Thiel College Electronic Invention Camp: An Outreach Initiative for Pre-College Inventors

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Abstract

Recent developments in microcontroller hardware and programming tools have empowered hobbyists of all ages in realizing innovative projects. The relative low cost and user-friendly aspects of the Arduino microcontroller make it an ideal choice for introducing K-12 students to the often-challenging concepts of programming and electronics. This paper presents the inaugural Electronics Invention Camp at Thiel College as an outreach program and recruitment tool. The camp took place for five days during summer 2016, with students meeting two hours each day for sessions covering a wide range of topics common to microcontroller projects. The syllabus included many important hardware and software topics, such as breadboarding; 8X8 displays; sensors; variables, conditional branching, and loops. The camp sought to foster attendee interest in both the art and engineering of electronics projects.

Keywords

Arduino, Electronics Education, K-12 Outreach, Microcontrollers, Summer Camps

Introduction

One of the key factors in successful education is sparking pupil interest. In the engineering disciplines, this can be a particularly challenging objective since technical aspects often overshadow the "fun" for would-be newcomers to the field. Also, the "big picture" can often be obscured by technicalities, and these barriers repel many prospective students. An important goal for outreach programs, then, is to give newcomers a means of exploring the applicability of discipline concepts in a non-threatening and exciting way. The hope is that these experiences will spark a deeper student curiosity in how things work and encourage further study.

In the summer of 2016, an inaugural Electronics Invention Camp was offered at Thiel College, organized by faculty from the physics and computer science departments. This camp consisted of topic-based modules centered around the Arduino microcontroller. The relative simplicity of this platform provides an approachable, hands-on method for introducing coding and circuits to prospective STEM students. It also introduces students to a potentially rewarding hobby.

Overview of Camp Syllabus

The Electronics Invention Camp consisted of several introductory modules that covered hardware topics like breadboarding, voltage and current in circuits, and how microcontrollers are used in many modern devices. Most of these were delivered on the first day of the camp. These introductory activities lead to more complex hands-on modules covering control of LEDs, LCD displays, switches, relays, motors, and various sensors using the Arduino Uno during the

remaining four days. A pivotal part of these modules was illustrating the association of basic programming concepts like variables, loops, and conditional tests with outcomes on the hardware devices. Most labs involved the Arduino, an external device with which to interface (such as a display or motor), and code to realize that interface.

In Figure 1, the five camp days are illustrated with a topic breakdown. Each day covered approximately two hours of material and consisted of lectures, demonstrations, and guided laboratories. The camp leaned heavily toward laboratories and exercises to employ a hands-on approach. Lectures were minimized, although they were obviously essential to provide background for the lab work. Demonstrations usually involved more complex code and/or hardware, so they were often used as exemplars of how basic concepts could be extended to realize more advanced systems.

Overview of the Camp Syllabus

Day 1: Basics	Day 2: Switches	Day 3: Displays	Day 4: Sensors	Day 5: Motors
[Lecture] Intro to the Arduino Uno	[Lecture] Intro to SPDT and Pushbuttons	[Lecture] Intro to LCD displays	[Lecture] Intro to sensors	[Lecture] Intro to motors and H-bridges
[Lecture] Voltage and Current	[Lab] Decoders and Seven-Segment Displays	[Lab] Message writing on LCD display	[Lab] Serial monitor circuit	[Demo] Char chassis sample circuit
[Demo] Breadboarding with LEDs	[Lab] Shift registers and LEDs	[Lecture] Intro to 8X8 LED displays	[Lab] Range finding parking assistant	[Lecture] Intro to stepper motors
[Lab] Flashing LEDs with the Arduino		[Lab] Scrolling and frame animations on 8X8 displays *	[Lab] Motion activated light with relay	[Lab] Game spinner
[Demo] Electronic Dice			[Demo] Sensor-controlled speaker	[Demo] Water pump
				[Demo] Self-driving car

Figure 1: Electronics Invention Camp Syllabus

In the next section, we discuss details for the “8X8 Matrix Display Module”, which is the lab indicated by an * in Figure 1. This provides a good exemplar of format for the other camp labs.

An Example Module

This section presents some details for the 8X8 Matrix Display Module, which was one of the highest-rated activities by our attendees. The overall execution of this activity followed closely the process for the other modules in the camp. The module introduced students to the coding and hardware configuration needed to interface an Arduino Uno microcontroller with an Adafruit 8X8 LED matrix.

A complete parts list is presented in Figure 2, while Figure 3 gives a breakdown of each activity along with time durations. The entire module took forty-five minutes to finish during the camp. The first fifteen minutes covered breadboarding and introductory coding. Because this module appeared during day three of our workshop, less time was needed for focusing on these exercises. Our participants already had about six hours of experience at the start of this module. The final 30 minutes of the module were largely dictated by participant interest. Additional

sample code provided exemplars of scrolling text messages and frame animations on the display. Participants used these code samples as a springboard to design their own animations.

The 8X8 Matrix Display Lab Parts List		
Part Name	**Quantity**	**Notes**
Adafruit 8X8 Display with Backpack	1	The backpack was soldered to the display before the lab session.
Bread board	1	The 8X8 display will be mounted on the bread board during the lab.
Computer with Arduino IDE installed	1	The Arduino IDE and all Adafruit headers were installed on the computer before the lab session.
Arduino Uno microcontroller board and USB cable	1	The board is plugged into the computer to provide a programming interface and to power the microcontroller and display.
Sample *.ino code files for each lab	3	Three sample files are included: basic display, animation, and scrolling message.
Short Jumper Wires	4	Jumper wires connect bread board to Arduino Uno board.

Figure 2: Parts List for the 8X8 LED Module

The 8X8 Matrix Display Lab Exercises		
Exercise	**Allotted Time**	**Notes**
Breadboard It!	5 minutes	Participants follow basic directions to connect the four-pin display to the Arduino.
Upload basic display sample code	5 minutes	After bread boarding, students upload the first Arduino code example to the board to test their hardware work.
Tutorial Code Walk-Through	5 minutes	Participants receive an explanation for each part of the sample Arduino program currently in use.
Upload and explore	15 minutes	Armed with the tutorial information, participants spend some time uploading and examining the other two sample programs for the 8X8 display. These illustrate scrolling text messages and frame animations.
Modify the code	15 minutes	Participants are instructed to explore the sample code and devise their own patterns/messages for display.

Figure 3: Exercises for the 8X8 LED Module

The primary goals of this module were to give students some familiarity with bitmaps for indicating pixel activation in a simple binary display. They also learned how to represent these bitmaps in code and how the microcontroller uses these bitmaps to activate the display. We felt this to be a relevant module for the camp because many people have seen similar (though much larger) displays used to present animated advertisements for stores, community centers, and schools. Completing this series of exercises sheds some light on how these familiar devices work and adds relevance to the material seen in the workshop.

Discussion and Future Directions

There were fourteen participants ranging in age from 11 – 16. Participation was offered free of charge. It should be noted that in several instances, family members (such as parents) also attended the sessions, making many labs a fun family activity. Such interaction was encouraged, particularly for younger children because the coding and breadboarding exercises were often too complex for them to carry out on their own.

Student engagement was an issue for a few labs, particularly with the 8X8 display exercises. While this module was the most liked by participants, its open-ended nature gave several students pause; they had difficulty when step by step directions were not provided. This was not entirely unexpected because the independent aspect is often the hardest to grasp for students. However, given the important focus of exploratory learning in many labs, this is an issue that will need to be addressed in future offerings.

Future iterations of the workshop might involve two weeks of sessions, with the first week centered around modules akin to the inaugural offering and the second week focusing on more in-depth projects based on student interests. This would better realize the "invention" aspect of the workshop. It is also hoped that future offerings will involve undergraduate STEM majors at Thiel College, allowing them to serve as mentors to the participating pre-college students during the experience. Such interaction should benefit everyone – providing current STEM majors with valuable teaching experience in their fields and giving pre-college students role models in their quest to understand the workshop material.

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