

Incorporating a Raspberry Pi into a Computer Information Systems Initial Course

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Abstract— The Raspberry Pi is a small computer useful for teaching students basic computer knowledge. This paper discusses the integration of the Raspberry Pi in an introductory information systems course. Previously, the initial course in the College of Engineering and Information Sciences was a general applications course not focused on computer science or engineering. A new course was developed integrating the raspberry pi with hands on labs to improve student engagement. The initial course should be exciting and motivating to students. By creating a new course with interesting labs that integrate the Raspberry Pi, higher pass rates and student satisfaction will be achieved.

Keywords— *Programming concepts, Introductory Course, Raspberry Pi, Computer Science*

I. INTRODUCTION

Introductory computer, engineering, and information systems courses can be challenging for students and instructors alike. Students enter the course with a wide range of abilities and desire to be engaged in the course material. Many are also seeking guidance on the correct field of study for their needs and interests. Instructors work to make the course engaging for the students while teaching needed problem solving, programming, and computer skills.

In the College of Engineering and Information Sciences (EIS) at DeVry University the initial computer course has evolved. Prior to July 2014 the initial course was COMP100, a 2 credit hour course covering computer basics as well as Microsoft Word, Microsoft Excel, and Microsoft PowerPoint. This course uses MyItLab [9] in a competency based learning format. While this course has had success using the competency based format [3], a new course designed to introduce students to the College of Engineering and Information Sciences was developed. The course number is CEIS100 and is titled “Introduction to Engineering and Information Sciences.” In lieu of a book, the students purchase a raspberry pi computer and use it for several lab activities [11].

Integrating the Raspberry Pi computer presented several obstacles. Students needed a monitor or TV to connect the raspberry pi and the proper cabling. Since the course was

taught in both online and onsite formats, a support system was developed to assist online students with troubleshooting. Campuses also had several raspberry pi computers available for students to use.

The raspberry pi was designed with the purpose of teaching programming and computer science [2][10][11]. While many students use electronics and game consoles, they are not exposed to computer architecture or programming concepts. Raspberry Pi creator Eben Upton wrote of the pi “It’s trying to be cheap, it’s trying to be robust, and it’s trying to be fun”. While the pi is compact, it has a wide range of capabilities. The pi has a Linux operating system with several applications such as scratch and python. Students are exposed to Linux and command line tools as well as programming languages such as python.

II. BACKGROUND

DeVry University focuses on hands on learning and incorporating labs into many EIS courses [4]. Utilizing a raspberry pi computer along with open source software incorporated in the labs provides valuable problem solving experiences for students. Dutson et al describe in detail a shift from hands on learning to more theory in engineering education [5]. Due to this shift, many students lacked practical skills upon graduation. Having a raspberry pi integrated into the curriculum, starting with CEIS100 has the potential to bring hands-on activities into both the online and onsite classroom.

Research has shown that students have benefitted from using the raspberry pi in computer science courses. [2][5][6][8][13]. Even so, more examination on the types of classes (introductory, higher-level) and the labs associated with the pi is needed. Jamieson and Herdtner in particular compared prototyping boards such as the Arduino, Raspberry Pi and Beagle Bone Black in Electrical and Computer Engineering Courses [6]. Their paper detailed some of the challenges associated with coding projects using a small prototyping board. East Tennessee State University developed an Architecture course around the Raspberry pi [14]. The course covered the ARM processor, hardware, basic I/O, and finally creating clusters using the pi.

This paper discusses the design of CEIS100, the incorporation of the raspberry pi into the course, and student outcomes. Each session students are encouraged to complete an end of session survey with a net promoter score. This score indicates the student's satisfaction with the course. Student comments and net promoter scores are evaluated for both online and onsite versions of CEIS100 and compared to the results of the net promoter scores of COMP100. The question this research sought to answer was "does this course prepare and excite students for engineering and information sciences?" This paper describes the findings and extrapolates on methods to improve the course.

III. INITIAL COURSE DESIGN

The CEIS100 course is one of the first courses that new freshmen take in their major. This course is taught in a lab/lecture classroom in which each student has a computer at his or her desk. In addition to this format, the course is also offered online. CEIS100 is a 2 credit hour class and the course description is below:

This course introduces basics of networking, programming logic, and electrical engineering concepts. Students are introduced to the concept of problem solving as well as the importance of ethics and communications in the engineering world. They also learn the importance of belonging to a professional organization. Students learn how to problem solve in the lab and how to complete a lab report. They also create their online portfolio and plan the courses they will take during their time at DeVry.

The course is 8 weeks in duration with the following topic breakdown by week:

1. Week 1 – Problem solving
2. Week 2 – Networking
3. Week 3 – Video game development
4. Week 4 – Basic programming skills with python
5. Week 5 – Programming languages and alternative career choices
6. Week 6 – Electrical Engineering Technology
7. Week 7 – Professional Organizations.

The topics in the class assist students in determining if the College of Engineering and Information Sciences is the correct college for them. Some students may determine based on the course material that they are better suited to pursue a different course of study. After the course, students can transition to an alternative college and pursue the right career for them if they choose.

IV. RASPBERRY PI COMPUTER

The Raspberry pi provides students with a functional computer at low cost. All assignments can be performed on

the pi and the students have the opportunity to set up the pi and determine what components they need to make it work.

Raspberry Pi (raspberrypi.org) is a low cost computer that can plug into a computer monitor or a TV [11]. While very small, it is powerful and convenient. The pi comes with an SD card preinstalled with a Linux operating system. The students can choose from a variety of operating systems when they boot up the pi for the first time, but the class recommends Raspbian. Figure 1 shows an example of a Raspberry Pi.



Fig. 1: Raspberry Pi Computer

There are several models students can choose from. The course is designed with the Raspberry Pi 2. The Raspberry Pi 2 has an ARM processor, 1 GB RAM, 4 USB ports, HDMI video output, audio output, MicroSD storage slot, 10/100Mbps Ethernet network port and 17 GPIO peripheral [11]. Using the Raspberry pi, students can create complex programs with Python and Scratch. They also learn some basics of the Linux operating system. The pi has several games and programs preinstalled and is capable of browsing the internet when connected using an Ethernet cable or wifi adapter.

V. RASPBERRY PI INTEGRATION IN CEIS100

CEIS100 provides the students with an overview of the majors in the College of Engineering and Information Sciences. Each week a new technology topic is explored. In week two students must purchase the raspberry pi. They are given several options on where to purchase the pi as well as the model number. Students are also welcome to purchase a mouse, keyboard, wifi adapter, and monitor along with the pi if they choose to do so. A keyboard and mouse are needed but some students have these components on hand.

After purchasing the raspberry pi in week 2, the students must identify the ports and slots on it. The students are given two weeks to purchase the pi since the week four lab requires the student to successfully set up their pi. In week 4 students connect the pi to a monitor or their television to start using it.

Students may have to purchase a converter cable to connect their monitor to the pi. This kind of problem solving of obtaining all the parts needed to set up the pi properly is part of the lab. The first lab using the pi involves getting familiar with the graphical user interface and learning some basic Linux commands.

In the fifth lab, students use python on the pi. They are given a brief introduction to programming basics in python and they are expected to write their own program on the raspberry pi. They also learn how to download a new package on the pi to allow them to take a screenshot.

The sixth lab in the course is another programming lab using Scratch [12]. Students create a simple game using two sprites on the raspberry pi. They are encouraged to add more detail and programming to the game and many take advantage of this often creating complex games using Scratch.

Each lab requires the student to write a report about what they learned in the lab. The lab report contains objectives, results and conclusions sections. This provides the students an opportunity for reflection on the lab.

The final project is a PowerPoint presentation summarizing the topics students learned in the class. Students also pick an area of focus and ensure they are in the correct major. In the class, students were exposed to majors available in the College of Engineering and Information Sciences.

In addition to the weekly labs, students are encouraged to attend a “Meet the Expert” session with an expert in each field. The expert explains his or her field or topic and leaves time for questions. Students must also write a paper about the expert’s presentation.

This course replaced COMP100, a course that taught Microsoft Word, Microsoft Excel and Microsoft Powerpoint using the MyItLab simulation from Pearson [9]. CEIS100 teaches these topics by integrating them in the lab requirements.

VI. RESULTS AND DISCUSSION

Two areas of student achievement were studied to determine the success of integrating the raspberry pi in CEIS100. These areas were end of course student surveys and grades. Pass rates in introductory information systems courses are notably low [1][7][13][14].

Each session, online surveys are administered to students. These surveys are optional, yet students are encouraged to complete them to give the instructor feedback on the course. The survey consists of a net promoter score and a comment section. The composite score of the course along with the comments were evaluated. Students rated the course from 1 to 10 with 10 being the highest score.

The mean student satisfaction with the course was 8.16 for all students. The number of students responding were 1214 in both onsite and online deliveries. For the onsite course the mean satisfaction was 8.54 and the online student satisfaction was 7.6. It is interesting to note that onsite students had approximately 11% higher satisfaction with the course than

online students. 720 online students were polled compared with 494 onsite students. Table 1 illustrates the number of students who responded with scores from 1 to 10.

These results are noteworthy since student satisfaction can lead to more motivated learners, higher grades, and better persistence. About 45% of the students rated CEIS100 with a 10, the highest score and 75% of students rated CEIS100 with an 8, 9 or 10. This indicates a high degree of satisfaction with the course overall. This student satisfaction survey was also administered to students taking COMP100. In COMP 100, 1572 students were polled and the mean satisfaction was 8.59. The online student satisfaction was 8.49 and onsite student satisfaction was 8.73. The data showed that 53% of students rated COMP100 with a 10 and 81% rated COMP100 with an 8, 9, or 10. These results indicate a higher average student net promoter score for COMP100.

TABLE I. STUDENT SATISFACTION RESULTS BASED ON SURVEY DATA FOR CEIS100

Course Score	Number of student respondents
10	551
9	170
8	191
7	96
6	49
5	48
4	12
3	17
2	18
1	9

In addition to student satisfaction surveys, student grades were assessed. The number of students who achieved grades of A-C, and those who passed and failed were tabulated for both CEIS100 and COMP100 in Table 2. This data does not include students who dropped the course, only those who completed the course.

TABLE II. STUDENT GRADES COMPARING CEIS100 AND COMP100

	Percent Grades (A-C)	Percent grade D	Percent Passed (grades A-D)	Percent Failed
CEIS100	90.6%	1.2%	91.8%	8.2%
COMP100	85%	4%	89%	11%

While the pass rates of both implementations of the course are high, more students passed CEIS100 than COMP100. CEIS100 had a 6% higher pass rate and a lower failure rate.

The pass rate results were not surprising and can be further examined. CEIS100 has labs and examples more closely related to the student's major than COMP100. In COMP100 predefined simulation labs were assigned which allowed for little creativity by the students. CEIS100 also required the students to purchase a raspberry pi computer and encouraged tinkering. Many students created interesting projects on their own with their raspberry pi computers.

Students really enjoyed working with the raspberry pi. Some comments by students were "This course was very interesting. Being able to utilize a Raspberry Pi was very helpful in the basic understanding of computer function[sic]." Another student commented about the material of the course along with the pi "I loved everything about this course. The raspberry pi was awesome. Learning python, scratch all of it was a learning experience, and I loved it."

Several students commented that they wanted to do more labs with the pi. One student commented "I would have gave[sic] the course grade a 10, if it had more interaction with iLab's. More things to do with the Raspberry Pi would be more helpful to not only the students but to the course shell."

Overall the course gives the student a good idea of the rigor involved in engineering and information sciences courses. Students have commented that the course assisted them in their chosen major. One student commented "Upon entry of EET I was very nervous about the complexity of the degree, and concerned if I could achieve such a large bite of the apple, CES100 was a class that helps "ease" you into your chosen field and introduce other options and advice on how to best use the resources available at DeVry. This class was invaluable to beginning my path to the harder curriculum."

Students did experience some frustrations with the raspberry pi. Rather than a textbook for the course, the raspberry pi was utilized. However, students had an issue with the extra purchase of the pi. Other students had difficulty getting the pi set up. If they did not have a TV with an HDMI input or a monitor with an HDMI input, the student had to purchase a converter cable. This type of problem solving can actually be beneficial to the student as in the business world situations like this may come up. However in this stage of their education, students may not have the tools to be able to work through this type of problem solving. Oftentimes faculty would

be tasked with helping the student set up the pi or troubleshoot problems with the pi. Each faculty was given a raspberry pi to work with prior to helping the students.

One result of this research was finding that student satisfaction was decreased, possibly due to frustration with connecting the raspberry pi. It can be extrapolated that first session students are given many new technologies initially such as a new Learning Management System, course work, discussions, and various logins to manage. One more device may overload the first term students with technology, especially nontraditional students. When adding new technologies to first term courses it is important to do so in a way that minimizes student frustration and simplifies the learning experience for the student. A self-contained system can now be purchased from the bookstore containing the raspberry pi, mouse, keyboard, and monitor. Purchasing all of these components are more expensive but reduce frustration in trying to connect the raspberry pi.

VII. COURSE IMPROVEMENT

The results from this study indicate that students were satisfied with CEIS100, and the course has a better pass rate than COMP100. These results are noteworthy, and are encouraging for future students. This course can still be improved to increase student comprehension and reduce frustration with the setup of the raspberry pi.

A new version of this course is under development using the raspberry pi 3. This course expands the use of the raspberry pi with weekly lab assignments that explore more of the functionality of the pi. In addition, students are required to do a final project using the pi. Students can use the GPIO input, write a python program, create a music player, or be creative with the pi. Instructions are given on how to start the project and the student must innovate to create a new design with the raspberry pi.

The labs in the new course use the raspberry pi more in depth compared to the first version of CEIS100. More Linux commands are explored along with networking commands. One week is dedicated to adding security to the raspberry pi as well.

A few students questioned whether they would use the pi again. The raspberry pi has been integrated in several classes. The Architecture and Operating Systems course requires students to use the raspberry pi for Linux scripting. Students also set up a web server using the pi. In addition, many students use the raspberry pi for their final project in Electrical Engineering Technology.

Based on comments from the student surveys it is evident that students were engaged by the raspberry pi but felt the course structure was disorganized. Future changes in CEIS100 are expected to address these concerns and lead to higher student satisfaction scores.

These options for course improvement provide opportunities for students to further use the knowledge they gained from CEIS100 and their raspberry pi. The benefit of

the raspberry pi in the course is that it motivates the students in their majors. Since this course is taught in both online and onsite environments, the online students can still feel as though they are doing “hands-on” work.

VIII. CONCLUSIONS

Introductory information systems courses are challenging courses for students to take and instructors to teach [1]. Determining the best method of teaching the basics of computers while making the course interesting and engaging is difficult to balance. To improve the student experience and pass rate a new course was developed titled CEIS100 that included the raspberry pi. This course replaces COMP100, a computer applications course. Data was analyzed for CEIS100 to determine student satisfaction, knowledge of the subject material, and pass rates. The data consisted of student satisfaction from end of course surveys, and grades. The course had an 90.6% pass rate with 75% of students rating the course with an 8, 9 or 10 out of 10. However, prior to CEIS100 the COMP100 course had an 85% pass rate indicating that implementing CEIS100 improved pass rate but not student satisfaction.

It was extrapolated that exposing too many new technologies to first term students can be overwhelming. A balance was sought between the innovation of using the raspberry pi in a first term course and student frustration by providing more options when purchasing the pi.

To challenge students and improve their comprehension of the material, adding more labs working with the raspberry pi and a course project was explored in a future development of this course. Based on the findings of this analysis, using the raspberry pi in CEIS100 to introduce information technology concepts was successful at DeVry University.

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