

Bucket Simulation: Emulating Swarmies with Humans, Buckets, and Candy

Team Synchronized Swarmies Members:

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Abstract

There is a significant lack of computer science, engineering, and robotics courses offered in elementary, middle, and high schools around the city of Pasadena. Due to insufficient early exposure to such topics, students are less likely to pursue these fields in college. The purpose of this outreach project is to introduce elementary, middle, and high school students to the fields of computer science, engineering, and robotics.

Of the resources which exist for students to be able to get experience with computer science and robotics, few are diversified to the most introductory levels. In particular, many of the materials which exist focus on a mathematical introduction to the subject and lose the human element. We designed our outreach with this in mind, and we hope that the experience for the students who have come through the program is engaging, rewarding, and mind-expanding.

Through demonstrations and presentations, the Swarmathon team conveyed the importance of these fields in our society. There is an existing interest in the future; in how our world might be made better by the interaction of people with the technology we develop. Our students see this. Many of them are also already interested in space and the exploration of our solar system. The idea of establishing a base on Mars is one that often appeals to students, no matter their age. But knowing how these events might occur is often the missing step. Seeing the connection between what they can do now, as students, and what we can do in the future, as a society, is revelatory.

We experienced positive outcomes and potential with the outreach events we have held, so far. And we have a number more scheduled in the next few weeks and months (now that the pressure of the competition is mostly relieved). By the end of the outreach activities, students became more interested in and inspired by pursuing studies in the science, technology, engineering, mathematics (STEM) fields.

Introduction

The PCC Swarmathon team participated as a guest speaker group in PCC's annual Tech Savvy Conference, an event run by the American Association of University Women (AAUW). The goal of the Tech Savvy Conference was to encourage and excite more young girls to learn about and become involved in technology-related fields. Over 200 young women from a number of different middle and high schools, including Washington STEAM Magnet Academy and McKinley Elementary school (both public

schools in Pasadena Unified School District), came to the PCC main campus to explore the STEM fields through a variety of interactive workshops.

Our team was granted timeslots for two workshops, and during each one, we met with around fifteen enthusiastic students in grades five through nine. The team spent many hours organizing the activities, contacting school faculty for visits, preparing effective demonstrations for the students, and rehearsing the presentation. After having completed the necessary preparations and carrying out both workshops, the Swarmathon team was able to successfully lead and document a highly informational and entertaining event for the visiting girls.

The content of each workshop included the following: basic team member introductions, a brief overview of the NASA Swarmathon competition, a short interactive demonstration of a Swarmie's sensors, a peek into coding and debugging, a dancing Swarmie, an introduction to algorithms, actual algorithm planning, and a second interactive activity where the girls had the chance to implement their algorithms while acting as a different piece of hardware in the Swarmies. Throughout the workshop, time was given for questions and comments. At the end, the team held a recorded interview, in which the girls were given an opportunity to share their opinions on the workshop, as well as what they learned about computer science and robotics.

Building on the success of this day, we are planning three further outreach opportunities. They are scheduled to take place after the submission deadline for this report, so we will discuss what we have planned and make particular mention of the parts of our agenda which are already confirmed. Notable highlights are the two open-house days at the PCC Robotics lab at the end of April - information about which is being disseminated to schools and groups in our area. The total number in the involved groups is in the thousands; we hope to have several hundred attend over the course of the two days. We will also be presenting at a STEM fair that a local special-needs high school is putting on in May - they serve primarily students on the Autism spectrum, and have invited us to come and discuss the Swarmathon and give a demonstration to students who may attend PCC or one of the other participating schools.

The Robot Maze Demonstration

The objective of the short interactive demonstration was to show the sonar sensors in action. The students created a single file line about two feet away from a wall, creating a trivial maze for the rover to solve. The students served as another wall to demonstrate that the rover could follow this straight path and not steer itself out of the maze. If the rover was going in the wrong direction, the students were allowed to move their feet to help redirect the rover and ensure that it reached the end of the maze. The students were laughing as they moved around and worked together to keep the rover from escaping.

Strategically, this was the first thing that we did with them, so that they would see how the robot detects an incoming collision and turns away to avoid it. This introduced the fact that the rovers do not plan their actions far ahead, and are very reactive to their environments. It also set the stage for discussing robotic vision and the difficulty in moving through unknown terrain.

The Robot Dance Demonstration

After the maze demonstration, team members David Wu and Xianmei Lei went into the code to change the velocity of the wheels. The objective of this demo was to provide a preview of actual programming code, to define the meaning of debugging, the sensitivity of code, and to teach the students that nothing is created perfectly the first time around.

While the Swarmie and the display were being set-up, team member Joe Renzullo used the time to quickly, but thoroughly, explain the concept of the global positioning system (GPS) and homing sites. You can see that video here:

<https://youtu.be/w-4-SV8heEI?t=4m12s> Because many of the students had not had exposure to robotics before, he explained how robots can move around by making the analogy to how our cell phones have apps on them that can tell (roughly) where they are. Then he talked about how the rovers do not always know where they are, and that because there is no “Google Maps” for Mars, we needed to find another approach.

Once the set-up was complete, the code was explained in terms intelligible to our audience and the code associated with the wheel velocity was edited. However, when the rover was turned on, nothing happened! There was a bug, a misplaced “.” in the code, that prevented it from compiling. After debugging and explaining the process, the

Swarmie was finally able to dance and spin around in circles, again entertaining the students.

The Algorithm Interactive Demonstration

Following the demonstration of the dancing Swarmie and a detailed talk about debugging code, the young students were then introduced to the concept of an algorithm. The Swarmathon team explained the idea of an algorithm using a metaphor to compare an algorithm to a cookbook. Through this comparison, the students were able to understand that an algorithm is essentially a step-by-step guide of instructions that are programmed in order to carry out a given task. The students were then guided through an interactive game intended to simulate the usage of different algorithms on multiple Swarmies collaborating to find QR codes in the Swarmathon competition.

In the activity, the Swarmathon team randomly distributed packaged candy on the clean floor and the students' task was to collectively find as much candy as possible, similar to how the Swarmies would be required to collectively find as many ID tags as possible. The students would wear buckets on their heads so that their vision would be limited to simulate the short camera range on the robots. The students were placed into pairs, with one acting as the Swarmie and the other as its sensor detector (sonar). The sensor detector was only allowed to say "stop" and tap her teammate on the shoulder (to avoid confusion of other groups saying "stop") if a collision between her partner and an obstacle was imminent.

In order to ensure safety, teammate Kristiana Rendón explained the activity in detail and did a short demonstration so that the students could aurally and visually understand the rules of the activity. The students were then given several minutes to develop their own search algorithms.

The activity was held in two 5-minute rounds, each of which would end after all of the candy was found, or the time limit was expired. After the conclusion of the first round, the students reversed roles, and the students simulating sensors in the first round became the rovers in the second round. The activity was quite successful and in one of the rounds, the students were actually able to find all of the candy.

Following the activity, each pair of students was asked about the algorithm that the pair used. We found that the majority of students chose to search randomly, picking up any

candy they found on their path. A small portion of the students chose a zig-zag algorithm, choosing to search to the right, then the left. Both algorithms resulted in finding lots of candy, and most of the candy was recovered by the student robots. The students especially enjoyed this event, as can be witnessed by the giggling in the video in the link below. Additionally, many of the students expressed their newfound desire to pursue careers in computer science or robotics.

Summary of Data

Based on data that was collected during and following the outreach program, we found that students enjoyed our event very much and had a positive experience. Results show that the students learned a lot about robotics, and were inspired by the Swarmathon team to become computer scientists or to work with NASA in the future. A detailed retrospective evaluation of the outreach program led us to believe that we were very successful in introducing the young students to STEM fields and fostering interest in these fields.

We had less of an impact on increasing their knowledge, however, and we think that the students were limited in their learning due to their young age and their lack of exposure to these fields. We also only had an hour with each group, and had much ground to cover. Nevertheless, we were able to explain basic concepts such as coding sensitivity, debugging, and algorithms. The potential for further interaction and outreach is gigantic.

With further outreach activities and meaningful relationships with the same students over a longer period of time, we strongly believe that the PCC Swarmathon team will be able to provide an exceptional educational experience for elementary, middle, and high school students in the Pasadena community. These outreach efforts will help empower them to create their own projects and to gain the necessary skills to become more involved within the STEM community.

Future Outreach Activities

In the future, we plan to hold additional events and outreach activities for elementary, middle, and high school students in Pasadena and surrounding regions.

On April 26th and 28th, from 8-11AM, we are opening the doors of the PCC Robotics Lab and inviting in the members of our communities. We have reached out to local middle and high schools, to the Catholic private elementary school across the street, to

four STEM clubs at Pasadena City College, to the Boys and Girls club of Pasadena, to students in both the first and second year of the PCC Pathways programs - a program for recent high school graduates who are enrolled at PCC - to two clubs on campus who focus on academic achievement for minority students, to the PCC outreach coordinators, and today, the possibility was raised of inviting the entire student body.

This is one of the coolest things the PCC Computer Science department has been able to do in the last decade, and it is the first time we have had a robotics lab on campus. For the students who were able to participate in the project, the experience was transformative. We hope to share our experience with those who are interested or might become interested if only they knew what options were available in their own proverbial back yards.

The first outreach we had was a smashing success, and now that we know where the kinks are, and since we have the time, we are extending this as widely as we can, given the short time we have left in the semester. Many of us (most, in fact) will be transferring to other schools next semester. But we have been in touch with the campus STEM organizations, and they are excited to pull in new students in the fall. We are making it our priority to ensure that the environment they walk into on the first day is even more exciting and fulfilling than the one we have been so privileged to have experienced.

The second planned outreach we have confirmed will take place on Saturday, May 28th. We will be giving an interactive presentation and demonstration to the students of the STEM³ Academy, which is a local school who specialize in serving students who have difficulties due to learning disabilities. In particular, they have focused on getting students involved in STEM fields (as their name implies). They note that many students who are on the Autism spectrum opt into STEM careers as-is, and see this as a meaningful way of engaging a population often turned away from other areas of academia. We are delighted to have been invited to participate, and cannot wait to share our joy with them.

One of the plans that the Swarmathon team has for the next year is to not only host events at PCC, but to visit nearby schools and bring Swarmathon to their students! The team will coordinate with school administrators and educators of computer science to schedule a day for the team to make guest appearances in STEM classes. We also plan to follow up with these students and get them involved in more engaging activities. By showing our passion for computer science and robotics, we hope to foster interest in computer science related activities to our audience.

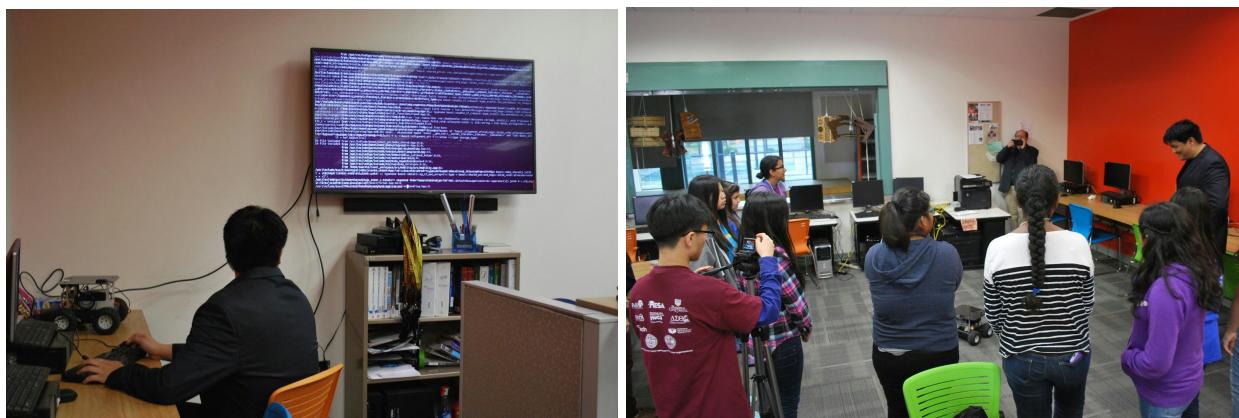
Based on the success from our participation in the Tech Savvy Conference, we will continue to use and improve our bucket simulation activity in future events. Similar to AAUW's mission, we also strive to increase the interest of computer science and robotics in young girls. Our team has discussed the creation of a peer mentoring program, in which we and future Swarmathon members, will become a resource for elementary, middle, and high school students regarding educational paths, internship opportunities, and career fields in computer science and/or robotics related areas. This may be done in partnership with an existing club, team, or independent program at the schools. We hope to reach and provide support to as many students as possible!

Conclusion

The members of the PCC Swarmathon team dedicated many hours of hard work to ensure that the outreach project was a successful endeavor. We firmly believe that this experience will spark numerous outreach activities that build upon the students' foundations in computer science and robotics. We hope that the students will return and participate in our future activities. We also hope that students and their educators will share these opportunities with their communities, so that our team will be able to educate and empower others on a grander scale. We, the members of the PCC Swarmathon team, are confident that the unwavering efforts of our team and those nationwide, will create a positive and everlasting impact in schools' curriculum, as well as a new wave of interest in computer science, engineering, and robotics worldwide.

Photos







Videos

Tech Savvy Event

<https://youtu.be/w-4-SV8heEI>

Team Member Interviews Following Tech Savvy

<https://www.youtube.com/watch?v=bZ-3vcUGPMk>

*Since the Tech Savvy Conference participants were minors, their parents signed a media release form providing consent for the Swarmathon team to take pictures and videos throughout the event. Uploading their pictures and videos, including those in this outreach report, were also approved under the release form.