IoT and E-Waste: An environmental impact study on the effect of electronic waste on the environment

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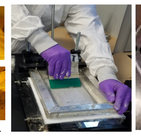
Summary

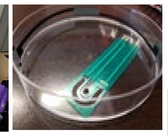
The Internet of Things (IoT) Research Experience for Teachers RET Site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers (CoMET) at the University of Central Florida (UCF) is researched based, hands-on learning approach to understanding of the Internet of Things, focusing on the design and fabrication of environmental sensors, hardware platform, and software and networking. Throughout our research this summer, I've received bits and pieces of what the IoT was and its applications. The reading requirement this week, although lengthy, really helped me understand the bigger picture of what truly IoT is and how important it is and is becoming. We are all connected. We live in a world where we can check our refrigerator for what we are missing when we are actually at the grocery store, or controlling our lightening in our homes, all being done while we are on vacation 1000s of miles away. These concepts, which were so futuristic growing up are now a reality. This research opened my eyes to what really is happening in our world today, understanding the background of the IoT, it's capabilities, and how everything is being connected, makes me a more informed citizen and teacher. I am very excited to share what I've learned about the IoT with my students. We are all using products of the IoT, but do not know how it's all working. It's very important to understand the connection between sensors, hardware and software, and the networks running it all. These new connections bring about concern for security and waste though. Future applications need to consider the impact on the environment and more on the security of all of this free flowing data. This is just a starting point for future standards that need to be created to keep information safe and also needs to address the impact, that creating all these new applications and devices used in the data exchange, will have on our environment.

All research photos shown below were taken by Heather Brough.

Figure 1. Module 1 - Photolithography: laboratory.

Figures 2-4. Module 1 - Photolithography: cleanroom.





Figures 5-6. Module 1 - Screen printing circuits for environmental sensors.

Figures 7-8. Module 3 - Basys programming

Figures 9-10. Module 4 - Raspberry Pi programming.

Research Activities

Research is segmented into several modules. Modules are focused lessons that dissect the research project. The modules are sensor devices, interface and testing, software and networking, and mobile programming. Each module, according to the RET: Collaborative Multidisciplinary Engineering design Experience for Teachers (CoMET) "Internet of Things", University of Central Florida, Orlando Campus Syllabus, is designed to allow teachers to develop an understanding of the engineering design process. [Cho, J. (2019). University of Central Florida. RET Site: Collaborative Multidisciplinary Engineering Design Experience for Teachers (CoMET) Teacher Handbook. Orlando, FL: UCF)].

The first module, the Sensor Device Module, introduces the design and fabrication of Environmental Sensors, with a focus on chemistry, physics, and environmental science. The key principles in the design and fabrication of Environmental Sensors, are materials synthesis, photomask design, cleanroom microfabrication, and device packaging.

The second module, the Interface and Testing Module, introduces interface hardware design for sensors and device testing, with a focus on physics and computer literacy. The key principles of the interface and testing phase are learning analog and digital circuit basics and conducting data analysis and validation.

The third module, the Software Networking Module, introduces the system software, with a focus on computer literacy. The key principles of system software are learning the basics of Linux operating systems and its processes and file systems. Linux is the operating system used for the Raspberry Pi. In order to understand Linux, the Java programming language must be learned. For networking, the key principles needed are basics of computer networking, the layered model, principles of TCP/IP, addresses and sockets. Basic learning of programming is possible using a web server in Java on a Raspberry Pi.

The last module, the Mobile Programming Module, focuses on computer science and includes a background on mobile operating systems and the introduction to Android (writing an Android program that accesses the Web). In this module, the key components are learning the Android platform and how to use the correct development tools.

Lesson Plan

Lesson Summary: Today, we live in an IoT world. Students will explore the **Internet of Things** (IoT). As our need for technology grows, so does the **accumulation of waste products** and discarded high tech equipment. Where does it go? Landfills are already overflowing and are not equipped to dispose of discarded technologies that are embedded with toxic chemicals, hazardous energy sources, and additional plastics and leaching metals. As we crave for a need for smaller, faster, and more efficient electronic devices, we need to also account for the additional environmental and health impacts they will also bring into our world. In this lesson, students will explore the **life cycle of a cellular phone**. Students will explore what a cellular phone is made of, where those materials come from, how those materials are combined to produce the product, the hardware and software used to drive the product, the use of the product and then the final disposal of the product. Along the way, students will research and understand the environmental impacts that each stage of a cellular phone's life cycle brings with its development.

Lesson Objective(s)/Learning Goal(s)

- Students will be able to describe the concept of sustainability and its significance to environmental science.
- Students will be able to describe how mineral resources can become economically depleted.
- Students will be able to discuss the harmful effects of mineral mining.
- Students will be able to explain how mineral resources can be used more sustainably.
- Students will be able to identify new materials that are replacing some metals for common use.
- Students will be able to explain how mineral resources can be used more sustainably.
- Students will be able to understand how chemicals in the environment can harm the human body.
- Students will be able to define and give examples of solid waste.
- Students will be able to explain what happened to solid waste after it's disposed.
- Students will be able to define and give examples of hazardous waste and understand why hazardous waste requires special handling.
- Students how waste management, waste reduction, and integrated waste management differ in their approaches to dealing with solid waste.
- Define the 4Rs approach to dealing with solid waste and identify ways individuals, industries, and communities can use this approach to limit waste and pollution.

Description of Lesson Activity/Experiences

1. Take the Pre-test.
2. Complete the Dissection of a SMART phone Laboratory Activity.
3. Discuss what it all means.
4. Watch video "The Story of Stuff" at https://storyofstuff.org/movies/story-of-electronics/
5. Begin Lesson – Intro Activity
6. Research Activity – "Where does it come from?" –a material search of cell phone components. View: https://www.compoundchem.com/2014/02/19/the-chemical-elements-of-a-smartphone/
7. Discuss research results.
8. Read Article on "IoT and E-Waste". Read and review: https://www.nwf.org/~/media/PDFs/Eco-schools/KQED-ewaste.ashx
9. Research Activity – "How is it produced?" –a manufacturing virtual tour. Watch and review: https://www.youtube.com/watch?v=V8ZVHpgYAzs
10. Discuss research results. Read and Review: https://bebusinessed.com/history/history-cell-phones/
11. Hand out IoT E-Waste Home Survey (students will complete as homework and return it next day).
12. Research Activity – "What do we do next?" –a mission on reducing E-waste, recycle it, reuse it or landfill bound? Read and review: https://eekwi.org/teacher/ecycle.htm
13. Discuss research results.
14. Write a research paper summarizing the research completed during the week: the dissection of the SMART phone, the life cycle of a SMART phone, and future research questions.

Extension: Create an E-Waste Recycled Art Project. Read and review: https://www.todaysoftmag.com/article/2582/reduce-reuse-recycle-an-environmental-approach-to-your-iot-projects

Extension: Create an Awareness Poster or Brochure on the Life Cycle of a SMART phone or any topic covered during this research lesson.

15. Take the Post-test.

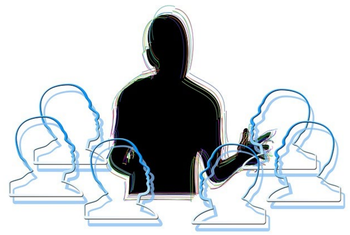
Lesson Learned and Assumptions

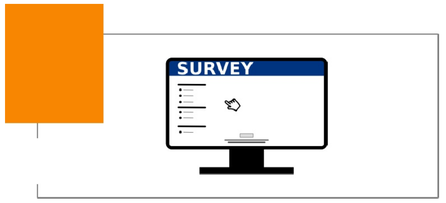
Every question has an answer. We live in a society where everything question we have, may be answered from using a device found at the bottom of our finger tips, whether is it is a SMART phone or a computer. The Internet of Things (IoT) has brought us out of the Stone Age and into a world where truly all you need to know how to do is search out answers using some sort of device. The days of waiting for information to be received through the mail or going down to a local library and sifting through the stacks of papers is gone. Today, we can find the answer to everything, we can communicate with others anywhere in the world and as far as we travel in space using the technology that we have in our world today. I am very excited to take the information learned from this portion of the research we've been doing this summer back to my classes. I believe that students will be engaged in this topic and since they are the key to the future, and all things will be digital in the future, no matter what profession children are plan on pursuing, this is where the focus should be. We are a connected world, we need to prepare future generations with the knowledge, and tools to survive and thrive in the future, but most importantly I want to inspire them to move forward investigate, explore, and become the next set of experts in the field of IoT.

Implementation Strategy

General Instructional Strategies

- Group Collaboration
- Cooperative Learning
- Technology
- Problem Solving
- Small Group Instruction
- Whole Class Instruction
- Modeling/Scaffold Instruction
- Checking for Understanding
- Providing Verbal Immediate Feedback
- Review of Material





All images shown on poster are available through Creative Commons.
Originally found on the website: http://ethicalcellphone.weebly.com/assignments.html

Acknowledgments

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References

Waste Management System using IOT. (2018). International Journal of Recent Trends in Engineering and Research, 4(4), 220-229. doi:10.23883/ijrter.2018.4231.wp68d

New Life for an Old Cell Phone. (2001). PsycEXTRA Dataset. doi: 10.1037/e511182006-007

Elie, A., & Ferrario, J. (n.d.). Electronic components in cell phone handsets: Thermal simulations and evaluation of modeling assumptions. 53rd Electronic Components and Technology Conference, 2003. Proceedings.doi:10.1109/ectc.2003.1216316

Anuj, M. (2013). A Study to Assess Economic Burden and Practice of Cell Phone Disposal among Medical Students. JOURNAL of CLINICAL AND DIAGNOSTIC RESEARCH. doi:10.7860/jcdr/2013/5265.2875

What is Nanotechnology? (2002). Nanotechnology, 14(1). doi:10.1088/0957-4484/14/1/001

Kao, Nawata, & Huang. (2019). Systemic Functions Evaluation based Technological Innovation System for the Sustainability of IoT in the Manufacturing Industry. Sustainability, 11(8), 2342. doi: 10.3390/su11082342

Cho, J. (2019). University of Central Florida. RET Site: Collaborative Multidisciplinary Engineering Design Experience for Teachers (CoMET) Teacher Handbook. Orlando, FL: UCF

Renato Grillo, R., de Jesus, & M., Fraceto, L. (2018). "Environmental Impact of Nanotechnology: Analyzing the Present for Building the Future." Frontiers in Environmental Science, [s. l.], 2018. Disponível em: <https://search.ebscohost.com/login.aspx?direct=true&db=edsdoj&AN=edsdoj.6d40601777f47d386b843678b688ed3&site=eds-live&scope=site>. Acesso em: 21 jun. 2019.

Al-Fuqaha, A., Guizani, M., & Mohammadi, M., (2015). "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications". IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, NO. 4