Da ‘House Gives Back

NASA SWARMATHON OUTREACH REPORT

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Introduction

According to the Program for International Student Assessment, national test results for 15 year old students in 64 developed and undeveloping nations show that American students score in the 27th percentile in science, and 34th in mathematics. Additionally, there is an unmet demand for people to fulfill STEM career positions in America, largely due to the unsatisfactory quality of STEM education in American school systems. This is especially true in the fields of Computer Science and Robotics, in which only one out every ten American public schools offers a Computer Science course, and in which most don't allow to count towards a student's graduation requirements. As a result, American students are discouraged from studying and engaging in computer science and engineering. As a global leader in technological innovation, the US must take steps to remedy this issue; an effort must be made by third-parties to encourage and build an interest in computer science and engineering among younger students. The Morehouse College RoboTigers Robotics Team already engages in outreach workshops to foster an interest in computer science and engineering among young students in the local community. Since the majority of the Morehouse College Swarmathon Team members are also members of the Robotics Team, this outreach project is an extension of the aforementioned Robotics Team outreach activities. The goal of this Swarmathon Outreach project is to cultivate an interest and teach skills in computer programming and robotics among local high school students.

Reaching Out to Woodland High

To accomplish this goal, it was necessary to identify local high schools. The list of high schools was narrowed to those which would be available for our teams presentation and which, including a diverse student population, would allow us to assess how different types of students benefitted from the outreach program. Woodland High School in Atlanta, GA best met these criteria, therefore, it was chosen to host our outreach program.

A week prior to the beginning of the outreach program, some of the team members travelled to the school to advertise the program and introduce ourselves to the classes potentially interested in our outreach program. As we had hoped, we found a diverse group of incredibly bright students who, while having little to no experience with programming, were already active members of the high school level VEX Robotics competition. We spoke with them about who we were, and our purpose for hosting the outreach program at their school. While discussing robotics and exchanging ideas to improve their VEX competition robot, we were able to interest them in attending our outreach program.

Outreach Outline and Presentation

The overall outreach was divided into two main parts: a presentation about computer programming, engineering, robotics, the Swarmathon competition, and each team member's individual experiences in STEM, and a hands on, group based programming tutorial. The bulk of the PowerPoint presentation consisted of basic concepts behind computer programming and its relation to current technology, what engineering is and its different types, and what the Swarmathon competition is, our research progress and the competition's end goals. In order for our presentation to better relate to the high school students, we sought to use concepts and examples with which they were either somewhat familiar, or that were easy to understand. For example, during the Swarmathon portion of the presentation, we explained to the students that the technology of most swarm robots are based on algorithms inspired by the search patterns of animals that regularly operate in large groups, such as, insects, fish, and birds. The high schools responded positively, and many were nodding their heads in understanding of the concepts

that we covered. The group based programming tutorial involved splitting the students up based on their prior programming experience, and teaching those students C++ programming skills appropriate to their level.

Personal Level

One of the reasons we wished to attend Woodland High School was because of its high racial diversity. The week prior to presenting, we were informed by the faculty that few, if any of the students travel far from home following graduation. Not many took the time to research what opportunities were available to them, instead preferring the nearby and "familiar" institutions. To better inform these students of their options, our team spoke on the nature of Historically Black Colleges and Universities. We spoke on why they were originally created: to afford black men and women of all walks of life an opportunity to receive not only a formal education, but an education on the history of their people as a whole. In case any of the students were skeptical about the benefits of attending an HBCU over a typical institution, we related our personal experiences during our time currently attending one. Given the diverse background of the student group, we made sure to emphasize that HBCUs were diverse as well; one of our Swarmathon team members was an international student from China.

The presentation also provided an opportunity for the students to hear about the benefits of a career in STEM, straight from the mouths of college students close to their age. Each team member spoke on summer internships and research opportunities. The students responded especially positively and enthusiastically to hearing that two team members, a freshman and a sophomore, accepted summer internships at Google. These team members were only a few years older than the high school students, were African-American - a historically underrepresented group in STEM fields - and were in a similar position in high school as many of the high schools students were currently in. When the high school students realized that it was possible to accomplish such lofty goals, and so soon, their eyes began to brighten, and they leaned forwards in their chairs and listened more attentively to the presentation. Even after the tutorials and activities, the students inquired to the team about how they could prepare to be in the same position.

Programming Tutorial Activity

In order to adequately meet the needs and given skill levels of the participating students we felt it necessary to divide the student body into three groups. The first two groups of students were given a brief look into our ROS code and an introductory C++ tutorial, made for those with little to no prior experience with programming. Within the third group, students who demonstrated familiarity with programming, C++ in particular, were extensively shown the ROS code and an explanation for the algorithms the team was currently experimenting on.

The first two groups, each headed by two members of the Swarmathon team, were presented with five exercises on various elementary programing techniques of C++. The first group taught tutorials, beginning with the universal Hello World introductory program. The team wanted to begin with the most basic of coding statements and in such a way was able to explain the concepts of information being output by the computer. Next came the concept of using simple inputs to create a desired output. For this exercise, the students were tasked to create a program in which data was entered to achieve as desired result. An example was created in which prompted the user to enter the number of apples they had. The program would then output "You have (entryValue) apples." In this way, variable assignments were also taught, as it was necessary to create the "entryValue" variable in order to input data. The students were informed on how variables could be used to store data as well as have data entered to them by the user. From here, concepts such as mathematical calculations became simple to explain. The students were taught that variables can also hold equations in which other variables can hold information entered by the user. The students were then asked to create a program that prompted the user to input two integer values and output their sum. From the previous lesson, the students understood that data could be stored in variables and sent to an equation. Knowing this, most students elected to create three variables, one for each entry and one for the formula itself, which was stored as data to be output. Finally, conditional statements were introduced, specifically if and else statements. If statements were explained conditions that must be fulfilled in order for a particular portion of code to run and else statements as code that runs in cases where the conditions of the if-statement prior were not met. Here, the students began to show initiative. They were tasked to create a simple username confirmation, a program that outputs "Access Granted" if the

user inputs the correct string; however, some students decided to experiment, using integers, adding else statements that outputted “Access Denied”, or even adding second conditions to input a password. The team members heading the first group were pleasantly surprised as the students were not only willing to learn, but, in many cases, showed an utter fascination with the subject presented to them, and were quick to learn new concepts.

The second group used a slightly different approach. First, the team members briefly scrolled through the Mobility and Obstacle Detection sources files from the ROS code, explaining what specific parts of the code did, how they worked, and how they could be modified. Although most of the students had little experience with coding, they were able to understand the explained ROS code enough to ask supplemental questions, and even correctly answer comprehension questions from the two team members. The ROS code was compiled, and a rover simulation run through Gazebo to show the students how the end result of the code looked. The students were fascinated by what the code was able to accomplish. By demonstrating the ROS code first, before giving the tutorial, the students were very enthusiastic to begin learning how to write basic C++ code. The Visual Studio IDE was loaded to give the students an example of an alternate method of typing, compiling and executing their code besides a text editor and command line. The students were taught how to code a Hello World program, and were given a much more in-depth explanation of basic C++ code. Once the students felt comfortable with their first program, they were moved on to simple input and output programs, then variable storing and manipulation programs, then creating basic classes and instantiating objects. More example programs were shown and demonstrated, including a coded game of Rock, Paper, Scissors that the students enthusiastically used to battle against a computer opponent. Many students were curious about other coding languages and their uses, so examples of Java, and MATLAB were also shown. Last, using the remaining time, the team members gave an explanation of the Swarmathon rovers’ hardware and answered any burning questions that the students had about college and programming based internships and jobs.

The third, which consists of the students with programming experience, would be able to have an in-depth tutorial of the Swarmathon-ROS software package, as well as implement some code changes themselves. These students were particularly interested in seeing how they can manipulate each rover’s movement, using some basic functions that they recall from their own programming experiences.

Survey and Statistics

About twenty-five students participated in the outreach program, and a random sample of ten students were given a survey to complete about the program. The survey asked basic demographical information, asked the student to rate their interests and comfortability with programming before and after participation in the outreach, and asked for their specific feedback and thoughts on the outreach.
A link to a Google spreadsheet with the data from the surveys can be found here:

https://docs.google.com/spreadsheets/d/1ujwXGYrVCVwPVO5v6SSLa051bsB_FL1g4X3JakvfZ1U/edit?usp=sharing
A link directly to the survey can be found here:
https://drive.google.com/open?id=1aVaiqKZCCbj-SxLDJlnTU0X42W96dhUJtwkoPJaB4s8

Nine males and one females filled out the survey (the actual gender ratio was smaller than this suggests, although there was still a greater majority of boys versus girls in the outreach program). Seven identified themselves as Black, four identified as White, one as Asian, one as Hispanic/Latino, two as other, and none as American Indian, Native Hawaiian or Pacific Islander. Four of the students were multiracial. Therefore, the backgrounds of the students in the outreach proved to be extremely diverse.

Five of the students were in the 11th grade, three were in the 12th grade and therefore, their last year of high school, and two were in the 10th grade. Most of the students were in their final years of high school, and were preparing to graduate and enroll in college/university. Teaching this specific group programming skills and encouraging an interest in computer science and robotics before they moved to college/university was especially important.

Next, the students were asked to rate their interest in computer programming and/or robotics before participating in the outreach program on a scale from 1 to 5, with 1 being not interested, and 5 being very interested. Six of the students said 5, one said 4, and three said 3. Averaging these values gives an overall initial rating of 4.3, showing that these students came in already interested about computer programming and robotics. It is unclear how the students interpreted the scale, especially whether choosing a 3 meant they were neutral about computer programming and robotics, or whether it meant they had a medium interest in the subjects. The Google forms used to conduct the survey would not allow for a labelling of each number on the scale. Nevertheless, when asked by the following question to rate their interest in computer programming and robotics after participating in the outreach program, eight said 5 and two said 4. Averaging these values gives an overall final rating of 4.8. Those individuals that did not give a 5 rating for their initial interests, gave a higher rating for their final interests. This means that for every single individual that did not already have a strong interest in computer programming and robotics, their interest in those subjects *increased* as a result of our outreach program, signaling success in our efforts to increase interest in computer programming and robotics in high school students.

The next set of questions were similar, but asked the students to rate their knowledge/comfortability with programming before and after participating in the outreach program, again on a scale from 1 to 5, with 1 being not knowledgeable/comfortable and 5 being very knowledgeable/comfortable. Before the outreach program, one student said 1, three students said 2, four students said 3, one student said 4 and one student said 5. The average of these ratings is a 2.8. This time, the ratings were more spread out, meaning that the students had anywhere to no experience to lots of experience. There is a contrast between the students' initial knowledge of programming and their initial interest; although these students were initially interested in computer programming, many were not knowledgeable in programming. After participating in the outreach program, when asked how comfortable they were with programming, two students said 2, two said 3, three said 4 and three said 5. The average of these ratings is a 3.7. The ratings were still spread out, but there was an increase in their comfortability in programming after participating in the outreach. Except for the individual that gave an initial rating of 5, every single individual's knowledgeability/comfortability with programming *increased* as a result of participating in our outreach program's programming tutorials, showing that we were again successful in teaching the students how to program.

Next the students were asked to list the programming languages they knew. Most listed C++ (obviously due to the outreach program), some listed Java, Python and/or EasyC, and a few listed Javascript, HTML, and/or CSS. It is possible the students misinterpreted the question as 'Which programming languages do you know *of*?' Or 'Which programming languages have you been *exposed* to?', but assuming they did not, the students know of a broad range of languages. Then, the students were asked which robotics programs they had participated in. Most listed VEX Robotics. Therefore, most of the students had been exposed to programming and had participated in robotics before the outreach program.

The second to last set of questions involved the students' thoughts about the outreach program. The first question asked the students to rate how they agree with the statement, "The program was engaging and interesting", on a scale from 1 to 5, 1 being that they disagree and 5 being that they agree. Nine of the students said 5, and one said 4. The second question asked the students to rate how they agree with the statement, "The content presented in this program was understandable", using the same scale. Eight students said 5, and two said 4. The third question asked the students to rate how they agree with the statement, "I was able to participate in the activities", using the same scale. Nine students said 5, and one student said 4. These ratings show an immense success in engaging the students in the program, presenting the content in an understandable format, and allowing each student to participate.

The last set of questions asked the students to list any topics they learned from the program and their specific thoughts on the outreach program as a whole. Most students said that they learned how to program or more about

some aspect of programming, and one mentioned that they learned how important the field of engineering is, and another how the Swarmathon code and simulations work. When describing their overall thoughts, the responses were extremely positive; “I loved it!”, “It was fun and very informational”, “The program was good and all the presenters were informative.” and “It was easy to understand but helped my understanding of coding majorly” were just a few of the responses.

Overall, our outreach program was interesting, engaging, educational, and fun for the high school students. They learned as a result of the outreach program, and left with a greater interest in programming and robotics. The group of students was very diverse, and no specific demographic displayed trends or similar results, meaning that our program reached the students no matter who they were. We felt extremely elated that our outreach program was such a success and that we were able to inspire an entire group of students. If they ever invite us to return, we would not hesitate to accept their invitation.

Future Outreaches

Plans are already being made to perform similar outreaches at other schools. Our point of contact for Woodland High School has offered to assist us with performing the same, or similar, outreach at the nearby middle school. We would use the same format as with our first outreach, and our presentation would remain the same, but our programming tutorials would be significantly simplified for the middle school audience. If we return to Woodland High School, we would use the same format as the first time if we received a different group of students, and we would provide a more advanced, individualized programming tutorial if we received the same students as before. The frequency of outreaches would increase in the upcoming years, if our outreaches continue to be successful.

A link to more pictures of the Morehouse College Swarmathon Outreach Program can be found at:
https://drive.google.com/open?id=0Byi6PVOgACQpN09RUGxOYkxSbGs