Electronics Experience for Global Education

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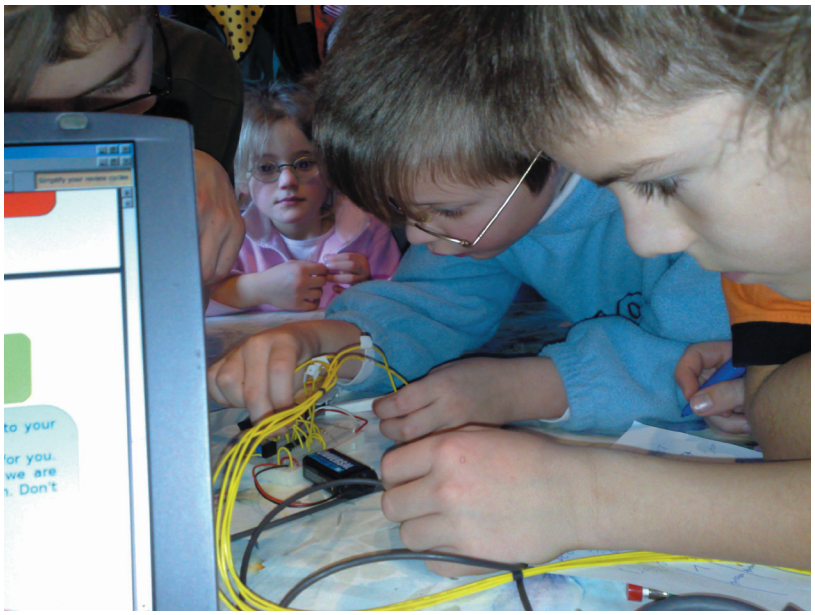
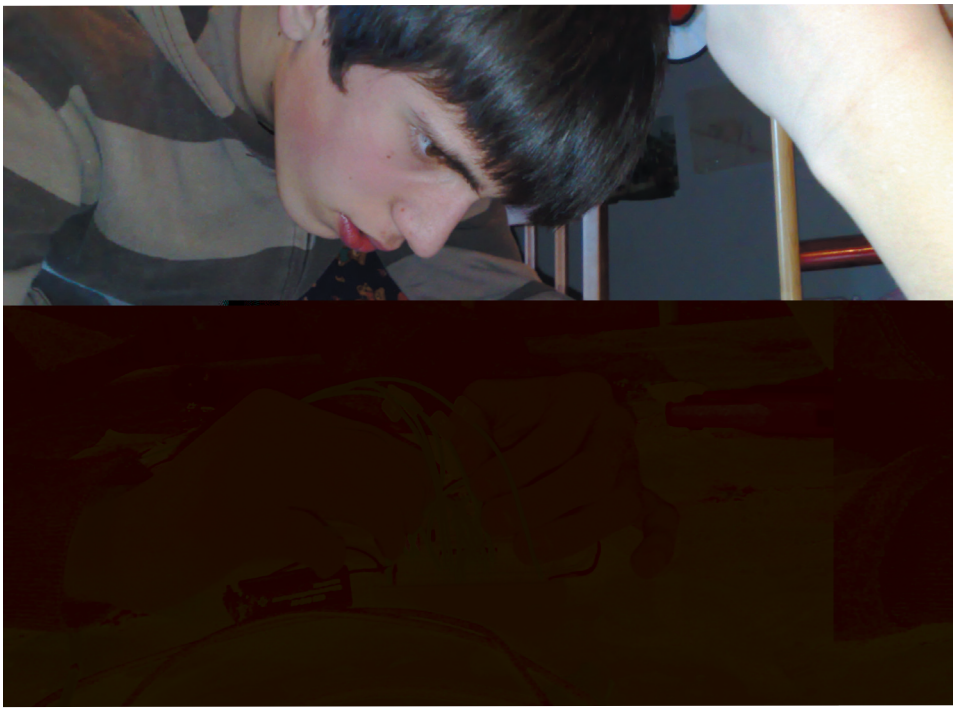
Every year, the world spawns more and more Linux hackers. The open source and free software movements, combined with the widespread availability of computers and the Internet have created an environment where twelve year olds can open an online tutorial and have a "Hello World" app in minutes. More and more popular services like Facebook and iGoogle are turning into "platforms" on which anyone can become a developer. The result is an army of millions of coders who are young, passionate about technology, and find themselves with more and more venues through which to develop their talents. All of this led to major advancements in the computing world over the course of a few years. There now exist open source software to rival most professionally available proprietary software. Among The Gimp, OpenOffice, VLC, Firefox, and Thunderbird, you have a fully functional open source desktop. Even more astounding is that nowadays, you don't have to spend days setting up a working Linux machine. New distributions like Ubuntu have developed a point-and-click install. User interfaces are getting better and better; some might even say they were bordering on being intuitive! Technologists, growing up in today's world, are in a new era where the wildest dreams of sci-fi writers are quickly becoming a reality. A person can pull out his cell phone and with a few finger swipes, check his e-mail or buy movie tickets. Unfortunately, there exists a gap in the hobbyist community between software and hardware. Take any high school kid that has compiled his own kernel; I am sure that he can tell you what a segfault is, what happens when you pipe something to /dev/null, and can maybe even make you a Web 2.0 app to track the progress of your fitness goals. But ask how the computer actually generates a 2.6 GHz clock or senses motion on a touchpad, and he will be stumped. He will be unable to tell you where and why a pull-up resistor is used, or even why everything is done in binary in the computer





science world. This would be fine if we existed in an abstract world where there was no need to interact through hardware. Unfortunately, most real people live in the real world, and almost any useful computer science technology has no choice but to interact directly in new and interesting ways.

The analog world is certainly scary, but no less intriguing to technologists than the lines of code that simulate a physics engine. A student that is hacking his X-server so that his bouncing cow screensaver stretches across his two monitors would also love to learn more about the hardware chip that is implementing those OpenGL instructions. If one told him that a modern car contains as many as 80 small computers, which control physical devices (microcontrollers), he would probably want to see some of the code that makes it all work. So then the question becomes obvious: if the line between hardware and software is quickly disappearing, why are kids not learning about hardware at a young age? If the champions of technology are companies creating innovative new devices rather than new software, why are schools teaching advanced Java and not advanced circuits? Why are we giving the next generation of engineers the impression that their creations are stuck inside the computer?

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To tackle this issue, we formed NerdKits, where we bundle electronics parts with instructional material to create microcontroller kits for beginners. We believe the best engineers are those that deeply understand the technology on which they are building. Every Linux hacker out there should not be afraid to build a circuit that turns on an LED. Whether future engineers will be developing new medical instruments for more efficient healthcare, creating control systems for cars and planes that pilot themselves, or augmenting reality with digital data, we believe the future of technology will continue to be converging the digital and physical domains, thus we aim to put this technology in the hands of anybody that is interested.

For the uninitiated, a significant problem with microcontrollers is the relatively steep learning curve. Sure, you can purchase an $8 microcontroller, and you can even get one that has a compiler for a language you know. But when it arrives, it comes with a 100 page datasheet full of circuit diagrams, and even scarier looking timing diagrams. (Non-sequential logic? Oh my!) The average person trying to tackle some project will most likely get as far as setting the fuses on the chip before putting the whole thing away out of frustration. Even if one gets as far as writing the code, the nuances of dealing with hardware registers, read/write bits, and timing will drive many software engineers crazy. So even as people become more and more comfortable with programming, the science of electronics will remain a dark art. At NerdKits, we aim to soften the learning curve by providing step-by-step, easy to understand projects, with explanations about why things are done the way they are. Moreover, we try to provide the intuition behind the concepts so that the user is ready to take on their own projects when they are ready. Our kits provide users with "the real thing," which are the powerful components that embedded systems engineers have been using for years. Users will utilize a solderless breadboard, so that they are not locked to any fixed design on a printed circuit board, and that the components can be reused and reintegrated to tackle larger projects as the user's skill level increases. Most importantly, we are always available to answer email support requests from our customers, because we have discovered that when

learning about microcontrollers, the most essential tool is a teacher with the experience to predict which of a dozen possible failures may have taken place.

NerdKits started at Zeta Beta Tau, our fraternity house at MIT, when the common freezer broke. We took it apart to discover that the mechanical thermostat was broken, but otherwise the freezer was working fine. We decided we could fix this using a microcontroller, a simple temperature sensor chip, and a relay. After a few days, the freezer was up and running! It even had an LCD that displayed the live temperature, and would beep whenever the ice cream was in danger of melting. As we worked, we noticed a curiously high number of computer science and mechanical engineering majors that kept gathering around, excited about what we were doing. Everybody thought it was really cool, but nobody thought they could do it. That's when we started talking about building a starter kit for microcontrollers: an all-inclusive kit that would guide you through a full project step by step, and then give you direction toward future projects. We did not want to spoon-feed anyone a cool science fair project; we wanted to providethe tools to design and build new systems. After we assembled the kit and all the educational material, we shipped our first kit in November 2007. Ever since then, we have been adding new projects and filming videos about the technical concepts and project ideas.

One of the goals behind NerdKits is to get kids excited about electronics, thus we were ecstatic when a college student studying at the Technical University of Vienna, Austria, emailed us, asking for a kit that he could use with kids at his church group. We sent the kit, and soon received an email detailing all the fun they had with the kit:

"[There] were eight kids, from 6-13 years old. They had never seen something like this before and were very excited. I started to tell them something about fundamentals like what is a microprocessor good for and what signals does it use. What they really liked was the binary system. It took some minutes until they really understood, but then they started calculating their age and the time into the binary system. That was really funny. I think some of them are better now than many of my electronics classmates."

This story, along with the photos displayed, has reinforced our belief that electronics can be learned and enjoyed by people of all ages. With any luck, one of these kids will go on to develop the next great biomedical device, energy efficiency solution, or consumer electronics product.

As the MIT OpenCourseWare website states, "MIT is committed to advancing education and discovery through knowledge open to everyone." As MIT students, we have an obligation to uphold that mission by educating in a way that will benefit the nation and the world in the 21st century. We hope to break down the barriers to entry in electronics, and help reignite the spirit of the hobbyist tinkering in the garage. While we are just EECS students pursuing what we do best, we can only imagine what will happen once other science and engineering disciplines start to follow a similar pattern, expanding their community of participants.

Humberto and Michael are seniors in Course VI and continue to develop the NerdKits offerings. More information and videos can be found at http://www.nerdkits.com/.