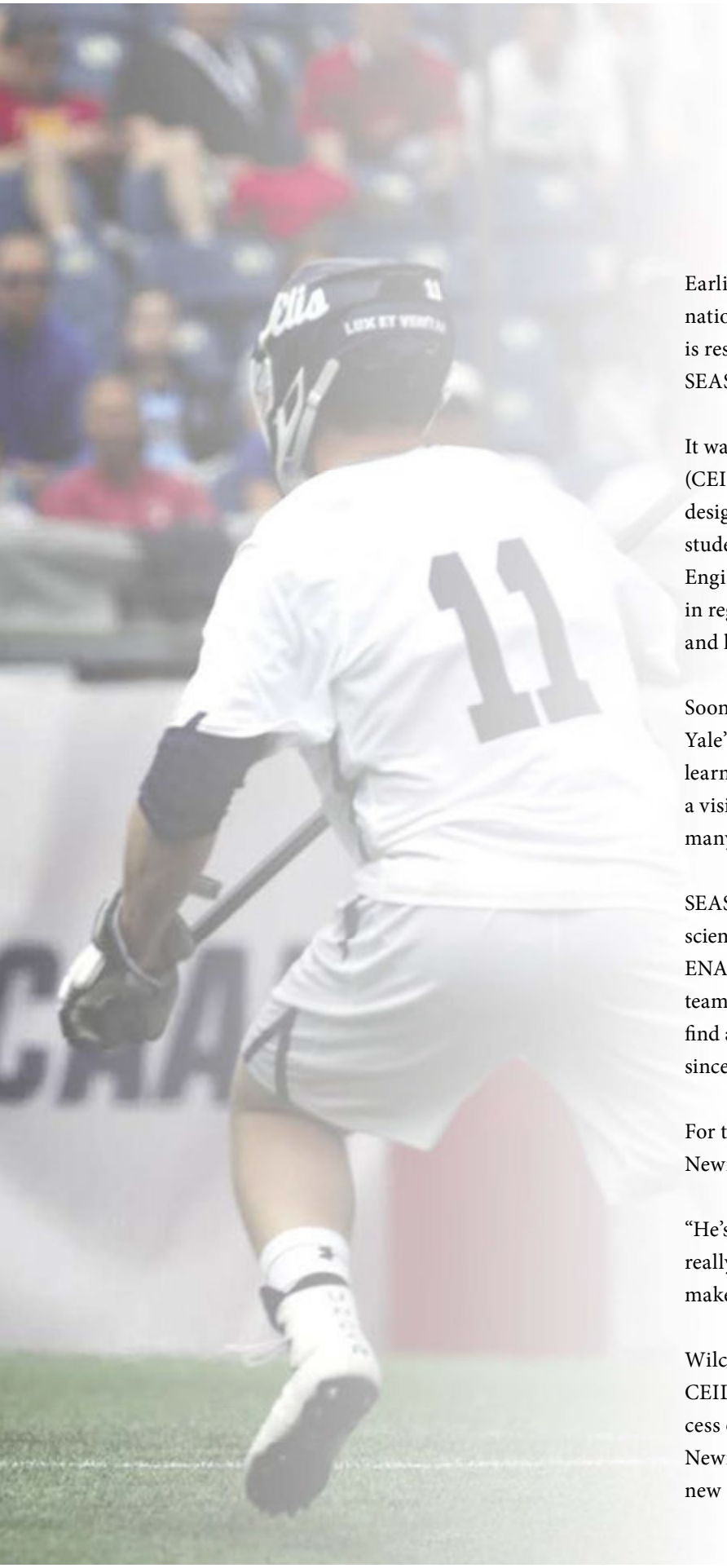
Yale

EDUCATION

Engineering a Championship

Yale's lacrosse team is now the best in the nation. The CEID has something to do with that.



Earlier this year, Yale Men's Lacrosse team won its first national championship since 1883. While no single factor is responsible for the team's success, it's certainly fair for SEAS to claim some of the credit.

It was at the Center for Engineering Innovation & Design (CEID) where students developed the Lightboard, a device designed to help goalies hone their reaction times. The students worked on it as part of the course, Introduction to Engineering Innovation & Design (ENAS 118), and it was in regular use by the lacrosse team, and later, the soccer and hockey teams.

Soon after he arrived at Yale in 2016, Thomas Newman, Yale's Director of Sports Performance and Innovation learned about the CEID and he didn't waste time paying a visit. "My mentors used to tell me, 'You can't have too many friends who are engineers.'"

SEAS Deputy Dean Vincent Wilczynski and senior research scientist Lawrence Wilen took Newman on as a client for ENAS 118, which they co-teach. For the course, student teams take on challenges from all areas at Yale and try to find a solution. Athletics was a natural fit, Newman said, since "there's never any shortage of problems in sports."

For their part, CEID and the class were happy to have Newman as a collaborator.

"He's a very good client for the 118 class," Wilen said. "He's really good with the student teams and understands what makes a good project."

Wilczynski said Newman works with everyone at the CEID along every step of the projects. As part of the process of developing new tools to help coaches and athletes, Newman challenges the staff and students to stretch in new directions.

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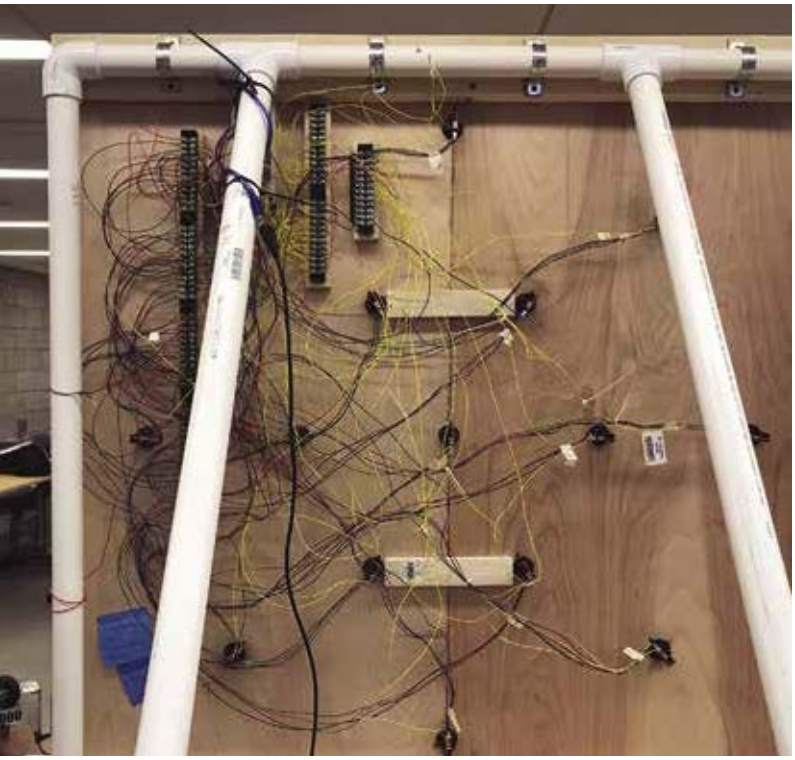
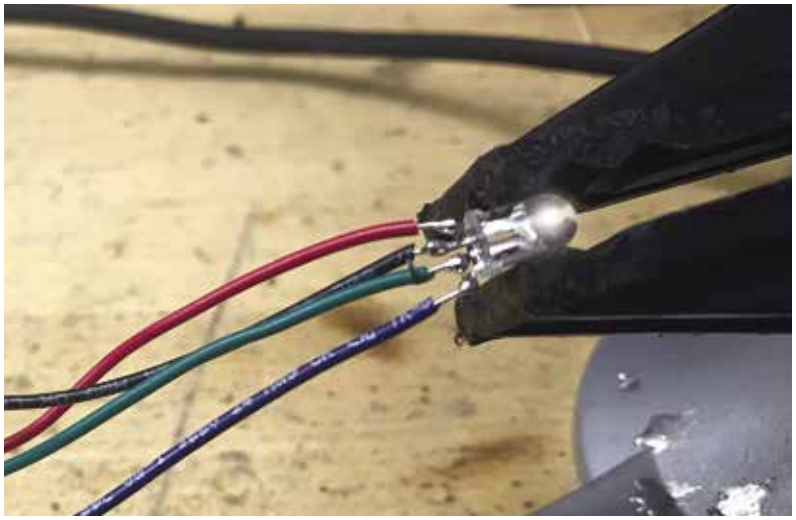




Top Left: *Wiring on the back of the Lightboard.*

Top Right: *The Lightboard is comprised of 15 LED lights, each capable of flashing different colors.*

Bottom: *Utilizing an Arduino, the Lightboard can be adjusted to create new games for different skills.*

Yale

EDUCATION

"We read some literature that when people react to a stimulus, our eyes move in concentric circles, so we designed the board with this concept in mind."

› Cece Gao, computer science major

"Coach Newman brings the same intensity to the CEID that he brings to the sidelines of our sports fields," Wilczynski said. "He gives guidance and encouragement to get each project across the finish line. Working with him is akin to an intense intellectual workout that is immensely rewarding and extremely inspiring."

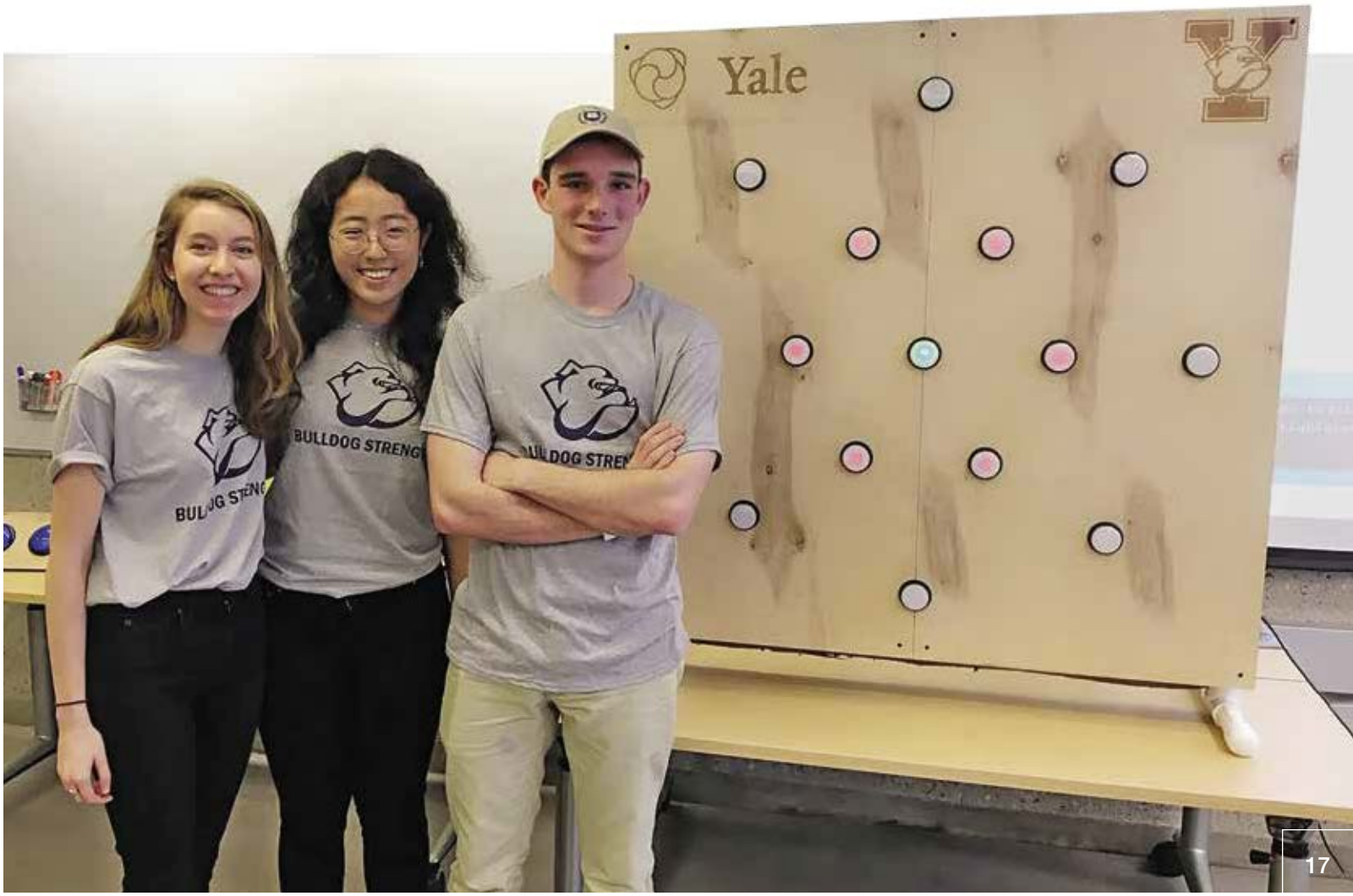
Newman said he sees his collaboration with the CEID as part of a larger culture at Yale.

"People ask me, 'What's the secret at Yale?'" Newman said. "The secret is we're Yale! I can walk down the street and have a coffee with some of the brightest minds in the world and they want to help us, and we help each other. That's the Yale community."

Lighting the Way

Work on the lightboard device came about after Newman told Wilen and Wilczynski about some issues they'd been having with the lacrosse team. Thanks to an unusually good defense, opposing teams don't get many shots on goal. But that also means Yale's goalies have fewer opportunities to build their skills. Improving reaction times is a big part of that. In lacrosse, the ball can come flying at the goalie at speeds well above 100 mph. A split second can be the difference between a win and a loss.

Three students — Cece Gao '21, Mary Clare McMahon '21, and Jacob Asher '21 — met with Newman and took up the challenge of engineering better reaction times for the team's goalies. The team brainstormed ideas. Inspiration



comes in all forms; for the ENAS 118 team, it was a psychology journal that sparked their best idea.

"We read some literature that when people react to a stimulus, our eyes move in concentric circles, so we designed the board with this concept in mind," said Gao, a computer science major.

Taking that as their focus, the team got to work, and soon, they had a prototype ready to present to Newman and the lacrosse team.

"It was really exciting to see how the team quickly got very competitive about it, which is what I think the lacrosse coaches were looking for," Gao said.

The final product is a board with 15 circular lights, each capable of flashing different colors. The user hits lights flashing certain colors as fast as he or she can. The board can be adjusted to create new games that may be a better fit for different players with different goals.

Above: *Mary Clare McMahon, Cece Gao, and Jacob Asher stand in front of the Lightboard, designed to improve better reaction times for the Yale Lacrosse goalies.*

It was soon adopted as a standard tool in practice, not just for lacrosse but also the soccer and hockey teams. Soon, Newman and the coaches had a body of data that gave a full picture of their players' reaction times.

"We're testing our goalies every day, so we know what their baseline is," Newman said.

Now, if a player shows up to practice and there's a significant dip in the Lightboard reaction times, he said, the coaches know there's something wrong.

"Maybe they need more sleep or change in training style," he said. "We have many tools to fix those issues, but we wouldn't have found those problems in the first place if we didn't have the

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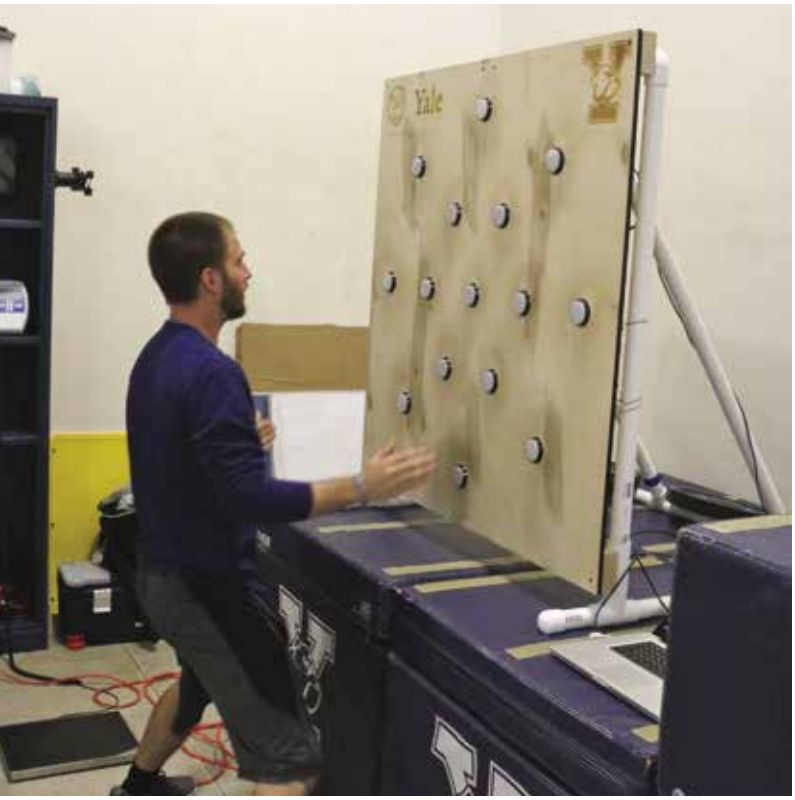

board. So we're able to have complete clarity of what's going on in the nervous systems of our players and relaying it to their coaches."

The information proved particularly critical on game days. If the players' Lightboard scores are low on game day, it's a red flag. There are a lot of factors that go into how well a goalie performs, but Newman said one thing they learned was that a poor performance on the Lightboard almost always means a poor performance on the field that same day.

That attention to detail paid off. In May, the Yale team beat Duke 13-11 to take home the national championship. Despite a heavy workload that semester, Gao said she and her fellow ENAS 118 students got caught up in the excitement.

"When the news came out that Yale won the national championship, I went on all forms of social media," Gao said. "The fact that our device could have an impact on their successful season was really exciting."

"When you talk about what goes into making a champion it's a lot of different components. Did we measure things? Did we improve things? Absolutely."

› Thomas Newman,
Director of Sports Performance
and Innovation

Left: *Anthony Belanger, assistant strength and conditioning coach, and Thomas Newman hold the NCAA Championship Trophy shortly after the team's victory.*

Above: *With its ability to improve reaction times, the Lightboard was adopted as a standard tool in practice — not just for lacrosse, but also for the soccer and hockey teams.*

Newman said he's happy to share credit for the team's success with the CEID.

"I think it's a huge part," he said. "When you talk about what goes into making a champion it's a lot of different components. Did we measure things? Did we improve things? Absolutely."

Andy Shay, coach of the Yale Men's Lacrosse team said he saw a definite "correlation to our goalie play and the pattern of games they were playing on the board."

"I understand that a number of studies need to be done to see a true correlation," he said, "but we did win a National Championship with the help of some stellar goalie play… so I'll take that as a positive."

More important than the Lightboard or any one training device, Newman said, is the overall relationship that the athletics department has developed with SEAS, and other schools on campus. "It's the fact that our athletes know they have a resource that others don't have," he said. "That makes them more confident, and they play better. Whether it's the CEID or strength and conditioning, we all play a role in making the program the best it can be. And now we can say we're the best program in the country."

The CEID folks are also happy about their role in helping the team, but they're even happier about what the Lightboard indicates about the larger culture at Yale.

"For one thing, it's a great recruiting tool," Wilen said. "When students visit, they come with their parents, and this shows them that Yale is very progressive in using technology and building the kinds of collaborations that they don't see at other schools."

Shay said he hopes the partnership will continue for a long time.

"I think the CEID and Yale Athletics would be missing a huge opportunity if we stopped this collaboration," he said. "We have some of the brightest and most innovative minds working to solve real issues in the world of sports. From my perspective, it has been incredibly beneficial."

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A Large-Scale Collaboration

Newman had another question. He wasn't sure if there was an answer but figured that the CEID was the best place to ask it. He wanted a device that could not just record how much weight athletes were pushing and pulling, but a way to record the lifting and pulling processes at multiple points. Wilen and former CEID Design Fellow Max Emerson got to work on a crane scale, a device that measures the force pulling on it — the mechanics are similar to a grocery store produce scale.

Most weight measurement devices, Wilen noted, tell only part of the story. The scale Wilen and Emerson devised quantifies and plots out the forces at work every step along the way of a particular motion. Wilen and Emerson took apart a crane scale that Newman gave them, installed a radio and frequency chip that sends the information to a computer.

"Before, we could say 'Oh, you got up to 200 pounds' — but that doesn't tell you how fast they got there," Wilen said. "It doesn't allow you to figure out how long they can hold it there. All of these things are easily done if you can just read that number as a function of time into a computer. That's the power of this thing — to be able to measure anything they want."

Depending on how they rig up the scale, users can get all sorts of information about what's happening and when.

"Every two seconds, it gives us an impulse reading," Newman said. "So we see peak force, we see average force — it gives us a window, and we're able to track all of that."

For Newman and the other coaches, it answered many long-vexing questions. When two linemen lock up and push each other and nobody is moving, the outside observer might not realize the complexity of forces at work. As Newman notes, though, "there is actually a raging battle of physics underway." The crane scale sheds light on the dynamic changes in the mysterious forces of unmoving objects. "How much does a defensive lineman push?" Newman asks, and shrugs. "We didn't know either. Hook him up on the scale, and now we know."

Not only do they know that now, but they also now know how much weight they need to put on the training sled to simulate the force of a defensive lineman — and that they need to vary that weight depending on the surface of the practice. Before they relied on equations and general strategies — now they've got hard data.

"Now we're not arbitrarily picking a weight," he said. "Understanding those levels gives us an incredible clarity of understanding of what we need to do, how much we need to do it, and then measure the on-field change. That allows us to develop very powerful defensive linemen."

And its usefulness goes well beyond the line of scrimmage. The crane scale is also being used for the sailing team. One particular revelation that emerged was when members of the women's team used the scale. Newman said their ability to fine-tune their control of large pulls became clear once they looked at the results on the scale.

"Even though they aren't moving they must have tremendous, fine-tuned control — that's the very thing that makes them so elite," he said. "When you have scales, you have clarity and you can fine-tune your training. It's one of the most powerful tools we have in the weight room."

As Newman said, sports are full of problems, and he's planning to bring more to ENAS 118 for the next semester.

"The relationship with the Engineering School is going to be so critical to our future success," Newman said. "What everybody's most excited about is the collaboration and innovation — we're able to do things here that many athletic departments can't do. That's because we have some of the smartest minds in the field coming together for one cause, which is to make Yale the best it can be and our players the best they can be, on and off the field."

"How much does a defensive lineman push? We didn't know either. Hook him up on the scale, and now we know."

› Thomas Newman

By modifying a crane scale with a radio and frequency chip that sends data to a computer, Newman and other coaches now have answers to long-vexing questions.