MICROCONTROLLER PLATFORM FOR THE ACCESSIBILITY APPLICATION DEVELOPMENT

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ABSTRACT

A development platform and related course materials were developed to provide deaf and hard-of-hearing students a visual development environment which allows them to develop a cost effective, customizable application for different possible accessibility solutions that will benefit the deaf and hard-of-hearing community. The development platform is based upon powerful microcontroller with Bluetooth and Wi-Fi technologies and it can be used for a wide variety of accessibility applications. There are three different configurations that the platform can provide: as a standalone device, device to device and device to app on the smart phone. This technology can ultimately be used to improve access to a wide variety of electronic and communication devices, while the students can learn in developing real-life solutions. Because of on-going development of specific solutions for the accessibility needs, it was cost effective and reduced the development cycle by creating a common platform as a base for most solutions. The benefits are low cost and small physical footprint; students' experiences and involvement; ability to move from research to commercialization and teaching. The course materials cover the basic concept of building hardware and software solutions. The students learn the functions of different components and programming. For a "best practice" approach to teaching a microcontroller, a variety of real-life examples or analogies can be given to help make that cognitive connection for the student. This provides a deeper understanding of software/hardware computer interfacing theory and applications. The students gained the benefits of learning the real solutions to real problems.

INTRODUCTION

Teaching engineering for deaf/hard-of-hearing (DHH) students presents several challenges as well as many rewards. For DHH students to be mainstreamed into a regular engineering program presents a series of barriers that they need to overcome. DHH student's learning characteristics are more like as foreign students since for them, written and spoken English is their second language with a steep learning curve to learn it at the same time they assimilate engineering course material. Engineering course material generally does not consider any type of learning accessibility for DHH students. While the university provides resources (such as e.g. sign language interpreters, note takers, real time captioning and specialized mentoring faculty), the instructor in the classrooms and/or the laboratories sometimes are not suited for the learning environment of a DHH student. For example, during a lecture, DHH students have to pay attention to the sign language interpreter to understand what the instructor is speaking, but they also need to divert their vision to the notes on the whiteboard/presentation slides and to the microcontroller development kit—forcing them to miss what the instructor is saying. This results in what Mayer, Heiser, and Lonn (2001) have identified as cognitive constraints on multimedia learning. Furthermore, such multiple presentations of information force students into a multitasking mode that may hinder their ability to focus (Richtel 2010). The ideal solution is to have the instructor make adjustments to utilize more visual strategies of teaching in a sequential logical manner that allows DHH students to focus and process relevant content without missing out on parallel messages that are being presented verbally by the instructor. What's even more challenging is that sign language is an idea oriented language not a verbose word-by-word interpretation. The difference between a classroom and a typical engineering lab is the addition of a computer, instrument, or a development kit such as a microcontroller kit in front of the student. The instructor needs to ensure that the DHH student has a chance to see all information before the instructor can proceed with the lecture or lab exercises.

BACKGROUND

The Internet of Things (IoT) is the currently driving technological force of global markets over the next several years. Many companies are focused on the IoT as revenues based on new products and services. One of major benefits of the IoT is to improve productivity and save costs. Consumer demand is also driving IoT adoption as the embrace new technology to improve health, energy savings and safety that will make new things we haven't even thought of yet. For example, due to the advent and heavy use of smartphones, they are now becoming the personal gateway to the IoT as shown as Figure 1.

Figure 1. *High–level Design Overview*

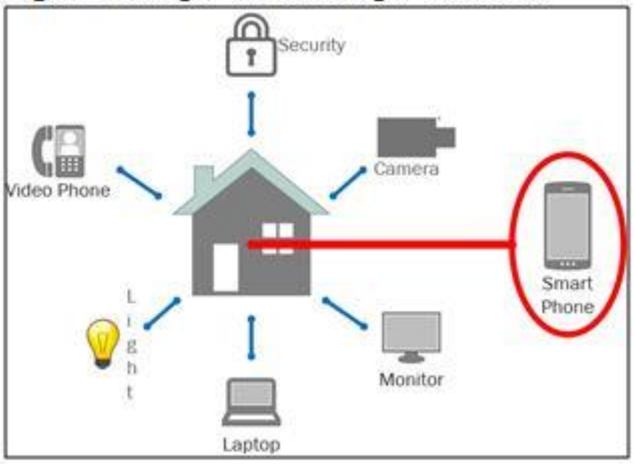
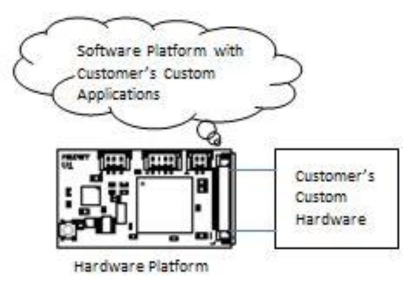


Figure 1 illustrates the connectivity between different control devices with computer based devices (smartphone and laptop). Based on this high-level design, there are three basic system configurations that IoT can be designed to meet the consumer's needs. The first configuration is a "Stand-alone Device". As an example of a door bell device, when someone rings the door bell, the stand-alone device detects the doorbell, it notify the person through a light flash. In Figure 2, there is a list of applications that are based on stand-alone device design. It can be either device to person or person to device.

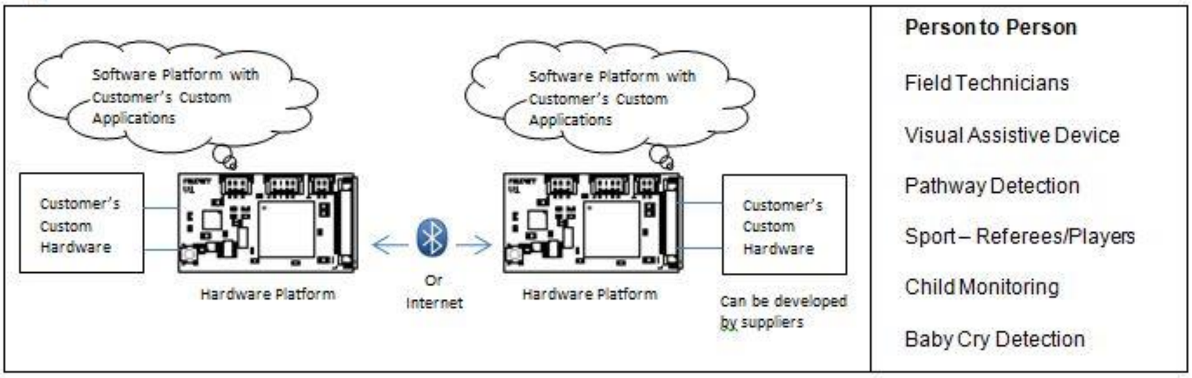
Figure 2. *Stand–alone Device*



Device to Person	Person to Device
Doorbell	Remote Control - PC projector
Alarm Clock / Timer	Remote Control - Lights
Medical Instrumentation	Remote Control - HC Door Opener
Marathon distance/pedometer	
Child Monitoring	
Baby Cry Detection	

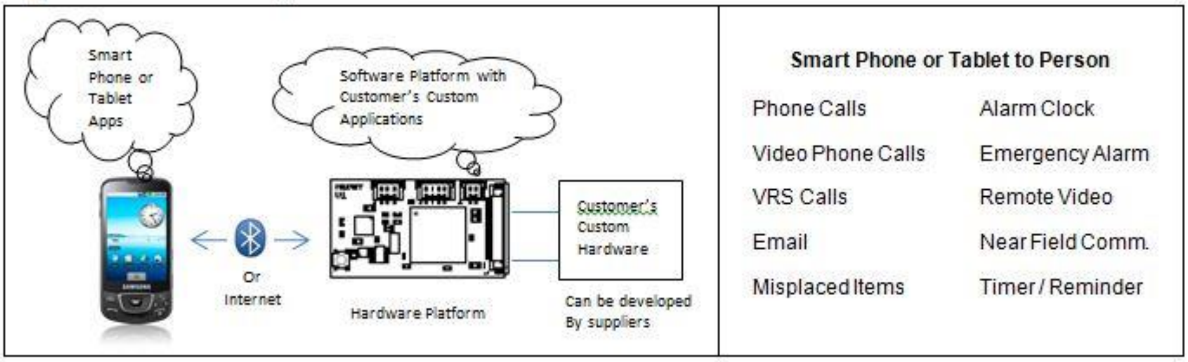
The second configuration as shown in Figure 3, is "Device to Device" and the purpose is for both devices to communicate remotely with each other's (person to person) to meet the application needs. As an example, a baby cry detection application is very common among the deaf community. The first device is configured as a sound detection and usually it is close by to a baby. When the baby cries, the sound detection notifies a person through the second device such as a flasher. The function of the second device provides notification to the person through a light flash or a bed shaker.

Figure 3. *Device to Device*



Third configuration is probably the most common IoT application which is a device to an application on a smartphone or a tablet as shown in Figure 4. The smartphone communicates the device through either internet or Bluetooth technology. A common application is when a smartphone receives video relay service (VRS) call, the smartphone notifies the person through the device such as a flasher.

Figure 4. *Device to Application*



CURRENT TEACHING MATERIAL

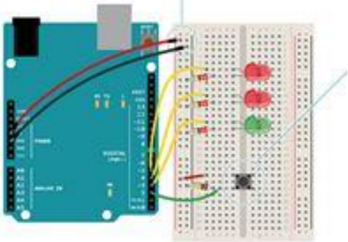
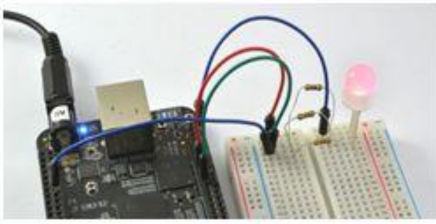
As mentioned before, engineering course material are generally not considered any type of learning accessibility for DHH students. This paper only focuses on the course material for the microcontroller development kit. A typical IoT device consists of a microcontroller with network connection and sensors as a hardware and embedded software as application. Companies offer their various fast paced microcontroller starter kits including course materials to cover the basic concept of building hardware and software solutions and develop students' IoT technical skills. In an ideal educational setting, DHH students should be able to learn the IoT through a visual development environment. The goal is to give and encourage them a way to quickly create popular smart device prototypes and services smoothly.

Based on our teaching experience at a university, a large number of DHH students struggle in learning the concept and development of microcontroller applications. A development platform and related course materials were developed to provide DHH students a visual development environment which allows them to develop a microcontroller application visually. When the DHH students learned the basic, they usually like to develop a cost effective, customizable application for different possible accessibility solutions that will benefit the DHH community. In the next two sections (Hardware and Software) the comparative analysis was observed to indicate the difference between a typical list of educational manual instructions for developing IoT solutions using embedded hardware and software.

Hardware

Various major hardware platforms such as Arduino, Raspberry Pi, Beaglebone, Netduino, etc. consisted of a microcontroller, a LED, various sensors (i.e. sound or motion detection) are available with their educational resources. In Figure 5, as an example of the two different illustrations for the hardware setup. Arduino's illustration on the left has better layout and based on our observation, DHH students can follow the instruction closely to connect wirings correctly.

Figure 5. Comparison of Two Visual Illustrations

	
Easy to Follow Illustration Source: Arduino	Difficult to Follow Illustration Source: Beaglebone

Software

Various major software programming like Java, C#, and C/C++ are available with their educational resources are available with their educational resources. Technical courses related to programming and networking are usually challenging for DHH learners. A cognitive connection between the abstract concept and the 'real world' meaning needs to occur for learners to be able to apply what they learn. One of most challenging is to learning programming languages. In Figure 6, as an example of the two different illustrations for the software development. The illustration on the left side, the software code is much clearer than the codes on the right. Code on the left has additional comments so that DHH students tend to follow closely and do it correctly.

Figure 6. Compared Concepts and Explanations

/ Blink* *Turns on an LED on for one second, then off for one second, repeatedly.* **/* *// the setup routine runs once when you press reset:* void setup() { *// initialize the digital pin as an output.* pinMode(led, OUTPUT); } *// the loop routine runs over and over again forever:* void loop()	#include <iostream> #include <stdio.h> #include <unistd.h> int main(){ cout << "LED Flash Start" << endl; FILE *LEDHandle = NULL; for(int i=0; i<10; i
Easy to Follow Concept and Explanation Source: Arduino	Difficult to Follow Concept and Explanation Source: Beaglebone

BEST PRACTICES

Engineering course material needs to be considered for any type of learning accessibility. Use of real-world examples and visual materials assists the student in grounding the information, which provides a platform to build later concepts upon.

For the real-world examples, the instructor can start with IoT Stand-alone device as shown in Figure 2. The first application can be setup as shown in Figure 5 and 6 which will allow the DHH students to develop the blinking LED application and see how it works visually. Then, as the DHH students build the foundation of understanding the concept of microcontroller, they can start developing applications as IoT Device to Application as shown in Figure 4. This will allow the students to build on their own experiences, and relate the concepts to things that have meaning in their own world. This can be an on-going development of specific solutions for the accessibility needs. This approach is cost effective and shorter development cycle by creating a common platform as a base for most solutions. The benefits are low cost and small physical footprint; students' experiences and involvement; ability to move from research to commercialization and teaching.

For the visual materials, it is required to take time for reviewing their various educational resources that will fit the best visual development environment for DHH students to learn and develop the IoT applications efficiently.

Below is a list of different example of visual material techniques,

- Work with DHH students to improve visual materials.
- Perform experiments with what works best within the realm of each material.
- Develop software program / hardware solutions that can be related to accessibility needs.
- Include IoT to the real world applications.
- "Walk with students" on some examples to get their visual perspective.
- Demonstrate the final solution so that DHH students know what to expect during the lab activities.
- Ensure students that they have a basic knowledge of hardware/software computer interfacing theory and applications.

It is important to know where your students are starting from (base knowledge) and to guide them from their current understanding of concepts and build on this knowledge. It is crucial for DHH students have a clear understanding of sequential patterns which is related to programming. Luckner, Bowen, Carter (2003) examined the sequential patterns as a way to teach DHH students the problem/solution-type situations. This enables students to build deeper knowledge of the concepts, and to apply them to the world, thus becoming problem-solvers.

CONCLUSION

As visual material techniques, instructors familiarize learning accessibility to help visual students maximize their learning time for choosing visual materials. This includes written words, line drawing pictures, detailed drawing, computer generated pictures, and real objects that visual students can recognize easily as suggested by Luckner, Bowen, Carter (2003). Combinations of words and some form of graphics including step by step is usually the best choice. Visual materials can be a 'tour guide' for your students. When giving examples related to coding, 'walk' the students through the code line by line including the code comments to develop "constructing" knowledge. Visual materials should include the transition from abstract to real concept. While the problems and practices are geared towards DHH students, traditionally, these techniques also benefit to any other differently enabled learners.

By the time students develop the knowledge of the concept, hardware, and software they will have a better understanding of hardware and software concepts by providing variety in lab activities with proper visual materials. The students gained the benefits of learning the real solutions to real problems which will prepare them well for their employment opportunity.

The key is to be flexible and acknowledge that some techniques do not necessarily benefit DHH or hearing learners! By enabling the DHH students, we are providing a good educational experience for ALL students

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