Sensing Energy Transformations with Circuit Design

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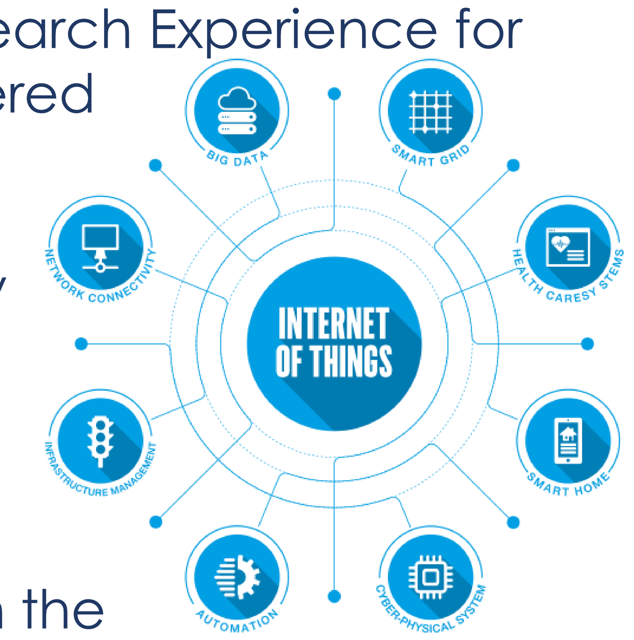
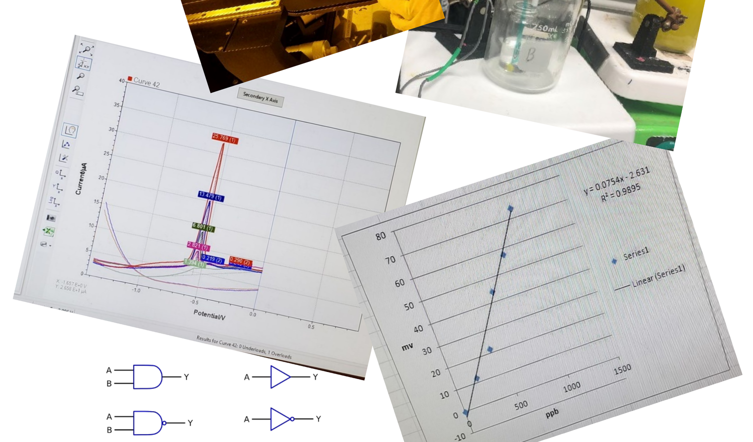
Summary

The Internet of Things (IoT) Research Experience for Teachers (RET) grant program offered at the University of Central Florida (UCF) afforded participants the opportunity to delve into a rapidly growing, highly sought-after field of potential careers for students that is rarely shared with lower secondary educators. "Smart" technology is already pervasive in the consumer market and is rapidly expanding. This program draws the connections between physical devices and the network protocols involved in the IoT. This lesson explores basic circuitry and sensor technology interfaces necessary for converting real world data to the IoT.

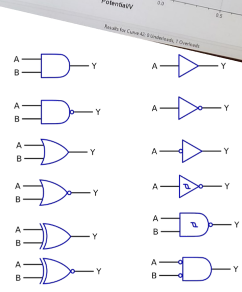


Research Activities

I. Design Fabrication of Environmental Sensors
- I. Photolithography
- II. Chemical Etching
- III. Screen-Printing



II. Embedded Systems
- I. Binary Language
- II. Boolean Algebra
- III. Logic Gates



III. FPGA Programming
- I. Basys3 board programming

IV. Software and Networking
- I. Integrated Development Environments (IDEs)
- II. Java Development Kit (JDK)
- III. Codingbat.org
- IV. Scratch (MIT)

V. Mobile Programming
- I. Raspberry Pi3

Lesson Plan

RET Site: Sensing Energy Transformations with Circuit Design

Course(s): High School Physical Science Honors
Suggested Length of Lesson: 2-3 Days

Lesson Summary:
Students gain a basic knowledge of sensors and their current applications, design their own circuits, and connect their circuits to power sources and various lamps. Students utilize sensory technology present in their cellphones to determine the transfer of energy from the power source and circuit to lumens.

Materials/Technology Needed:
- Cell phone
- Cell phone application "Lux Meter (Light Meter)", My Mobile Tools Dev
- Conductive ink pens
- Plastic transparency film and/or card stock
- Alligator clips
- Batteries (C, D or 9V recommended)
- Battery connection sets
- Lamps (LED, incandescent, etc.)
- Paper
- Pencil
- Measurement device
- Dye cutter/scanning machine and accessories (optional)

Relevance:
Unit: Energy Transformations
Standards:
- SC.912.P.10.1 - Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.
- SC.912.P.10.2 - Explore the Law of Conservation of Energy by differentiating among open, closed, and isolated systems and explain that the total energy in an isolated system is a conserved quantity.
- SC.912.P.10.6 - Create and interpret potential energy diagrams, for example: chemical reactions, orbits around a central body, motion of a pendulum.

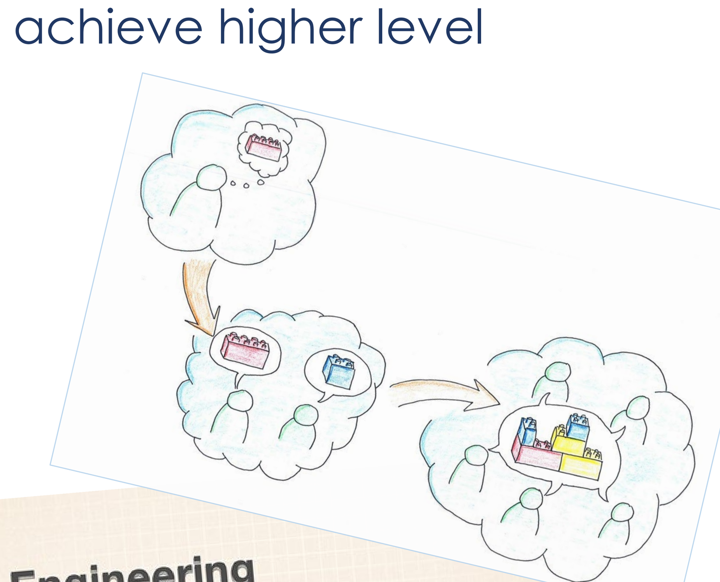
Description of Lesson Activity/Experiences
1. Students are presented with a problem to solve.
2. Student engineers design a draft of their own circuits using paper and pencil to sketch out their ideas. Teacher provides feedback as related to circuit functionalities and requirements.
3. Engineers collaborate with their shoulder partners to improve their individual designs or combine their designs. Teacher provides feedback as related to circuit functionalities and requirements.
4. Engineers collaborate with their table group (4-5 students) to develop two circuits with their idea of ideal features and create their final drafts of their group designs. Teacher provides feedback as related to sensor functionalities and requirements.
5. Development of conductive circuits using conductive ink pens:
6. Engineers allow sufficient dry time for the conductive sensors.
7. Engineers test their sensors.
8. Engineers compare group designs in relation to the energy transfer between the power source and the light source by collecting quantitative and qualitative data.
9. Engineers draw conclusions relating energy transfer from the power source to the light source with specific reference to the qualitative and quantitative data collected.

Lessons Learned

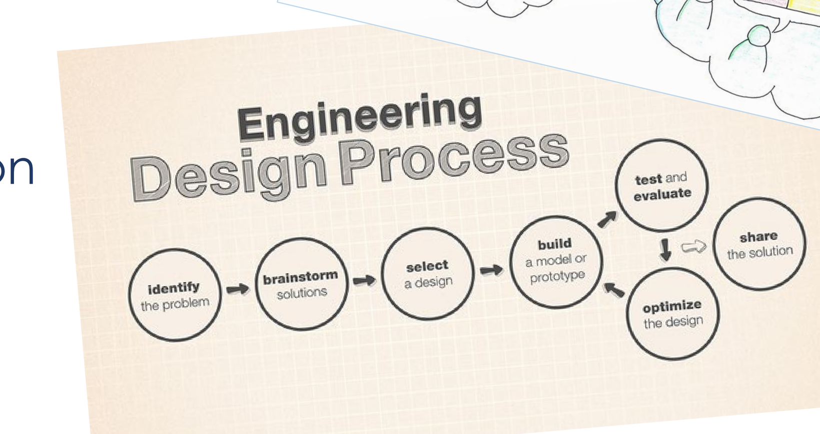
- Photolithography is a quick and financially feasible method of demonstrating the impact of ultraviolet light on photosensitive materials.
- Chemical etching is the method utilized in FPGAs and enables the development of micro- and nanosensor as well as extremely intricate computational hardware.
- Screen-printing is a multipurpose process that is used for both the creation of interesting clothing and functional conductive sensors.
- Boolean algebra is a true/false mathematic system used to express numerical languages like binary, effectively translating code into usable responses that can be applied to logic gates.
- FPGA programming enables the creation of most any functional physical technology from coding to implementation.
- Java is a common language utilized in programming to perform specific actions.

Implementation Strategy

The concepts learned in this activity will have implications in future units, including kinetic molecular theory and electricity. During this lesson, several educational strategies will be employed to begin the thinking processes needed to achieve higher level understanding.



- Engineering Design Challenge
- Pre- and Post-Assessments
- Think-Pair-Share
- Cooperative Learning
- Inquiry-Based Instruction
- Socratic Questioning
- Chunking



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