Board 388: Student Engagement - IoT-Based Learning Materials and Projects

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Student Engagement – IoT-Based Learning Materials and Projects

Abstract

Even with a return to in-person learning by many institutions since the COVID-19 pandemic, many educational institutions continue to offer a plethora of online learning opportunities for students. Student experience with hardware-based applications and projects though can be somewhat limited for engineering and computer science courses not offered in in-person educational settings. Problem-based learning exercises enable students to learn skills for analyzing or solving problems and processes in STEM applications and projects.

We describe ongoing activities at two Hispanic Serving Institutions (HSIs) for the development of engaged learning exercises and associated materials for two different IoT-based kits, one centered around a Raspberry Pi with associated sensors and actuators and a second commercial-off-the-shelf kit developed around a BeagleBone Green microcontroller with connected sensors and communication components. The Internet of Things (IoT)-based kits have been utilized to facilitate practical hardware experiences for remote student learning.

In this research we are currently concentrating on two research questions: Can transfer of learning be successfully achieved in remote hands-on engaged student learning (ESL) scenarios? and How well do online tutorials contribute to hands-on ESL, when coupled with physical hardware accessible at home? Preliminary assessment demonstrates that students benefit from the access to IoT-based course materials and many students incorporate IoT-based aspects into their senior design capstone projects.

Introduction

Internet of Things (IoT) capable products and applications continue to become more prevalent. As memory, digital storage, stand-alone processors, sensors, cloud-based storage and communication services have continued to generally become more affordable and readily available, research on new IoT applications continues. This project has developed materials on IoT concepts to facilitate students gaining hands-on IoT experience. The students working with the materials and or working on IoT related projects are enrolled in one of the following: 1. an Independent Study course in which the student learns about IoT and works on a project that utilizes IoT functionality, 2. a two-semester Capstone Senior Design course in which a student team works on a project that utilizes IoT functionality, or 3. a course on Sensors that includes an IoT-based sensor related project.

Background

The COVID-19 pandemic ignited a move by many universities and colleges to increase online or remote learning [1]-[12]. In this project, we describe ongoing activities at two Hispanic Serving Institutions (HSIs) for the development of engaged learning exercises and associated materials for two different IoT-based kits, one centered around a Raspberry Pi with associated sensors and actuators and a second commercial-off-the-shelf kit developed around a BeagleBone Green microcontroller with connected sensors and communication components. In this project, five lab exercises to introduce students to an IoT-based system using a motor and a sensor were

developed for a Raspberry Pi based system as discussed in more detail in [6]-[7]. These exercises were then ported to C as reported in more detail in [8] to be used on a Keysight IoT kit [13] that uses a BeagleBone Green microcontroller. More advanced exercises utilizing the Keysight kit are currently being developed; example topics include Xbee based communications for use with IoT as detailed in [14].

Example IoT Student Projects

Preliminary assessment demonstrates that many students incorporated IoT-based aspects into their senior design capstone projects. In Spring 2023, three capstone senior design IoT related projects involving a total of 16 students were completed at TAMUCC. These projects included 1. IoT-enabled Unmanned Traffic Management (UTM) System,[15], 2. Silver Security: IoT-based Home Security System for Elderly Care as shown in Figure 1a) [16], and Sand Scorpion: Metal Debris Detecting Robot with IoT [17]. In Spring 2023, three capstone senior design IoT related projects involving a total of 10 students were completed at TAMUK. These projects included 1. Real-Time Monitoring of Groundwater Levels in Wintergarden Region [18], 2. Database Website for Pressure Readings [19], and 3. Digital Pressure Recorder as shown in Figure 1b) [20].

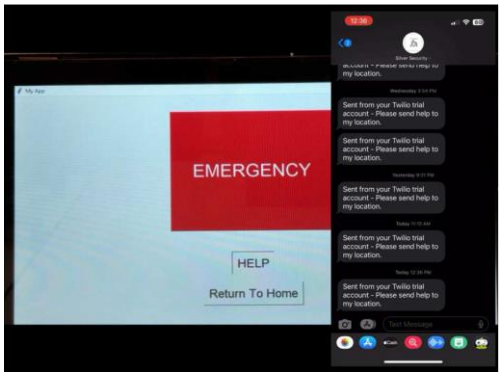

Figure 1 a) Silver Security Help Screen [16] 1 b) Digital Pressure Recorder [20]

Research Questions

Preliminary assessment demonstrates that students benefit from the access to IoT-based course materials. This paper addresses two research questions:

RQ1. Can transfer of learning be successfully achieved in remote hands-on engaged student learning (ESL) scenarios? and
RQ2. How well do online tutorials contribute to hands-on ESL, when coupled with physical hardware accessible at home?

Assessment

An IoT survey was given to the students to ascertain what the students have learned about IoT related concepts and knowledge. Eight survey questions related to research question RQ1 are the following [21]:

1. I understand my instructor's lectures and tutorials.
2. My instructor's lectures help me complete my work.
3. I have been able to transfer (use) the math I previously learned to my remote IoT-based assignments.
4. I have been able to transfer (use) what I learned in previous engineering and/or mathematics courses to my IoT-based assignments or projects.
5. I am able to model sensor behavior or sensor data from my IoT kit.
6. I was able to model sensor behavior or sensor data from my IoT kit using mathematical equations.
7. I was able to make connections between the abstract mathematics learned in calculus, linear algebra, statistics, and the physics-based applications in sensor networks.
8. I was able to apply uncertainty analysis to my IoT-based work.

There were thirteen survey questions related to research question RQ2. Seven of those survey questions are included below [21]:

1. I understand my instructor's lectures and tutorials.
2. My instructor's lectures help me complete my work.
3. The website and tutorials are useful for the IoT kits and projects.
4. I feel I receive enough support for my IoT-based assignments and projects even when not on campus.
5. I have used tutorials and demos to learn about IoT kits and their applications prepared by my instructor or TA.
6. I have used tutorials and demos to learn about IoT kits and their applications through external resources, such as the internet.
7. I find the tutorials and demos prepared by my instructor or TA to be useful.

The senior undergraduate students in the TAMUK Senior Capstone Design course who completed the survey (7 students) responded Very True (average of 50%) or Mostly True (average of 12.5 %) as seen in Table 1 for RQ1 and responded Very True (average of 54.7%) or Mostly True (average of 12.8 %) as seen in Table 2 for RQ2.

Table 1. – Research Question RQ1 Related Survey Results

Question (see above)	Very True	Mostly True	Somewhat True	Not True	N/A or Unsure
1	71.4 %	14.3 %	14.3 %	0.0 %	0.0 %
2	71.4 %	28.6 %	0.0 %	0.0 %	0.0 %
3	28.6 %	28.6 %	0.0 %	0.0 %	42.9 %
4	28.6 %	28.6 %	0.0 %	0.0 %	42.9 %
5	57.1 %	0.0 %	14.3 %	0.0 %	28.6 %
6	28.6 %	0.0 %	42.9 %	0.0 %	28.6 %
7	71.4 %	0.0 %	28.6 %	0.0 %	0.0 %
8	42.9 %	0.0 %	14.3 %	0.0 %	42.9 %

Table 2. – Research Question RQ2 Related Survey Results

Question (see above)	Very True	Mostly True	Somewhat True	Not True	N/A or Unsure
1	71.4 %	14.3 %	14.3 %	0.0 %	0.0 %
2	71.4 %	28.6 %	0.0 %	0.0 %	0.0 %
3*	33.3 %	33.3 %	0.0 %	0.0 %	33.3 %
4	42.9 %	0.0 %	14.3 %	0.0 %	42.9 %
5	71.4 %	0.0 %	0.0 %	0.0 %	28.6 %
6*	83.3 %	0.0 %	0.0 %	0.0 %	16.7 %
7	57.1 %	28.6 %	0.0 %	0.0 %	14.3 %
8	57.1 %	14.3 %	14.3 %	0.0 %	14.3 %
9	71.4 %	0.0 %	0.0 %	14.3 %	14.3 %
10*	33.3 %	16.7 %	16.7 %	0.0 %	33.3 %
11*	33.3 %	16.7 %	0.0 %	0.0 %	50.0 %
12	28.6 %	14.3 %	0.0 %	42.9 %	14.3 %
13	57.1 %	0.0 %	0.0 %	14.3 %	28.6 %

*Six students responded to the question

Conclusions

The initial data demonstrates that students see the benefit from IoT-based course materials. Based on the reported data 62.5 % of the responding students answered Very True or Mostly True to the survey questions that pertain to RQ1 and 67.5 % of the responding students answered Very True or Mostly True to the survey questions that pertain to RQ2. New IoT materials for the BeagleBone processor have been developed. The exercises were originally developed using C and later developed materials in this project have utilized Python. More advanced applications for the BeagleBone processor such as wireless communications using an Xbee are currently being developed and tested.

Acknowledgements

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