AN EDUCATOR'S PERSPECTIVE: THE IoT & THE IMPORTANCE OF MAKING

We recently spoke to Sara Willner-Giwerc, a PhD candidate at Tufts University in Boston, Massachusetts, US. Sara told us about her work using the Internet of Things with elementary school students, and how she thinks maker spaces can really engage students in learning.

Arduino Education: Hi Sara, it's great to talk to you! Can you tell us a bit about your background and your role now?

Sara Willner-Giwerc: Hello! I'm currently a PhD Candidate in Mechanical Engineering at Tufts University, where I conduct research at the Center for Engineering Education and Outreach (CEEO). My research is focused on designing technologies and learning experiences to maximize solution diversity in engineering classrooms.

I'm especially interested in finding ways to lower the barriers to entry for students to drive their own learning. Most recently, I've been exploring the different engineering practices that students engage in when they follow step-by-step instructions to solve an engineering problem with robotics, compared to when they're given less structured support materials and asked to solve a similar problem.

Before becoming a graduate student I received my B.S. in Mechanical Engineering from Tufts. As an undergraduate student I enjoyed doing as many cool projects at the CEEO as they'd let me join in on, and playing shortstop for the Tufts varsity softball team.

AE: And you do some work with the 'Internet of Things' (IoT), which seems to be a buzzword - can you explain a bit more about it?

SW-G: The Internet of Things is definitely a buzzword - which can make it hard to figure out what exactly it refers to. I like to define it as any system where devices communicate wirelessly through the internet. These devices range from everyday objects, such as watches and toaster ovens, to more complex computing devices. When these devices are connected to the internet, it's easy to send information to and receive information from them, regardless of where you or the device are physically located.

To break it down a little further, IoT systems contain three main components:

1. **Physical devices (things)** including sensors and/or actuators. These are items like smart light bulbs and thermostats. They take measurements (like temperature) or actuating (lights turning on/off).
2. **Data/device management software**: This is how the user can see information about their IoT devices, get data reports, and set up triggers and actions.
3. **Internet connection**: IoT requires a network connection. This is how the devices and the data or device management software talk to each other.

AE: That's a great explanation! How do elementary students respond when you introduce this to them? What are the first lessons like?
SW-G: I worked with a second grade (7-8 years olds) class, and we used small *internet-connected microprocessors to build an IoT Zoo.* During the first lesson, every student had an IoT hub, a button, and a sound recorder/speaker.

The first thing we did was each build an animal, and then record the noise that animal makes. Next, we used drag-and-drop software I wrote to make the animal noise play when the button was pressed.

Lastly, students found a partner, and had to make their button control the sound of their partner's animal. The goal here was to get them to understand that since all of the hubs were connected on the same WiFi network, they could gather and send information from all of them, not just their own. That was a lot of fun! Using visuals, like a whiteboard and pencil and paper drawings, of the system to help talk with students about how the devices were working was a key part of this lesson. Because you can't see the internet connection, I used visual aids to help make that connection more tangible for students.

I'm still not entirely sure what sound an alligator makes, but the students were able to understand how by changing the device name in the software they are easily able to connect their sensors to their friend's actuators!

For the next lesson, every student had one IoT hub, one sensor, and one actuator (every student had a different sensor and actuator this time). The new goal was for each student to build an exhibit for their animal, incorporating their sensor and

actuator, and to create a dashboard for the zoo keeper that had controls and sensor readings for all of the animals in the exhibit. The idea again here was to try and get students to think outside of their local system (their hub, sensor, and actuator) and think about the class-wide zoo and how to build a more "global" system. Students were successful in understanding how to send and receive information throughout the whole class, and there were a lot of creative exhibits and dashboards. This sparked a lot of interesting discussions regarding who had what sensors and what they did, who should get to control different actuators and when, etc. To be talking about internet security with second graders, and enabling them to understand why there should be procedures in place for making sure only the appropriate people can access certain devices, was a really interesting and unexpected outcome.

AE: That sounds amazing! We know you're also interested in maker spaces, can you tell us more about that?
SW-G: I'm really interested in the maker space as a way to engage more people in learning through play or learning by doing, and as a place for students and teachers to learn alongside one another. I'm especially interested in the kinds of learning experiences that unfold when we give students problems that have many different solutions as opposed to just one solution. Maker spaces and activities provide an opportunity to bring those high solution diversity experiences into the classroom.

AE: And why do you think making is so important to learning?
SW-G: One of the most important things that I think making brings to the table for learning is the opportunity for student agency. So often in school, students are not given the freedom to make decisions about their own learning. Making provides an opportunity for students to actively drive their own learning and think independently, as opposed to a more traditional classroom experience where students are asked to replicate the existing knowledge of others. What I've found accompanies increased student agency is students iterating on their designs, thinking critically, and in the end being proud of and taking ownership of their ideas.

AE: Absolutely. It's been great talking to you. Is there anything else you'd like to add?
SW-G: Yes! I've been especially excited about the role that IoT can play in education because of how easily the internet can facilitate collaboration across physical distances. Most often during making activities, students are creating their own local systems that serve a single purpose. These local systems are limited by the resources they have in their immediate possession and typically lack the ability to communicate with other devices.

By leveraging the Internet of Things, students are able to build more powerful systems that are no longer limited to only the resources they physically possess. This technological capability presents a cool opportunity for students to experience how

they can be more powerful when they connect and collaborate with others than they can be on their own.

Especially now, in this time of social distancing and *remote learning*, the ability to communicate with devices that aren't physically near us has become even more essential than it was previously. I'm really excited about the idea of using IoT to help students think about designing for more global systems. That being said, I recognize that there are still a lot of barriers to bringing IoT into classrooms and there is much more work to be done in both the technology and curriculum design to make these ideas a widespread reality in the education space.

INSPIRED? HERE'S WHAT YOU NEED TO GET STARTED WITH THE INTERNET OF THINGS

The Explore IoT Kit can be used to innovate, create, and transform. Take your first steps in building internet-connected objects, and explore the Internet of Things with Arduino Education.

To get the kit, you can *find your country's distributor*, or buy it in our *online store*.