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Using the Internet of Things (IoT) to Motivate Engineering Technology and Management (ETM) Students

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Abstract:

An Internet of Things (IoT) lab activity is introduced into an Engineering Technology and Management (ETM) electronics survey course not only for the pedagogical benefit but as a means to motivate students. Pre and post lab surveys are used to evaluate both the learning and motivational benefits of the lab experience.

The primary objective of this lab is to create enthusiasm for learning. The students use their personal smart phone to connect to the Arduino. This opens up an endless array of possibilities. In addition the lab supports the following learning outcomes: students have experience with networking, and students create an IoT application.

The existing electronics survey course uses the Arduino Uno as a platform to introduce real time programing and basic electronics. An additional lab activity is introduced using the IoT. The lab uses an IoT package called Blynk [1], www.blynk.cc. Blynk has an Arduino library that provides an interface to the Blynk server. The student must create code to interface between the Arduino Input Output (IO) and the libraries. The Arduino is connected to the Blynk server via the USB programming interface. The student then down loads the Blynk app to his/her phone. Once the Blynk app is configured the student can communicate wirelessly between the phone and the Arduino. Based on random observation the student's response is typically "cool".

The Blynk software and app are free. There is enough "energy" (credit) included with the app download to allow the student to complete the lab activity at no cost. Additional "energy" is available for $0.99 in case the student makes a mistake or wants to try to explore other applications.

Measuring "cool" is difficult but pre and post lab surveys are used to judge the students reaction to the lab experience. The resulting data is analyzed. The results are used to determine if the IoT lab should be made a permanent part of the course.

Introduction:

One of the issues with an electronics survey course is that the many students see the course as just another obstacle to graduation. Some students enjoy the projects and some don't. On the first day of the course the students are given a brief overview of the course and the applications of electronics. One of the items covered is a demonstration of Internet of Things (IoT) using an Arduino and a cell phone. The students are given a brief survey at the end of the class and 8 out of 37 (21%), indicate they are interested in IoT. We know students are enamored with their devices, and it would be interesting to see if this could translate into enthusiasm for electronics.

With this in mind, a lab was created with the following goals: 1) Engage students in the electronics class. 2) Provide meaningful learning outcomes. After discussion with associates in the department the following learning outcomes were established: 1) Students have experience with networking. 2) Students create an IoT application. The lab described here both engages students, and introduces the students to networking, and the IoT.

In [2] Abraham uses the IoT as means to foster interest in Electrical Engineering among pre engineering students. Her students are in a position to select between Electrical Engineering and another engineering major. In this paper the choice is between surviving electronics, and embracing it. Here IoT is used to engage Engineering Technology and Management (ETM) students, choosing to do more than survive. The students are not Electrical Engineering, or even Electrical Engineering Technology students. They learn welding, casting, machining, plastics, operations, quality, and business, in addition to programming and electronics. The students take two programing courses, and this electronics course. The electronics class is a junior level survey course in Engineering Technology and Management. Electronics is important in industry so engaging the students in this course is the only opportunity they have to learn this material.

In [3] Abraham goes on to develop the creation of an Innovation Laboratory at Seattle University. This laboratory is for the Electrical and Computer Engineering (ECE) courses, and goes beyond the requirements of the ETM students considered here.

Additional literature regarding instruction in IoT includes de Haan who uses the Arduino to teach IoT in a Media Technology course [4] [5]. Bruce uses the Raspberry Pi (RPi) in college level computer science education [6]. He uses the BeagleBone Black board [7] for an IoT relevant capstone project in technology education focusing on networks. Abraham [2] uses ThingWorx [8] as the software platform, and Arduino, or RPi as the hardware. Mullett [9] uses Arduino, or RPi as the hardware. Finally, Keinde [10] uses Blynk [1] as the software platform.

The existing class uses the Arduino as a platform to teach electronics, electrical components, power, and real-time programing. Each student has an Arduino and the components necessary for the laboratory activity, and every student has a smart phone. For our course the Arduino is the preferred zero cost option for the hardware. Blynk is chosen for the software platform because of the student friendly application development environment.

Lab Activity:

The lab activity allows the student to connect his/her smart phone to the Arduino via the "Cloud". This is shown graphically in Figure 1. The smart phone at "A" communicates wirelessly via the carrier to the internet, and the Blynk Server [1]. The Arduino is connected to the student's computer via the USB interface, and a serial connection is established to the cloud. Digital and analog data are transferred from the smart phone to the Arduino, and from the Arduino to the smart phone.

The connection between the smart phone and the Arduino provides a perfect opportunity to explore network connectivity. This course and this lab are the only opportunities for the students to learn these important techniques. As part of the pre-lab lecture the topics of Internet Protocol (IP) addresses, Media Access Control (MAC) addresses, and Terminal Control Protocol (TCP) IP are discussed. The OSI seven layer model is introduced, as well as the differences between the Open System Interconnection (OSI) model and TCP IP. The basics of wireless versus open communications and how this relates to the project are all part of the pre-lab lecture.

Figure 1 The Internet of Things (IoT) lab activity connects the students phone "A" to the Arduino "B". Includes public domain images.

One example used in class is an electric smoker. The smoker is an IoT device. The user starts and stops the smoker, and sets the temperature from his/her cellphone. The IoT device reports the temperature of the meat, and the on off status of the heating element. This is represented in the lab by using a potentiometer, a button, and some LEDs.

Students wire the components as shown in Figure 3. At this point in the course, approximately week ten, the students have some proficiency in this task. Normally in a group of 34 students there would be several that would have trouble wiring the components to the breadboard. In this case there were no wiring errors. Anecdotally this might suggest that the students were more engaged, and therefore less likely to make wiring errors.

The potentiometer is connected to the Arduino pin A0, and drives the "Gauge" display on the smart phone Figure 4. This is done by specifying the Arduino input pin A0 in the settings for the gauge widget on the smart phone Figure 2. Students are not required to program the Arduino, this allows them to concentrate on the cell phone app and not the details of the Arduino Blynk code. Examples and web-based code generators are available for the student should they decide to explore further.

The Blynk app comes with an energy balance of 2000. The slider and button each cost 200 the LED is 100 the gauge are 300 for a total of 800 energy points for the application. The student can complete the application at no cost using the energy that comes with the app. If the student makes a mistake or would like additional energy for further exploration additional energy points can be purchased at various rates from 100 four $0.99 through 28,000 for $19.99.

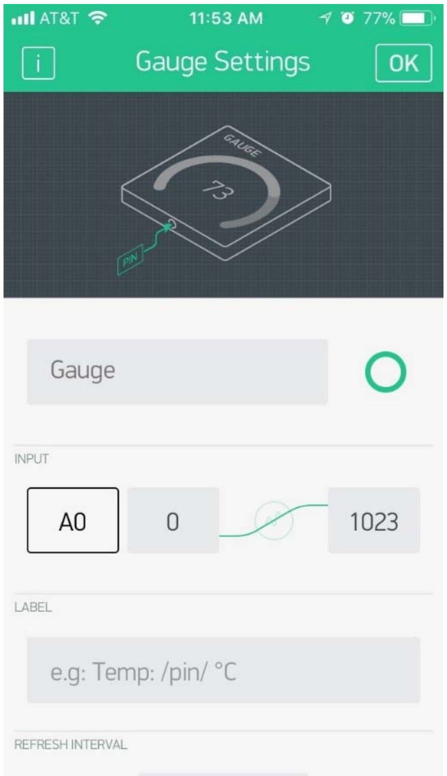

Figure 2 Gauge settings for the Arduino analog input A0.

The pushbutton connected to D7 of the Arduino controls the "LED" on the smart phone. This demonstrates analog and digital communication from the Arduino to the phone. This could be used to transmit the temperature of a smoker to the phone, analog, and the on / off state of the heating element, digital, from the IoT device (Arduino), to the smart phone.

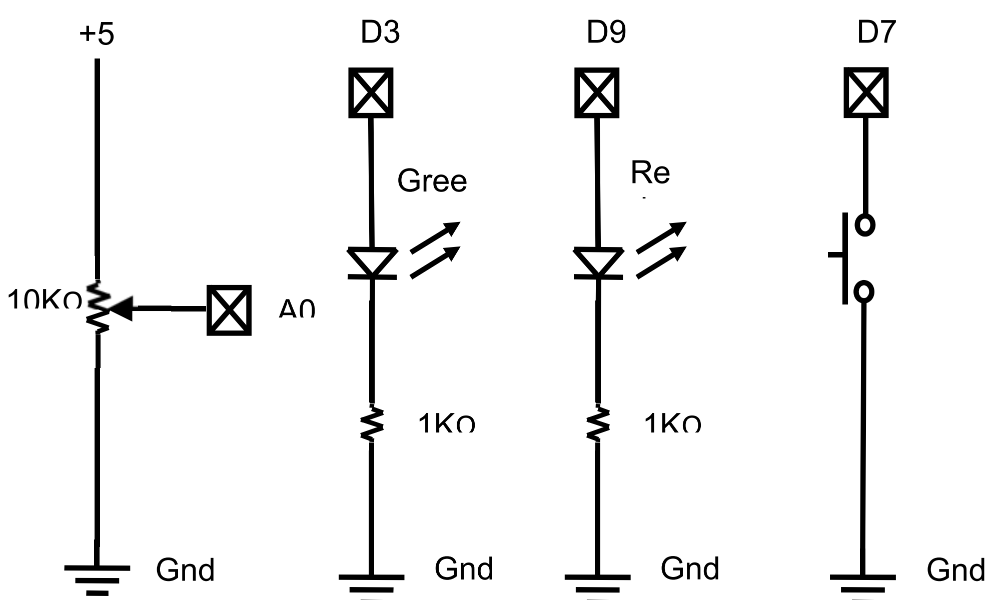

Figure 3 Arduino Input Output (IO) schematic used for the IoT lab.

Like-wise analog and digital data can be transferred from the phone to the Arduino. In the example of a smoker, the user could set the temperature reference from his/her phone, analog, and start or stop the smoker, digital. The “slider” in Figure 4 drives the green Light Emitting Diode (LED) connected to D3 in Figure 3. D3 is a Pulse Width Modulation (PWM) pin and varies proportionally with the position of the “slider”. The “Button” in Figure 4. Toggles the red LED on the Arduino. Again both analog and digital data is transmitted from the phone via the cloud to the Arduino.

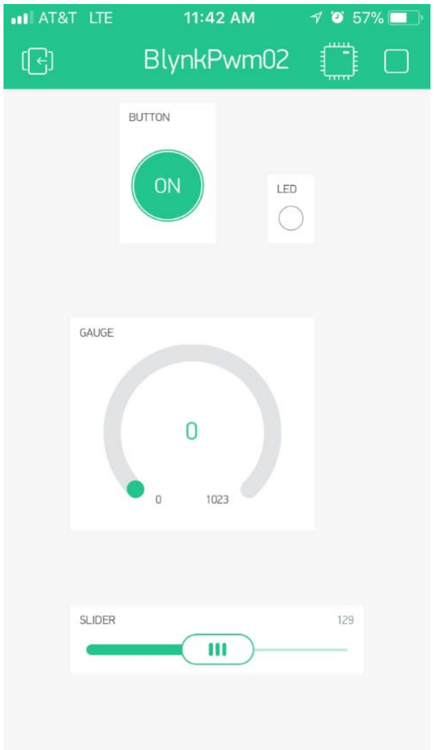

Figure 4 Blynk App configured by the student.

The student activity is designed to allow successful completion of the lab in two hours. The students wire the circuit shown in Figure 3. They download and install the Blynk libraries for the Arduino. The Arduino sketch is short but it is a bit cryptic so the students are given the sketch. This is uploaded to the Arduino. The student downloads the Blynk app on his/her phone and configures the app. Step by step instructions are given for each of the devices on the phone app. Finally the student modifies and executes the serial interface. When all is working, the students are required to demonstrate the system. Thirty-one of the thirty-five students were able to complete the lab in the allotted time. Part of the lab package included a four question post lab survey.

Survey / Results:

Pre and post lab surveys were used to collect data on the lab activity. The four open ended questions are:

1) Of the topics we have discussed so far, what do you find the most interesting?

2) Why does this interest you?
3) What topic do you think will be the most difficult?
4) Is there anything that the instructor can do to help you with the most difficult topic?

The first two questions pertain specifically to this paper. At the beginning of the class the students are presented with a variety of topics. These include, the Arduino, a Smoker, a pick and place robot, IoT, the final project which is an autonomous car going through a maze, and a prototype windshield wiper lift. Of 37 students given the six topics, eight were interested in IoT, five in the pick and place robot, and the rest were nonspecific. Of the eight which answered IoT five answered question two with some form of "endless possibilities."

Of the 37 students surveyed during the initial class meeting, 34 completed the lab and the second survey. Of the 34 students participating in the lab 24 students said the most interesting topic was IoT. Of these nineteen indicated that they were interested because of the "endless possibilities." In addition seven included some version of "cool" including "pretty cool", "very nice",and "amazing" in their answer to question two. Typical answers to questions 1 and 2 are: "This, current lab has been interesting as it relates one of our commonly used tools, the smart phone / cell phone, and it shows how to connect or Arduino computer to the server to our phone.", and "This is interesting to me because it shows how to implement an Arduino to the phone connection which is the type of program app developer's use.".

Questions three and four were used in an attempt to ensure that the presentation did not change between the two surveys. Pre-Lab survey responses for question three, what will be the most difficult, were scattered evenly between coding, wiring, and nonspecific responses. For question four, what can the instructor do …, the overwhelming response was slow down. The post-lab survey was conducted about ten weeks after the Pre-lab survey, and as part of the lab. For question three the dominate response was coding, followed by wiring, and schematics. For question four, the most common response was slow down.

For question three the response varied somewhat from pre to post survey. This is likely due to greater exposure to the material. The fourth question was unchanged. This indicates that instruction did not change appreciably over the pre / post survey period.

Conclusions:

A number of IoT experiments have been covered in the literature. These are performed with a variety of hardware and software platforms. Students are enamored with their smart phones and so a lab experiment that uses the smart phone might appeal to students. The lab described here use the Arduino, and Blynk to allow the student to interface between their smart phone, and the Arduino. Analog and digital connections in both directions are demonstrated. The lab is concise and fits neatly in a two hour window.

Based on the results of the lab there are some "next steps". The first would be to add additional IoT projects to the existing course. These might include an IoT thermostat, an IoT meat smoker, or an IoT coffee pot. One issue with this is that it would compete with existing requirements for the course and may not appeal to all students. Alternatively an elective follow on course could be developed to provide students with additional projects and more insight into networking. There are a number recently introduced Industrial IoT (IIoT) development platforms available that could be used to extend the capabilities beyond that which is possible with an Arduino Uno.

The lab meets the learning objectives. Students create an IoT device, the Arduino, and the smart phone application, Blynk. Students are introduced to networking. Based on the pre-and post-surveys the students are interested in the Internet of things, and the IoT lab generates enthusiasm for the course. The students enjoyed the opportunity to use their smart phones as part of class, and appreciate “endless possibilities.”

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