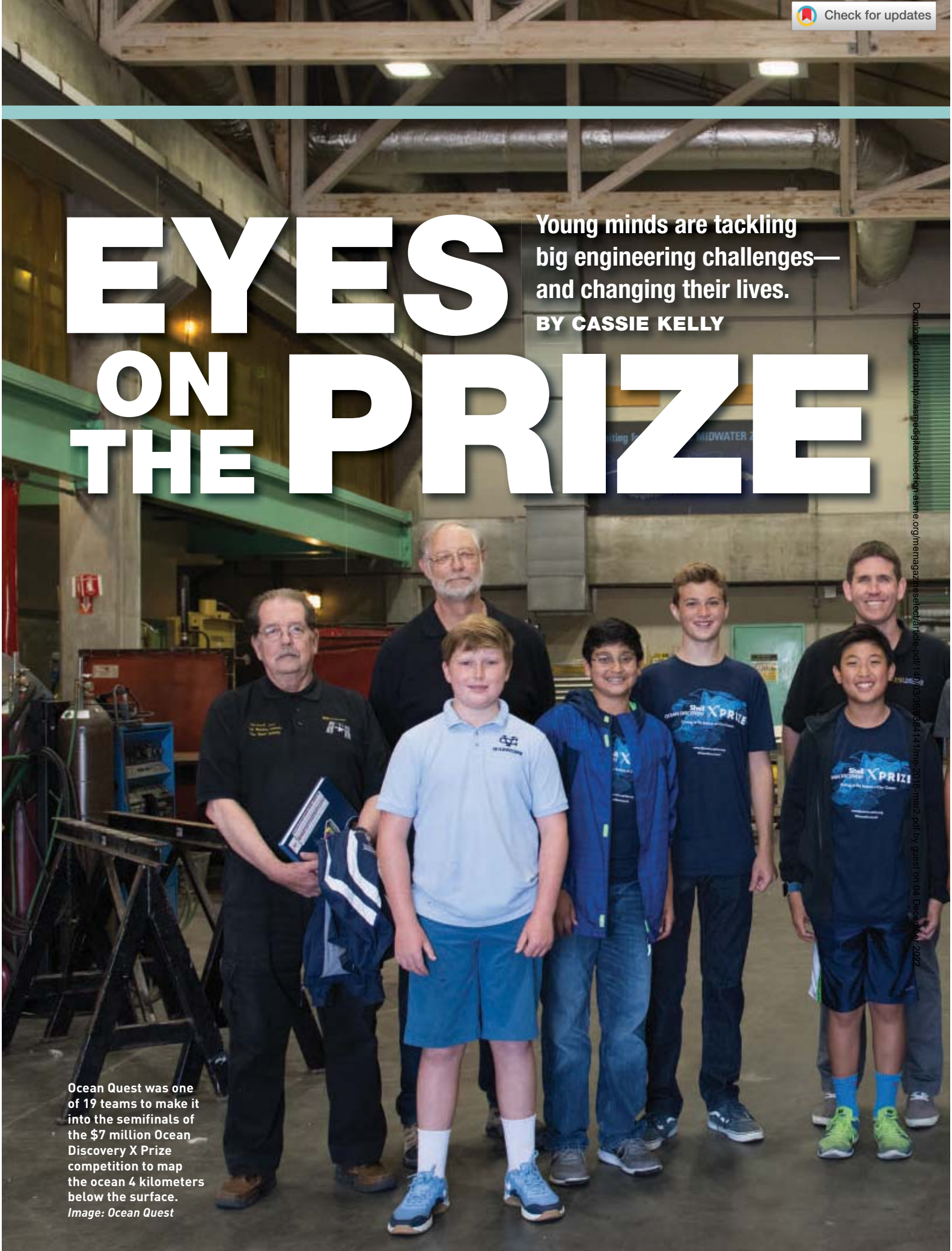
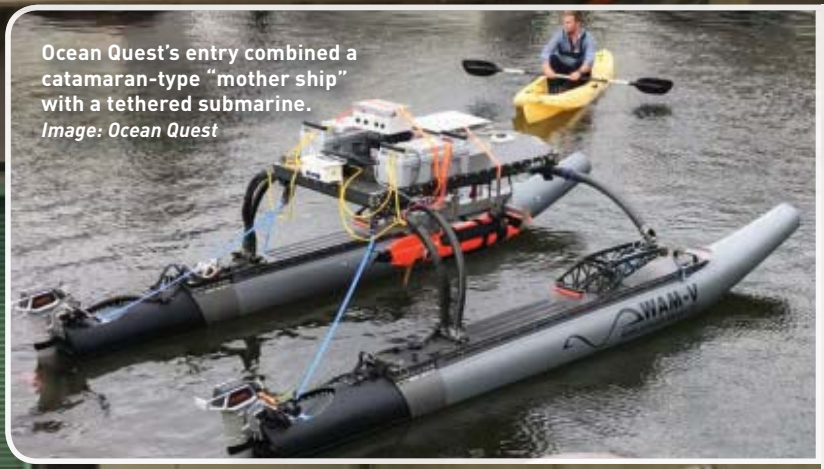
EYES ON THE PRIZE

Young minds are tackling big engineering challenges—and changing their lives.

BY CASSIE KELLY



Ocean Quest was one of 19 teams to make it into the semifinals of the $7 million Ocean Discovery X Prize competition to map the ocean 4 kilometers below the surface.
Image: Ocean Quest



Ocean Quest's entry combined a catamaran-type "mother ship" with a tethered submarine. *Image: Ocean Quest*

Every engineer knows the feeling when all those carefully crafted designs and calculations begin to unravel. The members of the Ocean Quest team felt it just weeks before the deadline for the Ocean Discovery X Prize.

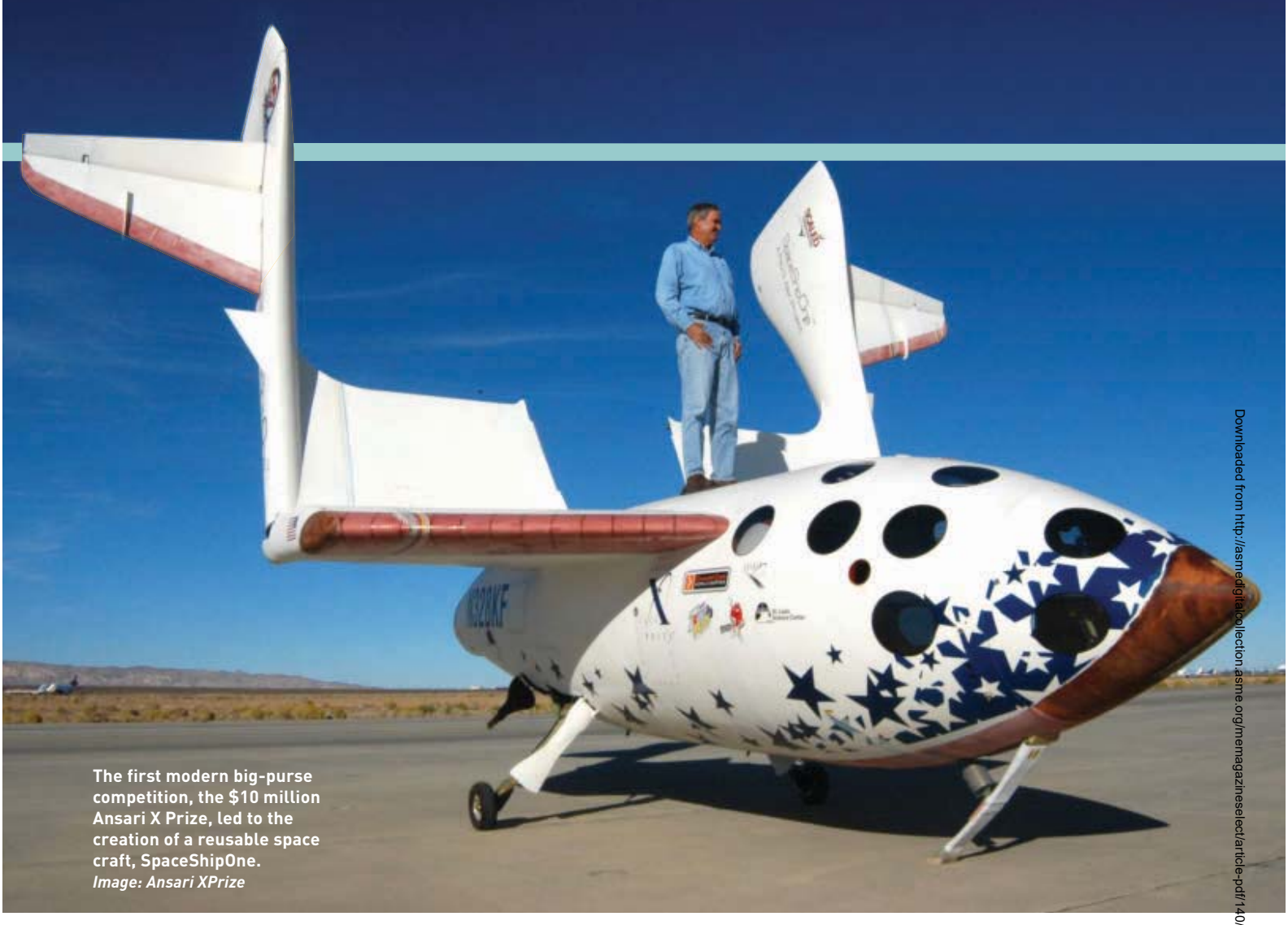
Sponsored by Royal Dutch Shell, the $4 million first prize will go to the best autonomous system for mapping and identifying geological, biological, and archeological objects 4 kilometers under the ocean. The National Oceanic and Atmospheric Administration is adding another $1 million for a system that traces a lingering chemical or biological signal back to its source.

But first, Ocean Quest had to get its proposal past the first round. Judges assess proposals on everything from autonomy, collision avoidance, speed, and durability to data management, image quality, and navigation. Only passing teams get to build prototypes.

Ocean Quest had spent months creating its X Prize proposal. The design was straightforward. It involved a catamaran-like "mother ship" on the surface, tethered by a series of cables to an underwater vehicle that images the seabed with sonar and collects chemical samples.

A few weeks before the due date, the team reviewed its proposal one last time—and discovered the design failed to meet all contest requirements.

"We pretty much had to redo our whole design and draft a new proposal in just a few days," said Ocean Quest member Rohan Viswanathan. "It seemed impossible."



The first modern big-purse competition, the $10 million Ansari X Prize, led to the creation of a reusable space craft, SpaceShipOne.
Image: Ansari XPrize

Rather than admit defeat, the team pulled together to redesign the system. After all, they had already done the heavy lifting—design, calculations, preliminary engineering. Now, it was a day and night sprint to reshape everything to fit the rules.

It worked. Several months later, the X Prize Foundation informed Ocean Quest that it was among the 19 teams to survive the first cut.

"Our advisor sent out a text that said, 'We made it, and now we're in this elite group of people all over the world,' " team member Mihir Kasmalkar said. "We all screamed and cheered and then got back to doing the real work."

They may have carried on longer and louder than other teams. That's because Kasmalkar, Viswanathan, and Ocean Quest's other members were all students at Valley Christian middle and high school in San Jose, Calif.

STRONG INCENTIVES

The young Ocean Quest team was not the typical competitor. The other 18 X Prize Ocean Discovery semifinalists included teams from universities, research institutes, and entrepreneurs seeking to commercialize profitable ocean mapping systems.

All those teams show how competitions and high-stake prizes can energize design challenges by turning them into a race.

They always have. The 1714 Longitude Prize, for example, spurred the invention of the marine chronometer, a precise clock that made celestial navigation possible. A century later, a French prize for food preservation led to the development of canning.

In 1927, the Orteig Prize prompted Charles Lindbergh's non-stop flight from New York to Paris. Fifty years later, the Kremer Prizes sparked aeronautical engineer Paul MacCready to build the human-powered Gossamer Albatross, which flew from England to France.

When the Soviet Union launched Sputnik, the first orbital satellite, it sparked a competitive frenzy of science fairs in the United States. When the USSR collapsed, that sense of urgency diminished, and the events became backwaters for science nerds.

First Robotics and the X Prize made science and engineering cool again. Launched in 1992, First Robotics turned building robots into a team sport. The contest challenged youth to invent robots to fling discs at a goal or balance on a beam. Every team started with a standard set of

parts, but the results were as diverse as the teams that built them.

The Ansari X Prize, the first modern high-stakes competition, generated a frenzy of media coverage. It promised $10 million to the first non-government team to launch a reusable manned spacecraft into space twice within two weeks. The contest, won by Burt Rutan and Scaled Composites' aircraft-launched SpaceShipOne in 2004, drew 26 student teams, startups, and entrepreneurs from around the world.

X Prize Foundation founder Peter Diamandis believed engineers had already solved many of space travel's big problems. He argued that a strong incentive—honor, glory, and $10 million—might be all it took for innovators to close the remaining gaps.

He may have been right. Richard Branson's Virgin Galactic has partnered with Scaled Composites to launch pleasure trips beyond Earth's atmosphere. More importantly, the excitement generated by the competition sparked other companies to look upwards. While some, like Elon Musk's Space X, are building launch rockets and satellites, others are trying to raise funds to mine asteroids and colonize Mars.

DARPA was watching. Its 2004 Grand Challenge offered $1 million to the first driverless car to complete a 150-mile course. No team got further than eight miles. Yet within three years later, six teams completed a 60-mile course through an abandoned military base, merging with traffic, obeying lights and stop signs, and pausing for pedestrians.

Today, high-stake engineering prizes and competitions are everywhere. Recent X Prizes draw scores of competitors to challenges as varied as water abundance, lunar landings, artificial intelligence, and adult learning. Other competitions seek to improve the efficiency of solar and battery-powered electric cars, race autonomous vehicles up Pikes Peak, and develop software apps in hackathons. ASME holds competitions for human-powered vehicles and product makeovers using 3-D design at its E-Fests.

The typical team might look like one of Ocean Quest's semifinal competitors, Duke University's Blue Devil Ocean Engineering team, which includes more than 50 students.

The Blue Devils' mother ship is a heavy lift drone that will drop autonomous robot pods into the ocean, where they will then disperse to map 200 square miles of ocean floor using synthetic aperture sonar.

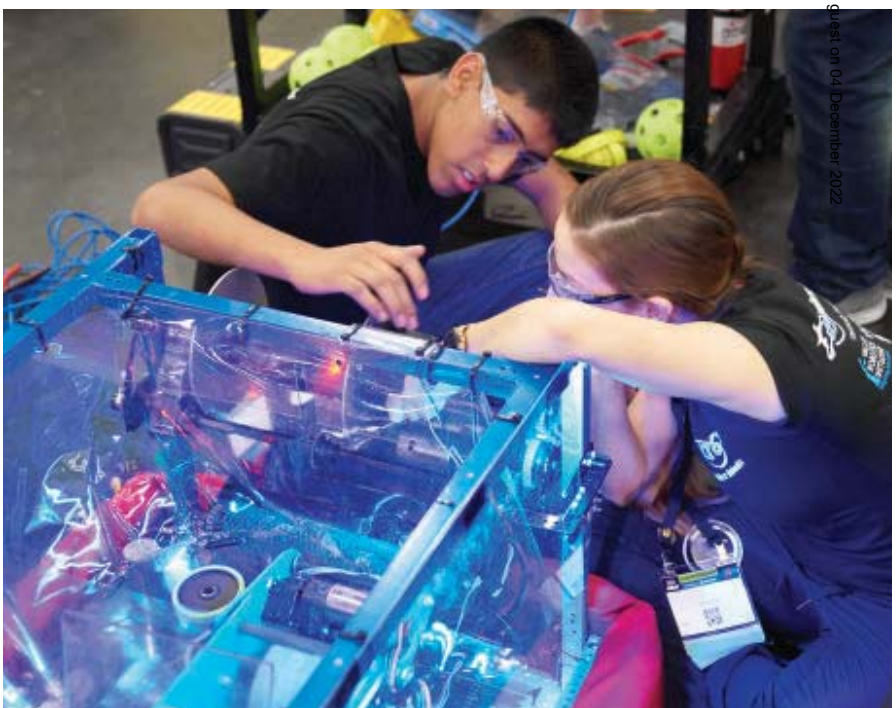
The students, mostly in their early 20s, are still learning the fundamentals of engineering in their undergraduate programs. They are also wrestling with technologies that professional engineers have yet to master and certainly want to win, but they are equally interested in learning through hands-on engineering.

"I knew this project would help strengthen my scientific background," said Hana Ounnoughene, a foreign exchange student from France who worked on the Ocean Discovery project at Duke this past summer.

"As an informatics major, I never studied electronics before. Then I started this project and had to learn how to make a Raspberry Pi operate 2,000 meters underwater. That's just something I never thought I would do, and it may even change my career plans," she said.

FUTURE CAREERS

She is not alone. When top companies announce positions like "machine learning deployment engineer" at Google, "big data engineer" at Apple, and "VR gameplay engineer" at Facebook to choose from, they are recruiting students for jobs that do not fall into neat



First Robotics turned engineering and programming into a team sport. It attracted 75,000 students in 2016. *Photo: First Robotics*

categories. To compete for those positions, students must have deep cross-disciplinary experience.

That's what they get at Ohio State University's EcoCAR Program. For more than 10 years, the school has been involved in Department of Energy's Advanced Vehicle Technology competitions. Since the first EcoCAR NeXt Challenge in 2008, OSU has dominated.

OSU's team goal is to build a hybrid electric Chevrolet Camaro that minimizes environmental impact without sacrificing sports car performance.

"The biggest draw for the program is that a mechanical engineer can work with a computer science major or electrical engineer, which is something that is very difficult to do in a university scenario," said team systems safety manager Simon Trask, who is pursuing a master's degree in mechanical engineering. "It's one of the reasons that we do so well, because we learn to communicate outside of the standard major-specific terms."

Those communications skills were put to the test when Trask's team faced a crisis of its own.

"We noticed a melt failure in the engine just a day before we had to ship the car for its final presentation," he said. "We knew we had to repair it as quickly as possible. But there was no panic, no giving up. It was like we hit crunch time and suddenly everything we had been training for kicked in. We finished it in just three hours. Ordinarily, a problem like that would have taken over a week to fix."

Such hurdles come standard with high-pressure competitions. Students compete not just against other teams but also against the clock. The best entry is not always the best design, but perhaps the most reliable, the most affordable, or the one they can complete by deadline.

This can produce an unsettling amount of stress. That is why X Prize Foundation's vice president of prize development, Chris Frangione, tries to balance audacity with feasibility. He wants competitors to stretch to reach their goals without growing so discouraged that they quit altogether.

"It's all about making sure there are as many teams as possible reaching these goals, so that we can more quickly and efficiently change the world," Frangione said. "To do that, we must consider the right amount of time, incentive, and level of support we give. Otherwise, the teams won't have the motivation to compete or the tools they need to succeed."

UNDER PRESSURE

At Ocean Quest, the students have found ways to cope with stress. "We pray together and do our work," 10th grader Micah Kim said. "We keep looking toward what can we do to make our model better and we don't let the doubts take over."

OSU's EcoCAR team members put their faith in each other. "We sit in a room together all day long, so we have to love each other or it's going to be one heck of a year," Trask said. "Half the time, it's so stressful, but that's why I got involved. We come

ASME fully embraces global student engineering competitions. These include contests for human-powered vehicles (right), product redesign using 3-D printing, predictive simulations, and hardware-led social innovations. Many are held at its E-Fest student engineering celebrations held around the world. *Photo: ASME*

in on weekends and late at night. It's when we're using our off time that I think it's the most fun."

Without their rock-solid work ethic and team mentality, the students probably wouldn't even get the car running, added OSU's EcoCAR advisor Shawn Midlam-Mohler.

"The students are in the program because they have a true passion for it," he said. "When professors are in the classroom giving homework or exams, students don't really respond. But with EcoCAR, we must tell them to go home or put in less time. No lecture can beat the real-world experience these students are getting."

This is because hands-on, competitive engineering lets students do what they came to school to do: innovate and build. In surveys and on internet chatrooms, students complain about the drudgery of learning engineering fundamentals. They learn the same concepts in a competition, but applying them to real challenges makes all the difference.

Schools have noticed. More and more universities are encouraging competitions and integrating them with course curricula.

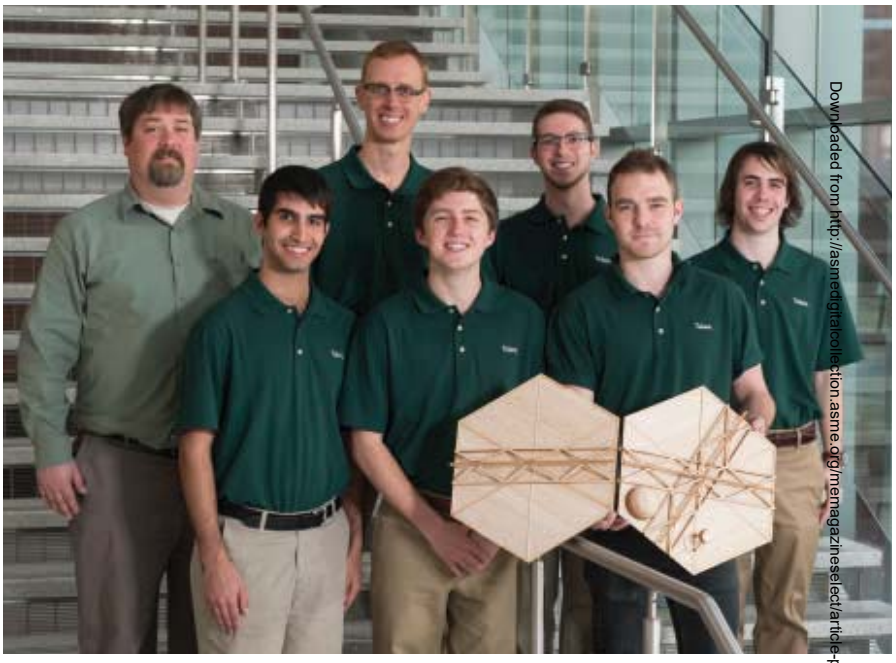
"What students learn in courses at Carnegie Mellon University helps students effectively compete in these competitions, and the competitions help our students better understand and apply what we are teaching them in our program," the school's dean of engineering, James Garrett, Jr., said.

His students placed first in the DARPA 2016 Cyber Grand Challenge for AI software that protects itself from hackers and viruses. In June 2017, students from Massachusetts Institute of Technology won the U.S. Department of Energy's Cleantech University Prize for a new way to reduce power plant water consumption.

Many competitions have gone international, including Intel's giant International Science and Engineering Fair and events held by ASME and other professional societies. Greenpower is cloning its popular U.K. solar-powered vehicle race in the United States.

These competitions are also reshaping what students know when they graduate school. In many cases, it prepares them for future careers that blend engineering prowess with digital savvy.

Industry leaders have taken notice. EcoCAR participants have careers lined up before they even have a chance to contemplate what to do with their futures.



NASA Big Idea Challenge winners from Tulane University, shown holding a model of a winning design for a self-assembled solar-electric space tug that can deliver payloads from low earth orbit to the lunar surface.
Photo: NASA/Harlen Capen

"General Motors is a huge recruiter of our students," Midlam-Mohler said. "In recent years, since participating in the competition, we've seen growing interest from Ford, Chrysler, and Honda. Our students often get multiple offers, and they can choose whoever they want."

At Duke, Blue Devil advisor and associate professor of electrical engineering Martin Brooke sees the same thing: "Our students are going all over the place after graduation."

Through competitions, students are fusing together disciplines to navigate a faster and more interconnected future. They are learning to rise to technical challenges, and discovering how to turn people with different skills into an effective team.

They have helped commercialize manned spaceflight, launch the autonomous car revolution, design fuel-miser sports cars, and plumb the ocean depths. They are developing new combinations of skills, and laying the foundations for new technologies and startups.

And those competitions are making engineering cool again for teens like the students on Valley Christian's Ocean Quest team. ME

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