by Jennifer Mason

THE LIMBER INVENTOR

Limits? Not for this young roboticist.

The arm on display dazzles viewers. It consists of 3D-printed plastic pieces with windshield-wiper motors to power its joints and knuckles. Brainwaves from an EEG (electroencephalography) headset control its movement. The user imagines giving a thumbs-up, and the limb obeys, curling the fingers into a fist while sprouting the thumb upwards.

Wave, pitch a ball, grab and hold—the robotic arm proves very capable.

THE GRAND PRIZE

Surprisingly, the arm was not forged in a glimmering laboratory by teams of brilliant scientists with millions of dollars to spend. Sixteen-year-old Easton LaChappelle designed, built, and programmed the invention, now on display at the 2012 Colorado State Science Fair.

"I actually did this in my bedroom," he grins.

The robotic arm won first and third place in different categories. But Easton is too preoccupied at the moment to worry about prizes, medals, and satin ribbons. He is focused on the 7-year-old girl admiring his invention.

At first, he wonders why she is so deeply fascinated, but then he sees she has a prosthetic arm. Compared to his robotic arm, her prosthetic is really more of a hook or claw.

A prosthetic replaces any part of the body that is missing. Humankind has been making prosthetics for a long time. One of the oldest known prosthetic limbs is a 3,000-year-old wooden big toe strapped to a mummy's foot.

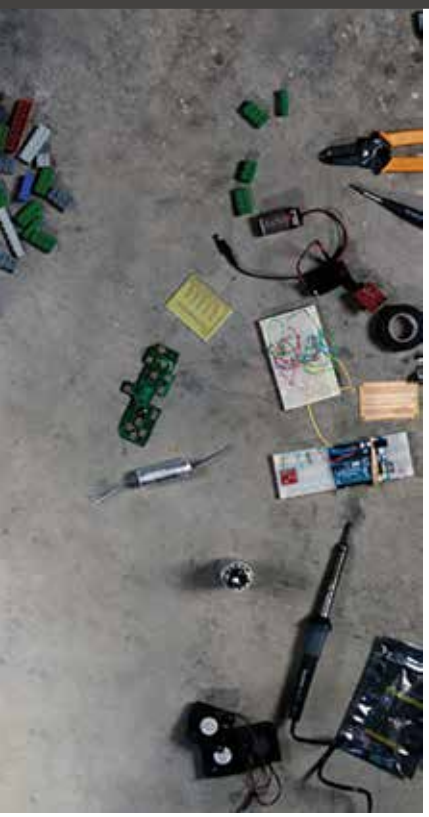
Prosthetics can mimic a missing body part or completely change and improve what they replace. For example, some Paralympians sprint on "blade feet." These lightweight, carbon fiber legs look like bent skis that strap around the thigh and knee joint. Today, the wildest prosthetics in development include mermaid tails, tentacle arms, and bionic eyeballs that actually see.

The World Health Organization (WHO) estimates 15 percent of the world's population lives with a disability. That's about 1 billion people, which includes roughly 100 million children. Diseases like cerebral palsy or spina bifida damage the brain or spinal cord, which impairs the movement and development of muscles and bones. Some people are born with all or part of a limb missing, called a congenital difference. Other conditions, like cancer or diabetes, can do so much damage to tissues and bones that surgeons have to amputate, or remove, ruined limbs. And severe injuries to the spinal cord can lead to temporary or permanent paralysis. People in all of these circumstances may benefit from prosthetics.

Back at the science fair, Easton gulps when the young girl's parents inform him that her prosthetic arm cost $80,000. He spent around $400 to build the robotic arm. Even more disturbing: her prosthetic arm is only temporary. She will be fitted with other, larger arms as she matures. In general, children may need a new prosthetic every year or two as they grow, whereas adults have to replace theirs after an average of three years of wear and tear.

Aha! Easton thinks. *If I can build a better, cheaper prosthetic, then I can help many others around the world.*

Before he can get to work though, the robotic arm wins big awards at other national and international science fairs. A media tsunami engulfs the young inventor. Easton is invited to give a TED Talk as well as other talks around the world. *Popular Science* magazine features Easton and his RoboArm. At the White House, President Barack Obama shakes hands with the robotic arm! When scientists at NASA see that article, they give Easton a call.



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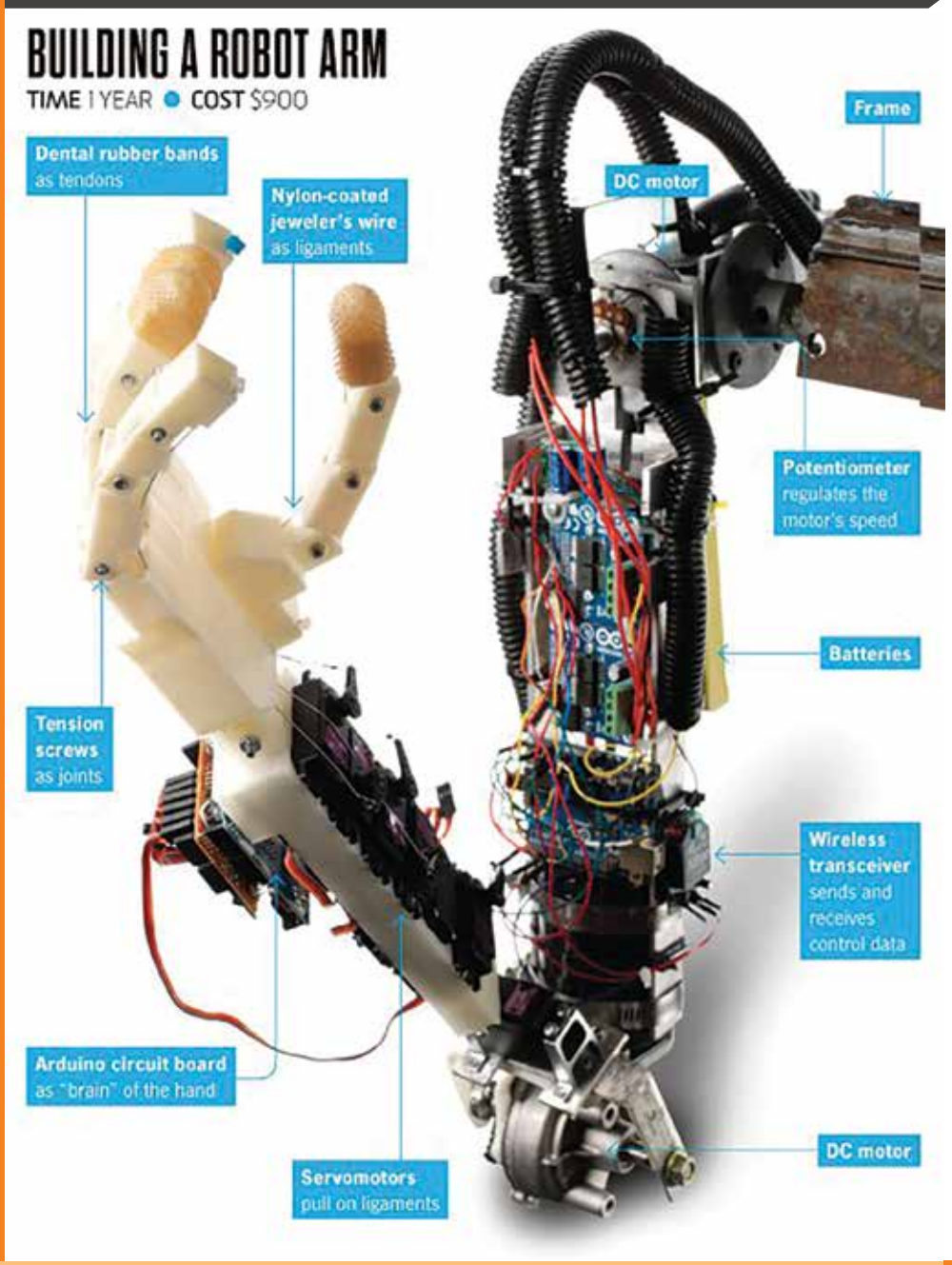

Would he like to come spend a summer working in their Robonaut program, which aims to build a robotic astronaut capable of performing dangerous tasks in outer space?

BORING INTO SCIENCE

Easton became an inventor because of a simple problem that many young people have: he got bored. He couldn't really help it, growing up in Mancos, Colorado—a tiny town miles away from other tiny towns. Surrounded by jagged, snowcapped peaks, Mancos and its grassy pastures resemble a hunk of chewed salad stuck between giant teeth.

"I definitely mountain biked and skied quite a bit . . . but for me, I discovered this passion [for creating things] at a very early age," Easton says.

He loved watching documentaries about the world's greatest inventors—especially Nikola Tesla. Following in their footsteps, Easton took apart and reassembled household appliances, but he yearned to make his own gadget. He wanted a challenge that combined his passions for mechanisms, electronics, and software code. It had to be interactive . . . something easy to build and easy to improve . . . something hands-on. . . . Hands. Bingo! He would make a robotic hand. When he was 14, Easton crafted a robotic hand with Legos, fishing line, model airplane motors, and electrical tubing for the fingers.

"It was about a nine-month process," Easton recalls. "There was a lot of trial and error."

To operate the robotic hand, he wore a glove covered in flex sensors that he sewed in place. The sensors measured

"A lot of people think of inventing as something very technical, but I think inventing and creativity go hand in hand. Turning any kind of idea into reality is inventing."

the amount of flex in each finger and transmitted this information to the software he programmed. As a result, the robotic hand imitated the gloved hand.

The creation was a homemade marvel, and yet, Easton wondered how he might improve the arm's design and function. For instance, could he use a 3D printer to make it more lifelike? Could he control it with his mind?

NO LIMITS, MANY QUESTIONS

During thoughts, sensations, and movements, nearly 100 billion neurons in the brain crackle, tick, pop, and buzz with chemicals and electricity.

Tatta-taktaktak, like scratchy radio static.

Pitta-pip-pip, like popcorn.

Researchers amplify and record this cacophony while a person is performing a specific action or thinking a certain thought. They feed the sounds into a computer. Mathematical algorithms sift through the noise in search of a pattern. This pattern can then be matched to the corresponding thought or action and translated into commands for a robotic limb.

To apply this technology to the 3D-printed robotic arm, Easton tore apart Mindflex, a toy with an EEG headset that enabled users to move a foam ball with their thoughts. He then built and programmed his own model.

But, how did he learn to write computer programming code? How did he master electronic circuitry? Mechanical design and engineering? Using flex sensors? Fabricating his own PCB boards? Designing a custom servo shield? Or heck, how did he work out the XBee modules needed for wireless communication?

"I turned to the internet," he confesses. Tutorials on YouTube, SparkFun, and Instructables paved the way.

Ultimately, he never allowed the limits of his location, resources, or knowledge to hinder his quest. "I think a lot of what we consider limits are fake," Easton says. "They are more of a mental block or a story we tell ourselves . . . like when you say you can't do something. What you do when you encounter a limit really shows what you can do."

Easton also adopted another tactic typical of inventors: he asked lots of questions. He emailed experts and Skyped with scientists.

"It's so surprising how many people want to help other people," he points out.

The determination and curiosity pay off. Despite being the youngest person in NASA's Robonaut program, Easton thrives at the summer internship. So much so that he decides to skip college. He wants to revolutionize the prosthetic industry and help individuals attain better

mobility without spending, well, an arm and a leg on their assistive arms or legs.

An advanced prosthetic arm can cost more than $100,000. At age 18, Easton launches his very own company, Unlimited Tomorrow. He will produce robotic prosthetics that work without surgery, and he will make them affordable—less than $1,000.

REACHING OUT

Momo Sutton can form a heart by gently pressing the tips of her fingers and thumbs together. If she pinches each index finger to a thumb, she can make two ring shapes. These she puts over her eyes, pretending to wear glasses.

Fist bumps, high-fives—the list goes on.

Despite being 10 years old, Momo has never been able to do any of these things with *both* hands. Born with a congenital difference, her right arm ends just below the elbow. Nevertheless, she learned how to tie her shoes and even swim in races with the residual limb. She used a basic hook-and-pulley prosthetic for other tasks like riding her bike. By twitching or shrugging her shoulders, Momo can pull or slacken the cables which enable the hook to open wide or pinch tight.

In June 2017, Easton changes Momo's life when he presents her with her very own robotic prosthetic device. It is the first, fully functioning model to come from Unlimited Tomorrow.

Five flexible fingers. Fourteen nimble knuckles. It is even textured to feel and look like skin. Five fingernails are waiting to be painted.

Momo gasps in delight.

With Easton's help, she attaches the arm and learns how to operate it.

The Amputee Coalition estimates as many as 2 million people in the United States live without one or more limbs. In 2017, there were more than 370 million amputees worldwide. That number includes 23 million kids and teenagers.

"Momo is going to be the first of a lot of people," Easton predicts, referring to his robotic arms' potentially limitless reach.

In addition to NASA's robonaut program, other industries are eager to use robots and robotic limbs for the riskiest jobs. For example, construction workers can avoid dangerous locations atop skyscrapers or deep underground by remotely operating a dexterous robotic limb. Security forces would rather use brain-powered robotic hands to defuse terrorist bombs.

No matter how this particular technology evolves, Easton is happy to see his homemade invention improving other peoples' lives.

"We're all born inventors," he insists. "A lot of people think of inventing as something very technical, but I think inventing and creativity go hand in hand. Turning any kind of idea into reality is inventing. It could be through artwork or food or writing."

Armed with that kind of limber thinking, Easton is an inventor like no other.

Jennifer Mason is a story hunter. She has explored foreign countries, canyon mazes, and burial crypts to gather the facts that make good stories. Her home and mountain biking haven in Durango, Colorado. sits 30 minutes away from Easton's robotic-arm bedroom laboratory!