The Falcon Robotics team in 2010.

JOSHUA DAVIS

ROBOTICS

Bottom-up innovation

Noel Sharkey ponders a riveting story of how social inequity can trump youth and scientific brilliance.

Joshua Davis's *Spare Parts* is in part a feel-good story of education in action. It tells how four ingenious, but educationally and financially deprived, teenagers were drawn into competitive robotics by exceptional teachers. Pacy and inspirational, it is also a disillusioning tale of how achievement can falter in the face of socio-economic inequities.

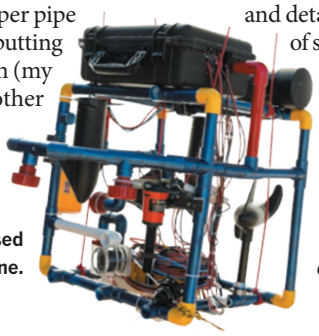
The story began in 2004. Cristian Arcega, Lorenzo Santillan, Luis Aranda and Oscar Vazquez were Mexican-born students at Carl Hayden Community High School, at the rough end of Phoenix, Arizona. None had ever seen the sea and not all were viewed as technologically gifted, but science teachers Allan Cameron and Fredi Lajvardi encouraged them to build a robotic submarine. The aim: enter the prestigious, NASA-sponsored Marine Advanced Technology Education Robotics Competition. With a budget of US$1,000, the team, calling itself Falcon Robotics, set out to compete against the corporate-funded likes of the Massachusetts Institute of Technology in Cambridge.

The four, Davis shows, became a case study in how creativity and imagination can triumph over riches and education. Their infectious enthusiasm got them cheap and free equipment. Stinky, their entry, looked more like plumbing than a robot. Its metre-tall rectangular frame was made from PVC pipes glued together; these provided housing for propellers, sensors, pumps and cameras. Their competitors had well-engineered craft built with aluminium hulls or sophisticated materials.

Spare Parts: Four Undocumented Teenagers, One Ugly Robot, and the Battle for the American Dream
JOSHUA DAVIS
Farrar, Straus & Giroux: 2014.

The teams were given a seven-part task centring on a mock-up of a German U-boat. Challenges ranged from measuring the boat's length and navigating inside to recovering 'lost' equipment. The Falcons had had limited time to test Stinky in a diving pool. So they improvised. To calculate depth, they adapted a laser range-finder; to determine length, they hooked a tape measure to the U-boat. A camera on Stinky's underside was used to find objects, and a makeshift robot arm picked them up. The hardest task involved sucking oil out of a barrel and bringing it to the surface. Santillan managed it by gluing a copper pipe to a US$35 suction pump and putting it inside a balloon. This solution (my favourite) worked — and no other team succeeded.

At the competition in California, the four were stunned by the other robots. Their hearts sank on hearing that they had won a special award. But NASA judge Lisa Spence loved Stinky's elegant simplicity, and they were pronounced overall winners. At that point in *Spare Parts*, they run down the beach, yelling at the tops of their voices. But this American dream slid into nightmare. Only Aranda was a legal resident. The other three were illegal immigrants, who had come over the border as children. They had no university funding and scant job prospects.



'Stinky', the improvised robotic submarine.

50 EGGS FILMS/*UNDERWATER DREAMS*

Davis's entry into the story provides some relief. A journalist, he saw a badly written press release about the team that haunted him. Finally he wrote a *Wired* magazine feature that caught public attention. A college fund was collected. Arcega, one of the brightest students in the school district, and team leader Vazquez went to Arizona State University. Santillan and Aranda trained in catering.

But as Davis eloquently reveals, undocumented Mexican Americans have a harrowing time. In Arizona, civilian 'immigration posses' recruited by a local sheriff hunt Latino areas for people committing small offences, and neocon senators push for stricter laws. In 2006, Republican senator Dean Martin pushed through Proposition 300, which stopped state universities offering reduced fees to undocumented residents. This tripled fees for the two at university. Arcega was forced to drop out. Only Vazquez managed to gather enough funding. He married, had a baby, graduated with the highest honours and was commended in front of President Barack Obama and a 70,000-strong audience.

He then returned to Mexico to apply for a US visa. Separated from his wife and child, he picked beans for less than $4 a day. His application and appeal were refused, and he was banned from entering the United States for ten years. After a flood of public and media support, he was finally granted permanent residency. He is now an engineer. Santillan is a sous chef. The brilliant Arcega lives at home, inventing in his makeshift lab. Aranda works nights, emptying dustbins.

This is perhaps the most gripping popular-science book I have read. Unsurprisingly, the story has been picked up by filmmakers: Sean McNamara's *Spare Parts* will be out in 2015; Mary Mazzio's acclaimed documentary *Underwater Dreams* (go.nature.com/rivauv) was released in July. The narrative drives itself, but it took Davis's considerable skill and detailed research to pull off a tale of scientific yearning thwarted by political and social impediments with such pathos. ■

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