From LEGO(R) to Arduino:
Enhancement of ECE freshman design with practical applications

Carlotta Berry
Daniel Chang
Christopher Miller
June 29, 2016
Lego MindStorms ⇒ Arduino Microcontrollers
Motivation

- Create a stronger emphasis on electrical and computer engineering concepts as early as the first quarter
  - Show what electrical and computer engineers can do
  - Help with retention within the ECE major

- Improve programming and circuit building skills

- Increase the technical rigor

- Encourage a maker spirit
Objectives

• Learn about concepts in electrical and computer engineering, such as electronics, systems, and basic programming

• Learn about teamwork and the design process

• Learn presentation and documentation skills

• Have Fun!
SparkFun Inventor Kit

- Sample programs
- Sample circuit diagrams
- Arduino Uno Microcontroller
- Resistors
- LEDs
- Pushbuttons/Keypad
- Buzzer
- Breadboard
- LCD
- Wireless Transceiver
- Sensors (infrared, temperature)

Donated by Rockwell Collins
Schedule

2 credit hours
Meets twice a week for 2-hour periods

• Weeks 1 - 4  Mini-Projects (8 total)
• Week 5        Midterm Project
• Weeks 6 - 8   Final Project
• Week 9       Competition
• Week 10      Final Report/Presentation
# Grading Scheme

**Individual (60%)**
- Mini-Projects (40%)
  - Demonstration
  - Journal
  - Code
- Midterm Project (10%)
- Participation (5%)
- Quizzes (5%)

**Team (40%)**
- Final Project (20%)
  - Demonstration
  - Memos
  - Code
- Final Presentation (10%)
- Final Report (10%)
Mini-Projects

• Learn to build simple circuits
• Learn to write simple programs in Sketch (similar to C)
• Keep an online journal about what they learned, observed, new skills, challenges, questions
Mini-Projects

1. LEDs (Digital Outputs)
2. Pushbuttons and Potentiometers (Inputs)
3. RGB LED & Buzzer (Outputs) [Video]
4. Temperature Sensor & LCD [Video]
5. Object Avoidance & Motors [Video]
6. Servos & Joystick [Video]
7. Keypad & Relay [Video]
8. Wireless Communication [Video]
Reflective learning journal
• States learning objectives
• High level procedure overview
• Observations
• New skills learned
• Challenges
• Questions
Demonstration and Code

• Show and explain a working mini-project in class

• Submit properly commented code with a header description

• Show efficiency and modularity by using variables, constants, functions, for loops, and conditionals
Midterm Project

- Multifunction Transistor Tester Kit
- Learn how to solder
- Learn how to recognize and test resistors, capacitors, inductors, diodes, transistors
- Keep for Rose-Hulman career
Quizzes

Weekly quizzes

• Hardware Components:
  - Electrical Components

• Software Components:
  - Functions
  - Syntax
  - Conditionals
Final Project

• Build on prior projects (integrate concepts)

• Working in teams of three
  - Alternating roles: Hardware, Software, and Documentation

• Less explicit instruction

• Several milestones and demonstration checkpoints

• Document progress in weekly memos

• Final Project Report and Presentation
Final Project

Simon Says
• 70s Electronic Memory Game
• Add statistics on LCD
• Add rewind mode

• Original Game
• Project Game
• Enhanced Game
Course Evaluations

**Positives:**
1. Appreciated integration of microcontrollers
2. Enjoyed creativity and soldering project
3. Less complaining about paperwork

**Criticisms:**
1. Less explicit instruction on mini-projects
2. More explicit programming and circuit instruction
3. Asked for robots for final project
4. More clear competition rules
5. Schedule too rigorous
Connections to other ECE Courses

**Freshmen:**
- ECE 203 – DC Circuits
- CSSE 120 – Introduction to Software Development

**Sophomore:**
- ECE 230 – Embedded Systems
- ECE 233 – Introduction to Digital Systems
Conclusions

• More instruction on hardware and software concepts in the beginning

• Bring back the robots, but with a focus on sensors and peripherals versus building

• Get more non-ECE majors to register for the course
Conclusions

• Presentations, Reports, and Memos were acceptable although greatly reduced from prior years

• As usual students need more explicit instruction on quality submissions, grammar, spelling, punctuation

• Although some students really struggled in the beginning, most were successful by the end

• No significant change in course grades or evaluations
Future Work

• Create a basic intro to programming and breadboard assignment

• Create more challenging/rigorous mini-projects, final projects, and competitions (remote, sensors, motors, wheels, robot, wireless communication)

• Stagger the soldering tutorials and increase midterm project work time due to space constraints
Questions

www.rose-hulman.edu

berry123@rose-hulman.edu
chang1@rose-hulman.edu
miller4@rose-hulman.edu
Future Work

- Put ethics professional development memo back in the course
- Create competition rules quizzes in addition to hardware and software quizzes
- Consider increasing the number of credit hours to 3 to match the workload