



Fredri Lajvardi in his lab at Carl Hayden High School in Phoenix, Arizona.

Grit and Innovation

The unlikely story of how four high school students won a national engineering competition | Joshua Davis

The following is an excerpt from the book "Spare Parts: Four Undocumented Teenagers, One Ugly Robot, and the Battle for the American Dream." In this excerpt, teacher Fredri Lajvardi and his team of students are beginning to research and problem solve how to design a robot to compete in a national underwater robotics competition.

The teachers out their plan at the next team meeting. This would be everyone's first year competing in an underwater-robotics event. They were at a real disadvantage, but they had a choice of whom they could lose to.

"Would you rather get beat by a bunch of high schoolers or by MIT?" Fredri asked

"Who's MIT?" Oscar said. None of the students had heard of the university.

"It's the best engineering school in the country," Allan said. "Maybe even the world."

"It's basically a school filled with

Cristians," Fredri said.

"So it's like a school for dorks?" Lorenzo quipped.

"Shut up," Cristian snapped.

Luis watched in bemused silence, a slight grin on his face.

"You want us to go up against the best school in the country?" Oscar asked, still trying to get his mind around the idea.

"We want you to have a good time and learn a lot," Fredri said. "And if you're in the mix with MIT, you'll probably learn more than you would from lesser teams."

"I'm not going to enter something to lose," Oscar said. After his years

as a standout ROTC cadet had failed to lead to a career in the military, he didn't want to waste his time again.

"Then let's work hard and build a great robot," Allan said.

"What are our chances of doing well?" Oscar asked.

"We can aim to not finish last," Fredri said, trying to be realistic. "That'll be a good goal."

Lorenzo giggled. "That can be like our motto: 'Don't finish last.'"

The idea of finishing last didn't sit well with Oscar. At the team's first design meeting in November 2003, he took charge: "We're gonna kick butt, okay?"

Lorenzo laughed until Oscar's stare shut him up. Oscar started going over the description of the contest. The Marine Advanced Technology Education Center's (MATE) official introduction to the Explorer class mission began with a quotation from Gen. George S. Patton: "Accept the challenges so that you may feel the exhilaration of victory."

Oscar liked that. He was ready, even if the others weren't, and he was determined to drag them along with him.

The third paragraph of the mission statement also made an impact: "This is an exploration mission. Exploration means discovery of the new and the unexpected. This competition will push your imagination and technical skills. Enter the event with the spirit of the men and women explorers who have set out into the unknown." The event organizers may not have been thinking about four boys from a ghetto high school, but the words resonated.

One of the first tasks was figuring

out how they were going to pay for it all. MATE would cover meals and housing in Santa Barbara and provided one hundred dollars for building supplies. That was about enough to cover the cost of driving to California. They were going to need a lot more than that, so Fredi printed up brochures that explained that anybody who donated to the club would get a dollar-for-dollar Arizona state tax deduction. Lorenzo didn't really understand what he was talking about. All he heard was that Fredi wanted him to ask people for money.

"I don't know anybody with money," Lorenzo said.

"Ask your family," Fredi said.

Lorenzo laughed. "They don't got nothing."

Still, Lorenzo took some brochures and asked an older cousin to donate. She had a job cleaning motel rooms and might have some spare cash. "I'm going to be competing

in an underwater robotics competition," he told her.

Lorenzo was known as a jokester in his family, and this was probably one of the weirdest requests the family had ever heard. The cousin refused to donate.

Cristian didn't have any better luck. His parents couldn't spare any money, so he phoned uncles and aunts in California and southern



Hear from Nationally Renowned STEM Teacher Fredi Lajvardi at the 2017 State Education Convention

FREDI LAJVARDI is a nationally recognized STEM educator and subject of the critically acclaimed documentary, "Underwater Dreams," and major motion picture, "Spare Parts."

For more than two decades, as a high school science teacher, Lajvardi has engaged, motivated and challenged students by making science fun and introducing them to the field of robotics. Lajvardi drew national attention in 2004, when he entered a high school team in a university-level national underwater robotics competition, where they not only proved their skills and ability to compete at that level, but they placed first, defeating leading universities, including MIT.

First covered by Wired magazine, their inspiring story drew attention from local and national media outlets and led to the acclaimed documentary, "Underwater Dreams." Their story was also adapted into the major motion picture, "Spare Parts," starring actor and comedian, George Lopez as Lajvardi.

Honored with numerous awards, including the IEEE National Outstanding Educator for 2005, the Arizona Department of Education Leadership Award for 2006, and the City of Phoenix Outstanding Teacher of the Year each year from 2005 to 2009, Lajvardi has and continues to be a significant contributor to the increasing interest and awareness of STEM education nationwide. With an effective leadership philosophy, incredible story and a spirited passion for teaching, Lajvardi offers valuable and inspiring insight on fostering teamwork, sparking creativity and helping individuals realize and maximize their potential.

Fredi Lajvardi will be giving the keynote address on Friday, Jan. 20 at the State Education Convention.



(Left to right) Oscar Vazquez, Luis Aranda, Lorenzo Santillan, Allan Cameron, Cristian Arcega and Fredi Lajvardi with their underwater robot.

Arizona. They said they'd think about it and never sent anything in.

Surprisingly, Luis made some early progress. One day, after work at Doc's, he approached his boss, Harold, and handed him a robotics brochure. Harold was astonished to learn that his giant, taciturn short-order cook was involved in a NASA-sponsored underwater-robotics contest. "I didn't see that coming," he said and wrote out a check for a hundred dollars.

Oscar tried a similar approach: he stopped by Quality Bedding, the mattress factory that his father worked at. Oscar had spent his summers assembling box frames

alongside his dad, so he knew the owner, Iris Oroz, and many of the employees. He handed a brochure to Oroz and explained that West Phoenix was going up against the best of the best. They needed local support if they were going to have a shot. His pitch resonated: Oroz wrote a check for four hundred dollars, and an employee chipped in another four hundred.

That gave them a budget of about nine hundred dollars. It wasn't much, but to four teens from West Phoenix it seemed like an extravagant amount of money to spend on a robot. Now that they had some funding, they began talking about

building the robot. The team started by breaking apart a small trebuchet they'd made during the pumpkin-hurling contest. They wanted to figure out how big their remotely operated vehicle (ROV) needed to be to accommodate propellers, sensors, and controls. They used the two-by-one lumber to make a simple box structure. Once it was done, they stood around the awkward wooden model in the robotics closet and talked through the tasks they were going to have to complete. The first: measure the depth and length of the mocked-up submarine.

Lorenzo pictured the submarine underwater and thought of the simplest possible approach: a length of string. If their ROV could stretch the string from one end to the other, they could measure it. Similarly, they could lower the string from the surface until it touched the bottom of the pool and get a depth reading that way. He proposed the idea to the group.

"And what if it doesn't reach the bottom?" Cristian pointed out. It seemed like a stupid idea.

Lorenzo thought about it for a second. "Yeah, that's a flaw."

The group continued brainstorming, but Lorenzo kept thinking about string. After a minute, he came up with a new approach: "Hey, what if we hung a string down from a floating thing. We could draw markings on it every foot and use a camera to see how far down it went."

This time, it took Cristian a minute to shoot the idea down: "The string could get caught in the propellers. And we're penalized if we leave anything behind in the pool, so we'd waste time trying to retrieve it."

Lorenzo looked disappointed. He thought he was on to something.

"But it wasn't a terrible idea," Cristian allowed.

Lorenzo brightened. "What about just using a tape measure? We can tie a loop onto the end, hook it on to the submarine, and drive the robot backward. The tape will just roll out."

"How do we read it?" Oscar asked. "Aim a camera at it," Lorenzo

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said. "We can read it off the video monitor."

"That could work," Oscar said.

Lorenzo flushed with pride. He rarely got compliments for his ideas. He was used to standing behind his godfather and brother, watching them come up with all the cool ideas while they worked on cars. He was expected to silently observe. Now he had a chance to contribute and it felt good.

"It won't work for depth though," Cristian pointed out. "There's nothing at the bottom of the pool to hook on to."

They decided that they'd need two solutions. Lorenzo's tape measure would work for the sub's length, but they'd need something else to gauge depth. They talked about using a scuba-diving computer — they might be able to borrow one from the dive shop — but its margin of error was too big for the precision measurements they were required to make.

"What about a laser tape

measure?" Oscar asked. He had worked with his brother on a construction site and seen people using devices that could pinpoint a distance just by aiming a laser beam at an object.

"Will it work underwater?" Cristian asked.

Oscar didn't know. He'd never used one himself.

"You guys should call somebody," Fredi advised. "The best way to figure something out is to call an expert."

Lorenzo was pretty sure nobody would help them, and Luis was obviously not going to make any calls. Cristian felt he could figure it out on his own given time. It wasn't a great attitude to have when asking for help, so Oscar decided to make the calls.

He started by googling laser tape measures and quickly came across a company called Distagage in Marathon, Florida. The company specialized in lasers that could read distance

as far as 330 feet with an accuracy of an eighth of an inch. Some units could even measure the slope and length of a roof from the ground. The site noted that their top-of-the-line device was "used by more construction professionals around the world than any other brand."

"Sounds expensive," Lorenzo said.

He was right. Models sold for \$375 to \$725 each. It seemed pointless to even consider them, but Fredi encouraged Oscar to call anyway. "Just ask for advice," Fredi said.

Greg De Tray answered Oscar's call in a mold-infested condo in Miami, Florida. He had only recently formed Distagage and still worked as an insurance adjuster. He had been sent to New York after 9/11, set up shop in Texas after hailstorms pelted the state, and was now in Florida helping Allstate deal with a massive outbreak of residential mold claims. He specialized in catastrophes.

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“Distagage,” he said, pulling his mask down. “How can I help you?”

De Tray had never intended to get into the laser range finder business. Initially, he had just bought one for himself because the mold-filled rooms he inspected were often nauseating and gave him headaches. The last thing he wanted to do was clamber over damp furniture with a tape measure. A laser range finder was an ideal solution: he didn’t have to move around much, and it allowed him to take fast measurements.

His wife and mother-in-law were also in the catastrophe adjustment business, so he decided to buy them range finders as well. But, when he called Leica, the device’s Swiss manufacturer, the representative told him that they no longer sold to individuals, only large distributors.

“I’m six feet tall and one hundred and eighty pounds,” De Tray said. “How big do I need to be?”

The sales rep laughed and told De Tray that he’d need to buy at least fifty. It was far beyond what most individuals wanted. But the salesman underestimated De Tray, who bristled at rules and noncreative thinking. De Tray spontaneously

wrote a check for about ten thousand dollars and bought himself fifty devices. Now, when he rolled from disaster to disaster, he pulled a six-foot-by-twelve-foot cargo trailer loaded with laser range finders and sold them to whoever wanted an extremely precise Swiss-made measuring device.

But he’d never gotten a call from a high schooler. Oscar explained that he was part of the Carl Hayden robotics team in Phoenix, Arizona. They were building an ROV to compete at a competition sponsored by NASA and needed to measure depth underwater. “We were thinking about buying a laser tape measure from Home Depot,” Oscar said.

“Those are pieces of crap,” De Tray said. He didn’t feel that they were really laser range finders. They had a laser, but it was only to show where the thing was pointed. The actual range finding was done acoustically and often provided faulty readings. Those so-called laser range finders gave the whole industry a bad name. “So definitely don’t get one of those.”

“Do your range finders work underwater?” Oscar asked.

“That’s a good question.” De Tray was intrigued by this mature-sounding kid from the desert. De Tray thought of himself as somebody willing to take risks (just look at all the range finders he was carting around). Clearly, these kids were also taking chances as well. They seemed similarly ready to try something new, despite what others might think, so he offered to do a test.

That afternoon, he stopped by a Wal-Mart, bought a clear-plastic Tupperware container, and headed for the pool at his Pompano Beach duplex. He put a range finder in the Tupperware, submerged it in the water, and took some readings. It didn’t work: the device gave a reading that was clearly wrong. He did it a few times but kept getting the same wrong answer.

At their next team meeting, Oscar called De Tray back and put him on speakerphone. “Sorry to say it, but it doesn’t work,” De Tray said. “It’s giving the wrong answer, but at least it’s giving the same wrong answer every time. It’s always about 30 percent off.”

“The index of refraction!” Cristian blurted.

Everybody turned to look at him. “What was that?” Lorenzo asked.

“The laser light is traveling through a medium that has a different density than air,” Cristian said. He got a blank stare from Lorenzo, who thought Cristian sometimes spoke a different language.

“I get it,” Oscar said. “Water is harder to move through than air.”

“It moves slower,” Cristian said.

“So if we take 30 percent off the readings, it’ll give us the right measurement,” Oscar said.

“Exactly,” Cristian said.

They may have solved the refraction problem, but De Tray’s devices still cost hundreds of dollars. But he was impressed. These kids had solved a problem he couldn’t solve, and he was supposed to be the expert. He could sense their excitement, and he was excited for them.



He decided to help: “I tell you what. You guys want to use my range finder on your robot, I’ll send you one. You can borrow it.”

Lorenzo was speechless. Nobody had ever given him anything of significant value before. Nor had he thought that random strangers would be interested in helping him. Oscar also felt a surge of gratitude. He had a fundamental faith in humanity, though it had been put to the test when the Army turned him down. This was a sign that things were looking up.

“Thank you, sir,” Oscar managed to say, trying to keep his emotions in check. “We really appreciate it.” ■

Excerpts from parts “One” and “Two” from SPARE PARTS: FOUR UNDOCUMENTED TEENAGERS, ONE UGLY ROBOT, AND THE BATTLE FOR THE AMERICAN DREAM by Joshua Davis. © Copyright 2014 by Joshua Davis. Reprinted by permission of Farrar, Straus and Giroux, LLC.

Underwater Robotic Competition Set for Spring

SeaPerch, an innovative robotics program that teaches students to build an underwater remotely operated vehicle (ROV), will be holding a regional competition for high school teams on Friday, March 3 at Kickapoo High School in Viola, Wisconsin. The winning team at this regional competition will qualify for the national SeaPerch competition in May (date and location TBD).

Students build the ROV from a kit comprised of low cost, easily accessible parts, following a curriculum that teaches science, technology, engineering and mathematics (STEM) with a marine engineering theme. Throughout the project, students learn engineering concepts, problem solving, and teamwork design skills and are exposed to all the exciting careers that are possible in naval architecture and marine/ocean engineering.

After the robot is constructed, students test their vehicles, deploy them on missions and compete in



their local regional competition. SeaPerch Challenges (competitions) include maneuvering the ROV through an obstacle course and recovering an object. Teams also present a poster and present their project to judges.

There will also be a middle school regional SeaPerch competition to be held in the Green Bay area (date TBD spring 2017). □

For more information, contact Herb Thomas USN (Ret.), vice president of the Madison Navy League, at cme2by@mwt.net or visit www.seaperch.org.

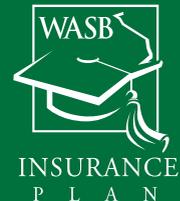


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