Digital Promise
Accelerating Innovation in Education

Pilot Study: Electronics Unit using Raspberry Pi for the Technology Education Course

Product Info

Product Name: Raspberry Pi

Product Description: Raspberry Pi is a single board computer with on-board WiFi, Bluetooth, and USB boot capabilities. Extensions used with this product included breadboards, sensors, lights, motors, card readers, and touch screens. Python was the computer programming language used to program the device. Additional equipment used to design and manufacture the housing for the electronics devices included CAD software and 3D printers.

Learning Focus: To pilot the design of an electronics and manufacturing unit to be embedded into a technology education engineering course for grades 9-12.

Teacher Training: Professional development sessions for this 30-day unit included: (1) one six-hour teacher training for five teachers including lead teacher; (2) one 45-minute lesson delivered to 15 students in the engineering class on site by expert from Carnegie Mellon University (CMU); (3) two six-hour workshops on Saturdays for student teams and teachers offered by an expert from CMU.

Student Usage Minimum: This 30-day unit was implemented within the high school engineering course in technology education. This is a baseline for a minimum amount of exposure we envision students should have to be successful in accomplishing the required tasks.

Device Specifications: Raspberry Pi uses Raspbian operating system. Each unit required a computer monitor, mouse, keyboard, and connection to the Internet.

Cost: The equipment costs were approximately $2560. Professional development costs, which included one 8-hour workshop for five teachers and two 8-hour workshops with 20 students and 2 teachers equaled $1200.

District Context

District demographics: District demographics: 3,221 total students across 4 schools. 1% are ELs; 8% in special education; 76% Caucasian; 1% Hispanic or Latino; 16% Asian; 2% Black or African; 12% of students received free or reduced-price lunches.

Pilot demographics: Sixteen students in the technology education engineering course at South Fayette High School participated in the pilot. There were 15 boys and 1 girl comprised of 12 seniors, 1 junior, and 3 sophomores. Composition of the course: 1 Hispanic or Latino student; 11 Caucasian students; 4 Asian students. Teachers involved in the study included the high school technology education teacher, a parent volunteer, the director of technology and innovation, and an expert from Carnegie Mellon University computer science department.

Pilot Goal

To pilot the design of an electronics and manufacturing unit to be embedded into a technology education course for grades 9-12, utilizing Raspberry Pi and extensions. The unit utilized electronics equipment such as Raspberry Pi with external extensions such as sensors, motors, LED lights, card readers, Python programming language, and manufacturing tools such as CAD and 3D printers.

Implementation Plan

Duration: October 2017 – January 2018

Quality of Support: Professional development was offered to students and teachers by staff from Carnegie Mellon Computer Science Department. Teachers participated in an all-day workshop to launch the project and participated in brainstorming sessions on the design of the unit. Student leaders and teachers participated in two all-day professional development sessions held on Saturdays in October and December. The intent of the training was to build expertise with student leaders so that they could lead and support activities in the classroom. One hundred percent of the students who attended the professional development reported that the workshops were extremely beneficial and helped them gain more exposure to computer programming and electronics. As a result of the workshops, student leaders were successful in guiding their teams to create a working project prototype. The teacher benefitted from the professional development and has indicated he would like to have more intensive training in the future to build on what he has learned. The teachers and student teams felt valued and supported by the administration.

Implementation Model: Students were asked to solve the problem: "How might we create a security system device to monitor and provide safe use of the Fab Lab equipment." The constraints of the project included: designing a system that would allow the teacher to know which students or community members were using Fab Lab equipment; the dates and times of use; automated prompts sent to users when utilizing equipment and; the ability to allow access to the machines or stop usage based on the users' credentials. Student teams participated in human centered design thinking routines for creative problem solving and innovation and investigated human computer interaction as they developed their design. Teams included distinct areas of responsibility: software developer/programmer, user interface designer, manufacturing and lead engineer, and prototype design. The project began with professional development for teachers and two additional all-day workshops were added for lead students. The project was implemented as a 30-day unit. The unit ended with teams presenting four unique prototypes of the card reader security systems which they named PASS. One prototype was selected as the device that will be utilized in the Fab Lab.

Data collected: Students completed: a pre-survey, October 2017; a post-survey, January 2018 and; an in-class focus group and presentation of their product prototypes, January 2018. The director of technology and innovation conducted an end of pilot interview with the teacher to gain insights into his personal reflections about the project and the future of expanding to other educational experiences. Through post-surveys we were able to collect personal reflections from students on their learning.

Findings

Actual implementation model: The original implementation plan was followed, and in addition, revisions were made. The revisions included adding two all-day workshops to train student leaders to support their teams.

Educator engagement: Our lead teacher realized the complexity of learning to use the tool for the purpose of this unit, which was to create an innovative electronic device to be used as a security system. With additional support the project was successful beyond his expectations. He has requested additional in-depth training so that he may expand this project into other areas such as the underwater ROV mobile robotic clubs he sponsors and for additional opportunities to extend this learning into other areas of the engineering course. Our teacher has identified many ways these tools and thinking strategies can be expanded beyond this pilot.

Educator satisfaction: Educators were excited about the tools, and most importantly, the instructional strategies that they embedded into the unit, that enabled the tools to be used to create an innovative solution for an authentic problem for their school community. The tools allowed students to collaboratively move from ideation to product prototype, which became an important outcome of the project.

Student engagement: Students were very engaged in this challenging pilot. The learning curve was steep. Several of the students took their learning beyond the classroom and participated in Saturday workshops to become more deeply immersed in their specific content area. Students worked within their team to create their unique prototype but often used their expertise to help other teams debug code and collaboratively problem solve manufacturing and design issues.

Student satisfaction: Student satisfaction was phenomenal. 100% of students felt that the project positively impacted their thoughts about coding/computer science as it relates to engineering; 93% felt inspired to tackle other similar projects in the future; 74% are encouraged to investigate computer science and electronics in the future; 100% of the students believe that the district should pursue more opportunities where university and professionals can share their expertise with their classes; 100% of the students who attended the Saturday workshops felt the workshops were extremely beneficial and helped them gain more exposure to computer programming and electronics and; 87% of the students believe that if they had been exposed to these concepts earlier, in elementary or middle school, they would have pursued more experiences in coding/computer science and electronics to a greater degree.

Student learning: Student learning took place on many levels, both technical and personal. Beginning the project, student pre-surveys showed that the majority of students did not have a technical understanding of the electronics involved in Raspberry Pi. At the conclusion of the project, the majority of students completing the post-survey were able to explain the purpose and functions of the Raspberry Pi; the components of the Raspberry Pi; the purpose of the breadboard and; the benefits of using Raspberry Pi for real-world applications. Although the majority of students were able to describe the purpose of GPIO connectors, they had a more difficult time with this question. On a personal and professional level, students identified characteristics that they learned about themselves through this project. A sampling of the responses we received included: the ability to improve communication skills; the opportunity to recognize my leadership abilities; to think like a programmer, breaking down complex ideas to solve more easily; the importance of being persistent when problems arise and; a recognition that I have an aptitude for redesigning models based on circumstances that arise.

Outcome

Purchasing Decision: Based on this pilot, we have added Raspberry Pi and additional electronics components into the budget for this technology education engineering course for the future. In addition, we are including Raspberry Pi in the budget for the upcoming AP CS Principles course and the proposed underwater ROV robotics course. Through this pilot study we were able to understand the rigor and depth of learning involved in embedding the instructional strategies and electronics capabilities into course content. Therefore, as we proceed, we will be researching school to college credits and honors designation for the newly designed courses.