

[SLICE OF MIT THEME MUSIC]

ANNOUNCER: You're listening to the *Slice of MIT* podcast, a production of the MIT Alumni Association.

JOE MCGONEGAL: This is the *MIT Alumni Books* podcast, and I'm Joe McGonegal. Andrew "Bunnie" Huang is a class of 1997 alum who went on to earn an MEng in course 6, and a PhD in course 6D. His new book, published in Spring 2017 by No Starch Press, is the *Hardware Hacker-- Adventures in Making and Breaking Hardware*. It's his second book following the 2003 *Hacking the Xbox-- An Introduction to Reverse Engineering*.

Huang truly embodies Mens et Manus-- mind and hand, and this new book is a chronicle of his intellectual and manual efforts to tinker with and improve on technology. Buddie Huang, thanks for patching in. Tell us about writing this book. Was the writing of it any more difficult than the publishing of it?

ANDREW HUANG: So actually the book was written over many, many years. In fact, the source material for the book comes from a series of blog posts that I had done. For a while, actually the publisher, No Starch Press, had been batting the idea around with me and trying to put them together into a cohesive arc and turn it into a story. And then I guess finally, we got around to doing it. There's enough material there, and he put together a table of contents that made sense. And then I spent a bit of time rewriting sections, adding some material to connect the story together, and bringing things up to date. We got to the point of a publication.

I would say that No Starch is a really good publisher to work with. They took a lot of the burden off of me. They had a copy editor working, a really talented editor working. It was actually one of the more fun books I had to work on recently.

MCGONEGAL: You don't get one page into the book before there's some great blurbs, they called them, from dignitaries who have read the book in advance. And the very first one you list is from Edward Snowden who said, "hardware, says Bunnie, is a world without secrets. If you go deep enough, even the most important key is expressed in silicon or fuses. Bunnie's is a world without mysteries, only unexplored spaces. This is a look inside a mind without peer." Why Edward Snowden gets the first word in your book-- talk about his influence on you.

ANDREW BUNNIE Well, I mean the publisher arranged for all the quotations. And then destiny put Edward's

HUANG: name first because he's the most recognizable of all the people on the list. I've had the fortune to have the opportunity to work with Ed over the past year and change. And it's been really interesting learning from him and understanding more about the world of privacy and surveillance and geopolitical problems that we're facing. And the things we need to be technologically-- to try and solve some of these problems and bring the power back into the hands of the users.

And so when we were talking about who would be the person that might be interested in looking at the book, and maybe considering the book and giving a quote to it, and we said, maybe Ed would be interested. And sent a copy to him, and those kind words were what he left.

MCGONEGAL: You write about mentoring media lab students over the years and bringing them on a tour of the electronics market in Shenzhen where you discovered a brand new world of hardware hacking and understanding the supply chain in the world of technology. But then the book seems to take us on that same tour-- much the same tour that you've given to a lot of your students. It seems like you wanted to bring that to the millions who don't get the personal Bunnie Huang tour of Shenzhen. And MIT students and MIT alumni probably know something. I was thinking of Micro Center down the street from us here. Compare Micro Center in Cambridge to Shenzhen.

HUANG: Yeah, if you were to take Micro Center and replicate that store and cover the entirety of Cambridge Court with that, and then stack that up about 10 stories tall, that would be about the scale of the markets in Shenzhen. So that's just the size. And then the variety, of course, is through the roof.

I mean, Micro Center back when I was a student, they still sold some components in bits and pieces. And that was the most fun to be able to grab a few ICs or whatever when you need it. I think those are largely gone now. But Huaqiangbei is just-- I mean, literally, I would have a production problem, and people are like, ah, we're missing 10,000 diodes for a production. And I'd say, OK well, we'll stop by the market on the way in. I'll pick up 10,000 diodes. And about \$10 later and 10 minutes of negotiations, I got my 10,000 diodes. And I just drive over to the factory, drop in the line, and we're ready to go.

That's the scale. I mean, the other competition they have is there's single stalls-- the market is a range of [INAUDIBLE] markets almost. If you've ever been to the meat and fish markets that

we have in Chinatown, same kind of arrangement-- very small stalls all specialized in different things.

And I did a back-of-the-envelope calculation and one of these stalls alone had more inventory in it than Digi-Key had in its entire inventory for that particular type of chip. The amount of just inventory that's sitting there is massive. So you can really just go there, over-the-counter, cash and carry, go to production, which is a very unique situation. Which you couldn't do in-- I mean, Micro Center, you just go there and you buy a couple parts to fix your computer. You have Micro Center in production quantities.

MCGONEGAL: You gain the appreciation there of the ecosystem of the technology surrounding all of our favorite devices in the world.

HUANG: Yeah, and what it takes to build them-- a lot of effort and a lot of people.

MCGONEGAL: I found an important moment in the book is about halfway through. You talk about, as a child first studying the schematic for the Apple II Computer. Why was that such a formative experience for you?

HUANG: It was huge, because as a child I was just curious, and I just liked the colors and the shapes of the stuff on the circuit board. And I would just touch it because I was curious. I had no idea what I was doing, but then when I was thumbing through the book, there's this thing that just folded out. It was an [INAUDIBLE] size sheet of schematics. And I realized that I recognized some of the 74-series part numbers were the same labels that were on the chips that are on the schematic. I was like, oh my god, there's something here that can tell me what's going on in this thing. I didn't understand it. But just the idea that I could understand it was what I really needed.

It's so easy to overlook a side path, or to think that a mountain is too tall or whatever it is, but the moment you're shown a map, and you're shown a way, even the tall stones can be scaled and passed. For me that was extremely formative, and a thing that you're passing it on to the future generations. I do a lot of open source work, because I feel like it's very important for us not to think that technology has become a black box and this mysterious thing that we can only buy from Apples and Googles and Samsungs at the end of the day.

One of the nice things about electronics technology versus biology is that everything in electronics is made by humans. By definition it's all understandable by humans. There's no

possible random chance event or divine intervention that could have brought this about. So there's nothing in our boxes that should make us feel we don't understand them, and I would like to give people the beginnings of the string to pull to discover that if they want to. Whereas in pre-medical and biology it's just incredibly complicated, and it wasn't necessarily designed and there's a lot of just-so things that happen. And so that's a completely different story in terms of trying to understand how humans work, for example.

MCGONEGAL: Your current project, or a current project of yours, Love to Code, and the accompanying Chibitronics-- you are aiming at that k-12 cohort.

HUANG: Absolutely, Chibitronics and Love to Code is all about trying to get more people included in the conversation of technology. It's not just k-12, but also getting underrepresented minorities, women, and people who have not been serviced by the technology curriculum, and show them that it's actually for them and that it's relevant. It's interesting to get into.

And I think that there's been this hazing ritual that you go through to learn electronics. There's a very typical path that I followed, and a bunch of other people at MIT have followed. But it tends to select for a very particular kind of personality. And we see this in the workplaces. We see this in society. You see it with people that you work with in the tech industry. And it creates a certain culture that almost alienates the rest of the world.

The really interesting thing is that now that technology has become something that the entirety of society depends upon, it's no longer the case that a few nerds can make decisions about the internet and society will just let them do it. We're getting to the point where technology is so important that people are going to legislate what technologists do. And we can't just go out and do what we want to do any more, because so much of the world depend upon the output of technologists.

And I think if we don't include more people and empower them to participate in the conversation, we run the risk of bad decisions being made through popular votes. At the very beginning of solving this problem is figuring out how to frame technology education in a way that everyone can feel that they can be involved in it. And it does involve changing the culture or changing the precepts and being more inclusive, including design and art and expression alongside technology so that people can see if humans can apply this in ways that amplify their capabilities in all walks of life.

MCGONEGAL: Now you said in one talk, if the demographics of the tech industry are too lopsided maybe we

need to change the ingredients in electronics to begin with. And that's what Love to Code is all about. Talk about some of the ingredients in these new electronic devices.

HUANG:

So Love the Code-- we actually are using paper instead of breadboard and circuit boards as a substrate. And the classic way of teaching with breadboards and wires-- and people who are in courses at MIT will recognize nerd kits and so forth-- they are really technical and can achieve certain things, but they're very-- almost hostile and cold in a way. The interesting thing about paper, which has been under appreciated, is that when you build a circuit using paper and copper tape, it's actually, mechanically speaking, almost the same properties of a circuit board. We can actually talk about the impedance of a trace on a piece of paper if you put a ground plating underneath it. But you can't talk about this in a breadboard. It's a wire and space and it's just basically [INAUDIBLE] rating and stuff, obviously. You can't really build good circuits.

So it turns out paper is actually an incredibly good substrate for doing circuitry in a way. You can do double sided. You can do circuit mount. You can do a bunch of stuff with it. But in addition to the technical properties, paper is a wonderful expressive medium. You can fold it into origami. You can play with light. It's self-documenting, you can write on it and put notes on it. You can make greeting cards. You can send notes to friends. It has this great blend of being both a great technical medium, and also being something that has an immediate connection you can make to people with it.

Now why am I learning how to blink an LED? Well, this breadboard is not very interesting, but if you put a blinking LED on the nose of Rudolph, and you give it to your friends, all of a sudden you have this motivation to want to learn more. Well, that was interesting. I want to make a star twinkle now. I want to learn how to make interaction and likes and that sort of thing.

And so it lets people who would normally say like, ah, technology-- I don't get it. Why would I want to build these digital [INAUDIBLE] things that don't look interesting? And all of sudden realize there's a very needed application for it. Hopefully that just gets them hooked in understanding that coding is just another way of expressing thought, and they can become involved in the conversation through that.

MCGONEGAL:

So that might help us build the next improved, say Google, in 20 years. But I didn't mention we are talking a week after all this media flurry following this Google memo from a Google

employee explaining why 80% of Google employees are male is essentially what he was setting out to do. Talk about what universities need to do, what industry needs to do, with existing demographics.

HUANG:

There's a couple of studies from universities. There's two of them, which put a bunch of research into figuring out how to get the undergraduate enrollment to gender parity. And a lot of it was just changing the culture. Computer science is interesting. It's one of the few subjects we are expected to know how to do it before we get into college. It's not like you go into medical school, people expecting you to know how to suture a wound or you'll do stitches or cut someone open.

But if you walk into MIT, a Computer Science class, and you've never written a line of C code in your life, or JavaScript, whatever it is, people would be like, what the heck are you doing here? Just weed you out and say go away. There's plenty of very intelligent people who can learn how to do it, but because the bar is already so high by the time that somebody even considers that maybe computers is a path that they want to engage in, they're thrown out of the pool. Even for example, the bias starts at a really young age. We look at the demographics of what parents will buy children in terms of engineering construction kits-- the gender based upon first name is the research study done on that. There's a huge number that basically bought for male children at the end of the day.

So the basic idea is that you just, first of all, create some courses that say, look, you don't have to be a genius in coding. Here's how to do it. It's OK if you don't know how to do it. Please come and join us. That's the first thing you do. And then second thing is create an environment that's more supportive that allows people to participate in the conversations-- not so much about the huffing and puffing and like, I'm hardcore. I stayed up all night and got my problem set done, and that's the super important thing. And the outcome is that they were able to normalize their enrollment to 50/50 enrollment at the end of the day.

So there's no path on how to fix things. In terms of how to fix things in existing corporate culture-- that's difficult because the analogy I made in one of my talks-- it's kind of like sauerkraut. Where if you take cabbage, nothing else, you just take cabbage and salt and fill it in a jar, it turns into sauerkraut, because there's a particular type of bacteria that creates acetic acid. It lowers the pH, kills off all the other bacteria, and every single time-- you don't even have to put preservatives or anything in there. The bacteria itself will do the job of making the environment so hostile to the other bacteria, the only thing that can survive is that

bacteria. If you want to make something else other than sauerkraut, you just don't throw more fresh cabbage in. You'll just get more sauerkraut.

So the problem in a lot of these corporate environments you see is that this particular culture is taking root. And it's such a low pH that you have to change the pH of the whole environment before you can even decide to throw something in there and hope that you can get something else other than the existing culture. I don't have an answer to that problem, but I'm hoping that by starting from the ground up, and rethinking education, rethinking what tech means, rethinking what the values are for technology, that we can create, as some would say, a holy clubhouse, for the different kind of people.

MCGONEGAL: A year ago you sued the US government over the Digital Millennium Copyright Act. What provoked that? And how is the lawsuit coming?

HUANG: So a lot has changed over the last year. What provoked that-- I have to be careful since it is an active lawsuit. What I can say is that this goes back to the whole thing about the Apple II schematics and being able to know that the path is there and that there's no boundaries. The inverse happens with the DMCA is bad. The chill of something as expansive as a DMCA, which basically makes it a crime to do any sort of decryption without the express approval of the copyright owner. The fact that decryption itself may be a criminal act, scares a lot of people away from even looking underneath the rock.

It's like saying you can't look underneath rocks. Looking underneath rocks without the permission of the rock owner is going to be illegal. So no one is going to look under these rocks anymore. And so then all the wonderful things that can be hidden underneath these rocks will never be found. And we'll never find oil. We'll never find minerals and whatever. It's because we don't want to look under these rocks.

I feel like I remember what it was like to be in a world before the DMCA. And I remember how I felt to be empowered and enabled to explore and own my equipment and take things apart and then remix them-- taking ideas and grow. And it was great. And then I had so many instances where I'm going to start up or thinking about doing a startup, and you think through the whole chain of stuff, and you're like, oh crap, the DMCA. We can't do that. The idea just dies on the vine. Just so many good ideas just die on the vine because of this.

It's not even we're even sure that it's illegal. It's just the possible threat. It makes it hard to raise money. It makes it hard to get the idea off the ground. It makes it hard to get people--

the crew people-- into the company, all this sort of stuff. And so it really stays against that. So this is a problem for innovation, particularly in the Western ecosystem that is greatly affected by this, and we should reform it if we want to keep on being competitive. There's other societies that aren't as wed to the DMCA, and they're becoming extremely innovative and competitive in part I think, because we don't have the same restrictions on their brains.

In terms of the status of the suit-- I think the short summary I can put up here is that something happened in November. And the courts are really, really busy right now. So I understand that the court dockets are extremely full right now for a lot of really good reasons. So we're just waiting our turn.

MCGONEGAL: Customers who bought your book on Amazon also bought books by Simon Monk, Craig Smith, Will Alsop, Ben Clark, Brendan Perry. Is the algorithm on Amazon doing its job right?

HUANG: I don't know. I actually would have to look up what those books are. I'm actually not familiar with what the titles of the books would be.

MCGONEGAL: In fairness, they all have the word "hacker" in the title.

HUANG: So Amazon has classified me in the weirdest places. The book doesn't actually fit into any category either. That's also the strange thing. It goes in everywhere from manufacturing to hacking to digital rights to biology. So the thing I like to say I like to do-- you know actually what I call dot connecting exercises. You learn a lot of point theory and you specialize in an area. And every now and then I just take a step back and connect the dots from silicon all the way to servers all the way to society. And then see where the arc goes.

What this book tries to do is it takes a step back and tries to connect a bunch of the dots, which means it doesn't really fall into a particular category. It's almost a half philosophy book, half technical book.

MCGONEGAL: You're algorithm busting. You're trying to bust the algorithm then.

HUANG: Defying the mold.

MCGONEGAL: Tell me what else you're reading right now, Bunnie.

HUANG: Oh my gosh, I'm reading a whole bunch of stuff that I can't talk about in time. I was actually doing a bunch of research right now on the subject of ethernet. That's all I can say. It's

interesting.

MCGONEGAL: Bunnie Huang '97 is the author of *The Hardware Hacker-- Adventures in Making and Breaking Hardware*. And it's available now from No Starch Press or at your favorite local hacker's bookstore. Bunnie, thanks for joining me.

HUANG: Yeah, thanks. Thanks for having me.

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