00:04

A friend called me a few weeks ago with bad news. She dropped her cell phone into the toilet. Anyone here done that before?

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(Laughter)

00:16

So it was a bad situation. You know, without getting into the details of exactly how that happened or how she got it out, let's just say it was a bad situation. And she panicked because, like for many of us, her phone is one of the most used and essential tools in her life. But, on the other hand, she had no idea how to fix it, because it's a completely mysterious black box.

00:39

So think about it: what would you do? What do you really understand about how your phone works? What are you willing to test or fix? For most people, the answer is, nothing. In fact, one survey found that almost 80 percent of smartphone users in this country have never even replaced their phone batteries, and 25 percent didn't even know this was possible.

01:06

Now, I'm an experimental physicist, hence the toys. I specialize in making new types of nanoscale electronic devices to study their fundamental quantum mechanical properties. But even I wouldn't know where to start in terms of testing elements on my phone if it broke. And phones are just one example of the many devices that we depend upon but can't test, take apart, or even fully understand. Cars, electronics, even toys are now so complicated and advanced that we're scared to open and fix them.

01:43

So here's the problem: there's a disconnect between us and the technology that we use. We're completely alienated from the devices that we most depend upon, which can make us feel helpless and empty. In fact, it's not surprising then that one study found that we are now more afraid of technology than we are of death.

02:09

(Laughter)

02:12

But I think that we can reconnect to our devices, rehumanize them in a sense, by doing more hands-on experiments. Why? Well, because an experiment is a procedure to test a hypothesis, demonstrate a fact. It's the way that we use our senses, our hands, to connect the world and figure out how it works. And that's the connection that we're missing.

02:42

So let me give you an example. Here's an experiment that I did recently to think about how a touchscreen works. It's just two metal plates, and I can put charge on one of the plates from a battery. OK. And I can measure the charge separation with this voltmeter here. Now -- let's make sure it's working. So when I wave my hand near the plates, you can see that the voltage changes just like the touchscreen responds to my hand.

03:13

But what is it about my hand? Now I need to do more experiments. So I can, say, take a piece of wood and touch one of the plates and see that not much happens, but if I take a piece of metal and touch the plate, then the voltage changes dramatically. So now I can do further experiments to see what the difference is between the wood and the metal, and I should find out that the wood is not conducting but the metal is conducting like my hand. And, you see, I build up my understanding. Like, now I can see why I can't use a touchscreen with gloves, because gloves aren't conducting. But I've also broken down some of the mystery behind the technology and built up my agency, my personal input and interactions with the basis of my devices.

04:00

But experimenting is a step beyond just taking things apart. It's testing and doing hands-on critical thinking. And it doesn't really matter whether I'm testing how a touchscreen works or if I'm measuring how conducting different types of materials are, or even if I'm just using my hands to see how hard it is to break different thicknesses of materials. In all cases, I'm gaining control and understanding of the basis of the things that I use.

04:27

And there's research behind this. For one, I'm using my hands, which seem to promote well-being. I'm also engaging in hands-on learning, which has been shown to improve understanding and retention, and even activate more parts of your brain. So hands-on thinking through experiments connects our understanding, even our sense of vitality, to the physical world and the things that we use. Looking things up on the internet does not have the same effect.

05:01

Now, for me this focus on experiments is also personal. I didn't grow up doing experiments. I didn't know what a physicist did. I remember my sister had a chemistry set that I always wanted to use but she never let me touch. I felt mentally disconnected from the world and didn't know why. In fact, when I was nine years old, my grandmother called me a solipsist, which is something I had to look up. It means that you think that yourself is all that exists. And at the time I was pretty offended, because whose grandmother calls them that?

05:35

(Laughter)

05:38

But I think that it was true. And it wasn't until years later, when I was in college and studying basic physics, that I had a revelation that the world, at least the physical world, could be tested and understood, that I started to gain a completely different sense of how the world worked and what my place was in it. And then later, when I was able my own testing and understanding through research, a big part of my connection to the world was complete.

06:08

Now, I know that not everyone is an experimental physicist by profession, but I think that everyone could be doing more hands-on experiments.

06:18

And actually I think we sort of -- I'll give you another example. I was recently working with some middle school students, helping them learn about magnetism, and I gave them a Magna Doodle to take apart. Remember one of these things? So at first, none of them wanted to touch it. They'd been told for so long not to break things that they're accustomed to just passive using. But

then I started asking them questions. You know, how does it work? What parts are magnetic? Can you make a hypothesis and test it? But they still didn't want to break it open. They wanted to take it home with them, really. Until, one kid finally sliced it through and found really cool stuff inside. And so this is something we can do here together. They're pretty easy to take apart. See, there's a magnet inside, and I can just cut this open. Cut it open again, you can split it. OK, so when I do that -- I don't know if you can see this, but there is sort of -- there it is, this oozy white stuff in here. Now you can see it on my finger. And when I drag the pen on it, you can see that these filaments are attached to it. So the kids saw this, and at this point they're like, this is really cool. They got excited. They all started ripping them open and taking them apart and yelling out the things that they discovered, how these magnetic filaments connected to the magnetic pen and that's how it wrote. Or, how the oozy white stuff kept things dispersed so it could write. And as they were leaving the room, two of them turned to me and said, "We loved that. Me and her are going home this weekend to do more experiments."

08:12

(Laughter)

08:18

Yeah, I know, the parents in there are worried about it, but it's a good thing! Experimenting is good, and actually I found it extremely gratifying, and I think hopefully it was very life-enriching for them. Because, even a basic magnet is something that we can experiment with at home. They're both simple and complex at the same time. For example, you can ask yourself, how can the same material both attract and repel? If I take a magnet, is it useful if I can get one of them to rotate the other, for example? Or, you can take this dollar bill over here, and I can take a set of magnets, and you can see that the dollar bill gets lifted by the magnets. There's magnetic ink hidden in here that prevents counterfeiting. Or, here I have some crushed-up bran cereal. OK? And that's also magnetic. Right? That has iron in it.

09:15

(Laughter)

09:17

And that can be good for you, right? OK, here's something else. This thing over here is not magnetic. I can't lift it up with the magnet. But now I'm going to make it cold. The same thing in here, cold, and when I make it cold, and put it on top of the magnet, so --

09:42

(Applause)

09:43

It's amazing.

09:49

That's not magnetic, but somehow it's interacting with a magnet. So clearly understanding this is going to take many more experiments. In fact, this is something that I've spent much of my career studying. It's called a superconductor.

10:03

Now, superconductors can be complex, but even simple experiments can connect us better to the world. So now if I tell you that flash memory works by rotating small magnets, then you can imagine it. You've seen it. Or, if I say that MRI machines use magnetism to rotate magnetic particles in your body, you've seen it done. You've interacted with the technology and understood the basis of these devices.

10:37

Now, I know that it's hard to add more things to our lives, especially experiments. But I think that the challenge is worth it. Think about how something works, then take it apart to test it. Manipulate something and prove some physical principle to yourself. Put the human back in the technology. You'll be surprised at the connections that you make.

11:04

Thank you.

11:06

(Applause)