Programming Radios for K12 Curriculum

Rafer Cooley, Shaya Wolf, and Dr. Mike Borowczak
[rcooley2, swolf4, mike.borowczak]@uwyo.edu
University of Wyoming, CEDAR Lab & Center

Abstract: Modern technology has developed to the point that the ease of use often allows many users to overlook the actual processes occurring inside of these devices. However, we propose that a basic conceptual understanding of the underlying technology will enable increased ease of use of the services provided by such technology as well as the necessary knowledge to protect oneself in an ever-increasingly digital era. The modern teenager is the first generation to be defined as Digital Natives, in other words they have grown up immersed in the modern technological era and have not experienced life otherwise[1]. However a problem arises with this where these users of technology did not experience the previous versions of such or witness the progression of improvements made and therefore may not fully understand how the technology functions. This is why we propose a workshop aimed towards upper level high-school students, using low-cost cyber-physical computing boards to actively engage students and develop a realization of how this technology works through and informational and practical workshop. The workshop will present the technological processes through basic Computer Science and Cybersecurity concepts while the activities contained within the workshop shall be tiered so as to accommodate ranges of students from those who have never programmed before to students who actively engage in computer science activities but may not have experienced computer code influencing real world objects such as robots. Using the Micro-Bit development boards developed by BBC, we have developed an engaging set of activities to help teach basic Computer Science principles while also educating students about Cybersecurity topics and best-practices.

FOCUS

During our workshop activities we would like to focus on developing an understanding of a technology that is used by around half of the population of the world[2]. The Digital Native generation has proven to be generally adept with the use of technology within their lives but not necessarily knowing how that technology works. This is potentially dangerous as many modern technologies have been known to be flawed in terms of security and/or privacy which could lead to undesired consequences arising from the use of this technology. By teaching participants how to use and break radio communications we hope to show through demonstration and hands on activities how participants can use this technology more securely and responsibly.

LEARNING OBJECTIVES

Specific: Students will learn how to develop and program using the Micro-Bit development board and online IDE. While using this environment participants will learn foundational principles about radio communication which will be related back to their personal experiences with the technology (i.e. wifi). After learning the basics of radio communication participants will then use this knowledge to first transmit messages to a partner using the radio transceivers provided on the MicroBit board. Then participants will learn how to intercept and inject messages from/to other's communication streams. Participants will then use deterrence measures presented to them to program wireless controllers for robots which are also controlled by MicroBit boards, then stress test other groups deterrence measures to show their efficacy.

Measurable: Skill development can be measured through checkpoints built into the workshop by determining whether participants can successfully pass messages over the air to their partners and whether they can successfully send operational signals to the robot. The next measurable will then be whether or not the participants can successfully intercept messages sent by other groups. Finally we will be able to qualitatively measure the extent to which each groups deterrence measures work or not based on the amount of others able to control their robot.

Achievable: From prior experience we believe that the students will have little to no difficulty accomplishing the tasks put forth in this activity. Those past experiences, however, have also shown that some teachers require more time to accomplish some of the tasks, so we anticipate modifying

Relevant: In order to complete the workshop tasks, participants will gain knowledge pertaining to the technology that is used in each of their wireless devices. The ease of use of modern day mobile technology often makes it easy to overlook or dismiss the underlying technology when a rudimentary understanding could enable even more capabilities and ease of use.

Time-Bound: From previous activities of a similar nature we believe that our 4 checkpoint activities can be accomplished within the 60 minute time allotment. We believe that those who are interested will desire to remain longer than the 60 minute allotment as our last activity is an exploration session.

INSTRUCTIONAL STRATEGIES

The main strategy we will be using in this workshop will be short instructional lectures for each checkpoint followed by hands-on, learning by doing activities. The time slot given for the workshop will be divided into several distinct yet related activities depicted in the outline below. Workshop leads will give a short presentation at the beginning of each activity describing the relevant Computer Science and Cybersecurity principles followed by examples of how those principles can be applied within the MicroBit environment. The very last activity of the workshop is a guided free exploration session to encourage creative problem solving among participants.

OUTLINE

The following steps are the planned sequence of checkpoints to be accomplished within a 60 minute time block.

1. (5 min.) Introduce the attendees to the MicroBit environment and boards. Each participant will be assigned a computer and a MicroBit board for development. After explaining all of the different features and functionalities of the boards we will continue to demonstrate the different categories of program blocks available in the browser-based IDE.
2. (15 min.) Participants will then be given an introduction to radio communications with respect to the MicroBit boards including an overview of radio groups/channels, how to send and receive messages, as well as the additional information that is associated with the messages(i.e. time sent/received). After this introduction, participants will be grouped into pairs with each pair being assigned a unique number. Groups will then be tasked with sending a hello-acknowledge sequence back and forth between devices on the channel corresponding with their assigned numbers.
3. (10 min.) After successfully sending messages back and forth on their respective channels, groups are then tasked with snooping on the communications of other groups through the switching of channels. To accomplish this participants must program the functionality to be able to increment/decrement radio group after a button click.
4. (10 min.) Participants are then shown basic encoding techniques that could be used to deter sniffing and spoofing of messages between MicroBits. These will include but is not limited to methods such as a Ceasar Cipher, shared keys, and message signing.
5. (10 min.) Participants are then given a robot that can be controlled by a MicroBit as well as the code necessary to provide basic movement and communication functionality between a MicroBit remote control and MicroBit robot controller.
6. (10 min.) The workshop will then conclude with an exploratory session encouraging participants to explore possible deficiencies of other groups defense strategies. An example will be given through an explanation of how the presenters have performed replay attacks against previous students
7. The link to a post-activity feedback form will then be given to the participants to fill out and provide valuable feedback to determine which methods worked and which need refining.

RMS ASEE TARGET AUDIENCE

Our target audience will be junior high and/or high school students and teachers. We believe that students will find our activities both interesting and fun while we hope that teachers will take the lessons and materials we present and then modify them for incorporation into their classes curriculum.

PRESENTER CREDENTIALS

The presenters have both developed and presented similar materials to this activity at the GenCyber Wyoming summer camp in 2018. This camp was aimed at helping students in rural areas of Wyoming interested in computer science and cybersecurity while providing them with cheap hardware and the knowledge they need to explore their interests further.

REQUIREMENTS

Our activity is best suited for a computer lab where students can each have their own computer. No special software will be needed as our development environment can be reached through a web browser. We only require participants to bring a curious attitude. We will be able to provide a limited amount of MicroBit boards and accompanying MicroBot robots.
An ideal number of students would be 20 while our max capacity would be 30 students, due to limited supplies of Micro-Bit boards.

REFERENCES

[1] Qiu, W., & Zhao, Y. (2009). Game Design as a Compelling Experience. In R. Ferdig (Ed.), *Handbook of Research on Effective Electronic Gaming in Education* (pp. 1041-1056). Hershey, PA: IGI Global. doi:10.4018/978-1-59904-808-6.ch060

[2] World Internet Users Statistics and 2019 World Population Stats. (n.d.). Retrieved from https://www.internetworldstats.com/stats.htm