Hands-on Microcontroller Workshop for Grades 6-12

Abstract: We are frequently asked to give hands-on STEM workshops to visiting K-12 students. The goal of these activities is to excite student interest in STEM areas by presenting novel and fun hands-on activities. This paper describes a one-hour workshop aimed at grades 6-12 that gives students a taste of basic electronics and computer engineering. The challenge was to come up with meaningful and interesting activities that could be completed in 40-60 minutes. The result is a two-part workshop in which participants start with simple experiments in electricity and go on to build a game-playing computer.

Part one illustrates concepts of current and voltage and introduces a few simple components such as coin cell battery, resistors, LED, pushbutton switch, and photoresistor. The operation of each component is discussed while students experiment with them using simple breadboard circuits.

Part two of the workshop introduces the idea of a microcontroller and discusses how it expands what can be done with simple components. The pushbutton switch and photoresistor take on new roles as sensor inputs. Computer software makes decisions based on sensor inputs and then acts on the world by controlling outputs such as LEDs. The software is preprogrammed on provided microcontroller chips.

The completed circuit runs one of two selectable games: Whack-a-Mole and Simon Says. A simple modification transforms the circuit into a light meter that indicates ambient light conditions. The cost of the parts is minimal (about $3-4), allowing us to send a working kit home with each participant.

FOCUS

This workshop was originally developed as a hands-on activity for students in grades 5 or 6 through 12 as a fun way to spur their interest in topics related to electrical and computer engineering. Students experiment with a series of basic circuits and conclude by building a simple game-playing computer based on the ATTiny microcontroller. Although ASEE participants may enjoy learning some electronics, the main objective is to provide information to those who might want to develop a similar hands-on workshop for presentation at their own institutions. Hence, after we work through the original STEM workshop, we will conclude by providing information and suggestions about producing a similar workshop.

LEARNING OBJECTIVES

The first part of the workshop introduces basic elements of an electric circuit through a series of hands-on experiments where students gain a physical understanding of voltage and current. They connect a battery, LEDs (light-emitting diodes), switches, resistors, and photoresistors to see how LED behavior can be controlled.

In the second part of the workshop, the same components are now connected to a small microcontroller chip. Small snippets of computer code are shown to explain how software is used to sense the world through sensor inputs, make intelligent decisions based on those measurements, and then act on the world by turning LEDs on and off to fulfill some objective. The depth of this discussion is adjusted to reflect the age group of the student participants. For example, the learning objective for 5^{th} graders is to give them a feel for simple electricity while exciting them about the technology. The objective for high school students is for them to understand the concept of software-controlled embedded systems and their potential use in every-day electronic devices. The objective for ASEE participants is that they will have a starting point to design a similar workshop for their own STEM audience.

INSTRUCTIONAL STRATIGIES

During the workshop, each participant will access a PDF version of the workshop presentation and will have it displayed on their own monitor. The exercises comprise a series of short 5 to 10-minute hands-on experiments. After the presenter briefly introduces theory and goals, students work through the exercise at their own pace by following the presentation slides. Slides contain instructions and images of circuits to be constructed, which allows students to zoom in or out, and go forward and backward through the slides as needed.

OUTLINE

Part 1 (20 min). Participants are first shown how to access the on-line presentation material, which they bring up on their own computer screens. By following the straightforward graphical instructions, students work through a series of simple experiments that demonstrate basic electronic concepts:

- Voltage and current ideas are introduced by means of a coin cell battery and LED.
- The idea of a breadboard circuit is explained.
    - Students use jumper wires and a breadboard to make a battery and LED circuit.

- Switches, resistors, and photoresistors are explained.
    - Students add a pushbutton switch to their circuit.
    - Students add resistors to their circuit to see effect of different resistor values on LED brightness.
    - A photoresistor is added to investigate the effect of ambient light level on LED brightness.

Part 2 (20 min). Microcontrollers are simple computers that are included in many common electronic devices ranging from electric tooth brushes to TV remote controls. These "embedded systems" use sensors to measure the world around them (such as temperature or light sensors); they use outputs to control the world (such as lights, motors, and speakers); and they have software to intelligently control the outputs based on real-time sensor inputs. In our case, the input sensors are pushbutton switches, the outputs are LEDs, and the software applications are simple games.

After introducing concepts, participants build their game-playing computer using switches, resistors, LEDs, and a small microcontroller chip preprogrammed to run one of several user-selectable applications:

- "Blink program." Simply turns the LED on and off once per second.
- "Whack-a-Mole." A game.
- "Simon Says." A game.
- Ambient light tool: Uses a photoresistor to measure ambient light and turn on one of two LEDs to indicate light level.

Part 3 (20 min). The session wraps up with a discussion period to answer questions and take comments and suggestions. Information is presented to help anyone wanting to develop a similar microcontroller-based workshop for their STEM students, including:

- What microcontrollers to use.
- How to develop software and upload it to the chips.
- Cost and sourcing information.

RMS ASEE TARGET AUDIENCE

Although designed for students in grades 5-12, this ASEE workshop will also be of interest to educators interested in learning some basic electronics. However, it is primarily geared toward anyone interested in developing their own similar workshop. Information is provided about where to source parts, how the software works, and how to upload the software onto microcontroller chips

PRESENTER CREDENTIALS

Brett Gilman, Computer Engineering undergraduate student, Powell, WY.
Ryan Hassell, Electrical Engineering undergraduate student, Westminster, CO.
Aisha Balogun Mohammed, Computer Engineering undergraduate student, Ilorin, Nigeria
Madison Shippy, Electrical Engineering undergraduate student, Cheyenne, WY.

Robert Kubichek, associate professor of Electrical and Computer Engineering at the University of Wyoming.
Suresh Muknahallipatna, professor of Electrical and Computer Engineering at the University of Wyoming.

REQUIREMENTS

Participants will receive a bag of all needed electronic components, which they get to keep.
A computer will be available for each participant.
Participants will be provided with all presentation and development files via on-line link
Participants who have difficulty seeing small parts should bring a pair of reading glasses.
Ideal number of participants depends on venue and number of available computers. There should be no more than one person per computer screen. Maximum number of participants we can handle comfortably is about 35-40.

REFERENCES

N/A