Building Something with the Raspberry Pi

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In 2017 Ryan Korn and I submitted a grant proposal in the annual Harrisburg University President's Grant process. Our proposal was to partner with a local high school to install a classroom of 20 Raspberry Pi's, along with the requisite peripherals. In that classroom students would be challenged to design something that combined programming with physical computing. In our presentation to the school we suggested that this project would give students the opportunity to be "amazing."

As part of the grant, the top three students would be given scholarships to HU and the top five finalists would all be permitted to keep the Pi they used for their project. All students involved in the project would be invited to meet with the admissions team during the showcase.

It took until May of 2020 to complete the work on this grant. There have been some very satisfying moments, and more than a few interesting challenges. The purpose of this article is to trace some of the steps for those who might be interested in retracing the activities of our grant and putting Raspberry Pi's in classrooms in their own schools.

Overview of the Pi

The Raspberry Pi microcomputer has had a significant effect on educators and education since its development and release in 2012. With a large installed base of over 15 million units, this $39, single-board computer has been used in projects that include the teaching of programming, science and mathematics. It has also inspired a new generation of makers who are using the devices to create robots, weather stations, and media centers.

Eben Upton, the inventor of the Pi, has described how he wanted to design something that he could give to prospective computer science students, then challenge them to build something that would demonstrate their skills. The Pi comes with a full suite of open-source software, including operating system, productivity software and programming tools and echoes the early days of computers in schools when students learned to program. The "company" behind the Pi is an educational charity and if you are interested in more information a vast array of free books and magazines is available to help teachers from their website.

When I first heard of the Pi, and read the articles around it, it reminded me of the early days of the Apple II in schools, back before the internet and the use of classroom computers as "information appliances." At that time, Steve Jobs had said, "I think everyone should learn how to program a computer, because it teaches you how to think." In the ensuing years, and across the various improvements in the computers in classrooms, that message had faded.

Similar to the early days of the original IBM PC, a wide variety of add-on boards and peripherals have been introduced to facilitate teaching and learning with the Pi. These peripherals added an amazing array of learning opportunities for students to develop projects that incorporated both programming and physical computing.

This was the genesis of our grant. We proposed putting in a classroom of PI's and associated peripherals. We would use University Students to assist the teacher of the class, and the enticement for "amazing" projects was going to be a combination of scholarships to the University, and the ability for the top projects to keep their Pi's. We proposed building a robust classroom capable of teaching both programming and physical computing, support it, motivate it, and then see what happened.

The first (and unexpected) bump

The first bump in the road for this project came from a direction we did not anticipate.

Our presentation to prospective schools was, we thought, rather modest. In return for the University investment, our expectation was that the local school would provide a room to house that equipment, a teacher, and a class of interested students who would take the class for a year.

We had a local school who volunteered to host the class. We had several meetings in the spring of 2018 to arrange the details of the class, including the location for the class, the teacher and the course description for the students. Unfortunately, we did not put that into writing, and we did not get any signatures. We had a kickoff meeting scheduled for August of 2018, just before the school year started, to confirm the details of the class and determine what remained to be done.

That meeting was very different from what we expected. First, we were told that the class would not be for the full year, but for only half the year. We would not be setting up the equipment in a dedicated room, but would need to break it down after every class, and finally, we would only be getting 3 or 4 students and we were not sure if any of them were interested or could do anything. After some soul searching, we decided to put the project on hold and recruit another school.

We needed to ask the University President for permission to delay the project for a year, since the grants were normally offered in a specific year. After hearing of our troubles, he granted that extension and we then set about to recruit a more amenable venue for the project. The school that stepped up was Carlisle High School in Carlisle Pennsylvania. And this led to the next challenge.

The teacher who volunteered to teach the class, Robyn Wolfe, was willing to take a leap of faith and try this new class on, but had a logical reservation in that she did not know much about the Pi, and certainly not enough to teach a full year class in it. The summer before the program I was preparing to deliver a new class at the University, "The Raspberry Pi in STEM education." This was a one-week summer intensive and I arranged for her to take the class without cost to get her familiar with this new device she would need to know.

That class covered a lot about the Pi on a very accelerated schedule, but it did so in a way the fit the traditional definition of a survey class. It dropped students into the deep end of the Raspberry Pi pool and tour the various capabilities and requirements. Robyn would eventually craft the content of that survey into a credible High School class, with the requisite objectives, assessments and week-by-week

breakdowns. You can see the compiled history of her class here, and for those thinking of teaching a similar class it is probably a good idea to trace what she did over the course of the year.

Purchase of Pi's and peripherals

One of the major components of the grant we had written was the purchase of all the materials that would be needed by a class looking to study with the Pi. This was one more part of the project that would also not go smoothly, but this time the reason was good. Between the time we were approved for the grant, and the time we would need to purchase the equipment the Raspberry Pi foundation introduced the Pi 4.

Because it was introduced about a week before we had planned to order the gear for the class, this meant that it was in short supply, with many distributors either completely out of stock, or restricting orders to one or two units. We decided to make the switch, since the Pi 3 would seem old by the time students started the class. We placed our original order of monitors, cables, keyboards and mice, but then needed to shop multiple vendors to obtain the 20 Pi's we needed for our class. Eventually we did obtain the needed number, but because of the way the order was processed we ended with 20 cables that fit the Pi 3. The Pi 4 had upgraded to a micro-hdmi cable. This meant returns, rework and delays. Fortunately, the remaining peripherals we had detailed remained the same, and orders were processed without incident for sense hats, cameras, motors, and other sundry maker supplies like breadboards.

That is not to say that we did not need to do some additional emergency ordering. This was the first time we had done a project like this and we did not foresee some of the places it would go. For example, one thing we had not considered was the need to solder wires. There were several project instructions that included this aspect of making, and at first blush it sounds like something simple – get some solder, some flux and a soldering iron. The new wrinkle was doing it safely in a high school classroom. This meant purchasing safety gloves, eye protectors and small fans to vent the smoke and fumes.

The good news is that we were able to provision the classroom with 20 Rasberry Pi 4's, and all needed peripherals for about $5,500, including needed provisions for the student projects.

One additional feature that had been built into the course was the necessary and logical division of the course into fall and spring, with the fall being used to develop fundamental coding and physical computing skills, and exploring the capabilities of the Pi. The spring was to be used for students to develop a project that would use those skills to create something of note. We had structured the curriculum to include researching the projects to determine what could be done, developing a list of additional components that would need to be purchased, and a project plan of how to achieve this project within the time constraints of the class.

Project Presentations

There we several important milestones for the project. The first would be the "shark tank" presentations. We did not want the students to think that the additional funding was guaranteed, so we created a

scenario where they needed to present their project ideas. This would include a description of what the project would do, a list of additional materials that would be needed, expected learning outcomes, and an estimate of how hard the project would be. The goal of this would be to give the students opportunities to work on presentation skills, project planning and some elements of persuasive discourse.

An additional area that we thought would be "easy" when we wrote the grant was the recruitment of Harrisburg University student teaching assistants to work in the high school. When we received the grant there were a number of students would have been perfect teaching assistants, but when we were forced to delay for a year, those students graduated. The year we began working with CASD the pool of potential teaching assistants was considerably smaller. The qualities we needed included deep technical expertise with Linux, Python and physical computing, an ability to communicate that knowledge in clear language, and the ability to troubleshoot were all required skills. We did not realize how difficult it would be to find someone for the role. Eventually we would find a Harrisburg University graduate who agreed to work on the project, but we lost two months trying to find her. Those two months were early in the semester and at a time when the class would have benefitted the most from some teaching assistants.

The goal of the entire grant and class was the creation of student projects that would be defined by the students themselves. We wanted to see what the students would develop if we provided an environment where their creativity could flourish. We had set aside additional funding in the grant for the purchase of components that might be needed for the project.

We had discussed how this would be done and decided that we did not want to just give them money. If a student needed extra components, they would need to tell us why. A shark tank presentation was required for additional funding, and the students would need to include several important elements in addition to the presentation of the idea. They would need a detailed list of materials, a project plan that laid out detailed milestones to ensure the project would be done, and an assessment of the difficulty of the project.

During the shark tank we reviewed a number of fascinating ideas, including a wearable computer that would work as a proximity sensor for the visually impaired, a music tone trainer for the stand-up bass and a "magic mirror" that would display relevant data such as temperature and weather in a bathroom mirror. There were others. They were all interesting and they were all funded.

Final Presentations

The projects were originally to have been presented at a showcase day at the University. The students were competing for three scholarships and we hoped that would bring out the best presentation and demonstration skills. Unfortunately, the Corona Virus Lockdown occurred at a time that not only precluded any kind of live presentations, but also closed the schools when they were scheduled to be doing the bulk of the work on the projects. Robyn was able to get permission for the students to take their Pi's and project materials home and they continued to work on the projects. It is a tribute to the

students that they were able to complete their projects without much of the support network that had been setup to help them.

With so much of their lives being cancelled, including the last days of senior year, the senior prom, graduation and the other things that make up a very special time for most seniors, we elected to not cancel the presentations and judging, but to them online. Students were requested to create a video that demonstrated their projects. You can see the student presentations here.

The project judging was based on the student presentations. The judges reviewed the video presentation and voted online. Mikael Kaufman took first place for his Magic Mirror project and received a $1500 scholarship to Harrisburg University, Isaac Fisher came in second for his Music and Machines project, and received a $1000 scholarship, and Tony Rivera come in 3rd for his wearable electronics project and received a $750 scholarship. The people's choice award went to Sam Francese for is Snake Box project.

The awards ceremony was attended by all the students, everyone directly involved in the project, and by the President of Harrisburg University and the University Provost, multiple faculty and staff members from the high school, including the principle, Michael Black. All in all, it was as good as a virtual presentation could be.

Final thoughts

As we look back on the project, I think several things can be said. The most important is that the class itself was a success. The original students who signed up were curious about the PI. Many had no programming experience, and yet were able to create credible projects. Some of these students graduated and had plans to continue working in programming and computing. Some of the Juniors in the class volunteered to work on the Pi class next year at CASD.

For the school, word of mouth on the original class resulted in more than 25 students registering for the class next year. It remains to be seen whether they will create 2 sections of the class. This is not bad for something that pretty much no one had heard of prior to the grant.

I have become even more of an advocate of the Pi as a teaching tool. I believe it delivers on the promise of the "personal" computer that was made in 1982 with the introduction of the Apple II in the classroom. It is a way for students at any grade level to become involved in coding, and for teachers of STEM topics to blend those in with digital tools. I intend to promote it for teachers in the Learning Technologies program at Harrisburg University, and hopefully, can share what we learned with other schools interested in implementing a Pi-based curriculum.

I will close by explaining the title of this article. The "something" we built could be the projects themselves. It could be the high school curriculum Robyn crafted. It could be the Presidential grant program that can now serve as a model for future projects. It can be a commitment to STEM education with the Raspberry Pi, as stated in the title of HU course LTMS 503. I think the right answer is that it is all these things.