NASA Swarmathon 2017

Outreach Report

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Dr. Bhattacharya has read and authorized the submission of this paper.

As Fayetteville State University's Swarmathon Outreach Project, our outreach team mentored two groups of high school students in the NetLogo Swarmathon competition. The purpose was to expose the high schoolers to programming, not just for robotics but in general terms. The most daunting task for a younger populace when contemplating a Science, Technology, Engineering, and Mathematics (STEM) based career, is overcoming the feeling that it is too difficult or complicated to tackle. Therefore, the overarching goal was to help our high school students gain confidence and help them realize they could have a future in fields that implemented STEM based processes and methodologies. Our intent was to be available to assist them when needed, but to also help them discover the tools and skills that would foster that sense of confidence.

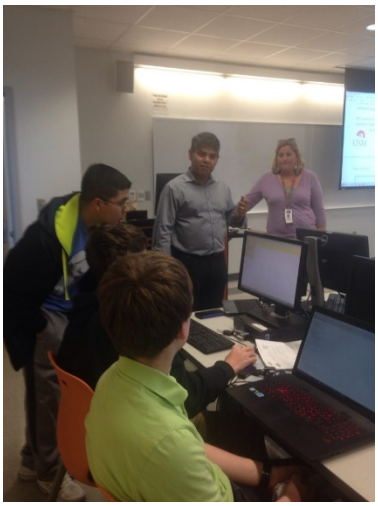

Fig 1. Dr Bhattacharya and students

The team started our outreach project by evaluating high schools in the area. Our principal investigator, Dr. Sambit Bhattacharya, had an established relationship with several of these prevailing schools. Two schools accepted the challenge: Jack Britt High School and Terry Sanford High School, both located in Fayetteville, North Carolina. Each school initially had their own respective teams. Teams were composed of four students from Terry Sanford and seven from Jack Britt.

Of the seven Jack Britt High School students, six were male. The team members are participants in the Integrated Systems Technology Academy of Engineering (ISTA), a STEM academy at Jack Britt High with a curriculum incorporating drafting and integrated technology courses and a requirement that students maintain a 3.0 GPA.

Terry Sanford's team consisted of two males and two females. One is taking a computer science course while the remaining three are involved in the school's CyberPatriot program. This is a national competitive endeavor by the Air Force Association in which students solve the networking and hacking problems that might face a small company. In 2014, the Terry Sanford team won the North Carolina Service Division Championship and finished as number 34 out of 402 teams.

Overall, the students come from a varied background and experience level. The ages range from 14 years of age to 18 years of age. Ethnicity and race reflect a level of diversity consistent with the district the schools are located in, with the team including three African-Americans, one Asian, one Hispanic and seven Caucasian participants. 57% of the students surveyed during the March 23, 2017 workshop had no experience with programing prior to the NetLogo project. The remaining participants had previous experience with various programming and languages such as Python and C++, while others indicated they had some knowledge of networking. All pupils had access to a laptop or personal computer at home and at school. All

members had plans to pursue a STEM career and survey results revealed 89% indicated this choice was reinforced by their involvement with the Swarmathon project. For most of the students, this shared career aspiration was also the main catalyst for initial interest in the NetLogo project.

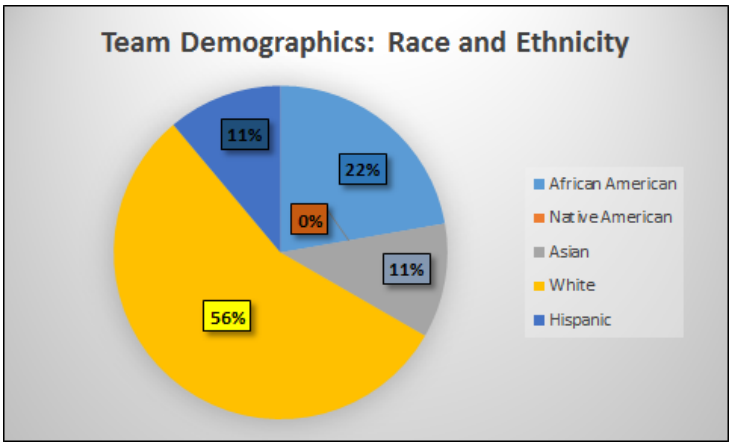

Figure 2. Race and Ethnicity of surveyed participants at Workshop Two

The Swarmathon High School Division competition consist of students programing virtual rovers to search and recover resources using the NetLogo language. NetLogo offers a low threshold for entrance for those participants that had little programming experience. It focuses on using agents to teach programming concepts and processes. The members traversed through several modules to help teach how to use and manipulate the environments. The modules started out with basic biologically based search environments, building upon complexity. With each new module, it called for additional input and higher level thought from the participant.

As mentors to the high schoolers we engaged with them in many ways. In the early stages of the partnership we assisted with helping the students with any questions or problems they had with understanding what the modules may be requiring them to do. Some students were confused by verbiage that was used or unfamiliar ideas that were expressed in the modules. The mentoring team walked them through step-by-step, while helping them to decipher the meaning and usage of the new jargon or concepts. Mentors encouraged critical thinking and problem-solving rather than directly providing quick and easy answers that would not foster learning.

Once the students understood what was being asked or required by the modules, the mentors helped with completion of the modules. Several mentors spent time with individual students to help not only complete the modules, but to help the students grasp the concepts that were being proposed. Other mentors were designated room rover and helped with specific portions of the modules. For instance, some students were not sure how to complete adding a radio button in the first module. Several of the mentors circulated among the students to promote task completion. Assistance was provided by proposing scenarios, asking questions to encourage

students to examine an issue from multiple perspectives, or redirecting them to resources available within the modules pertaining to the challenge at hand.

There was a lot of interaction between the mentors and participants, even on matters not particularly related to programming or the Swarmathon High School Division competition. A frequent area of discussion was answering questions on what was college was like. The mentors took this time to connect with the students using real world anecdotes. The second most addressed question was why the mentors chose computer science and was it entertaining. We were able to take some time to explain our backgrounds and circumstances. As mentors, we explained that programming or any life endeavor is about what the participant puts in, not just how smart you are or how easy good ideas may come to you. We tried to take time to make sure that they saw us as nothing more than adult students, with all the usual trappings of having to study, take tests, and juggle having other responsibilities. These interactions gave the students a sense that STEM based courses were attainable for the average student. Many of the high schoolers noted that it showed them that you did not have to be a “super-genius” to pursue science, technology, engineering or mathematics. As mentors, we felt this illustrated one of the greater goals of the outreach program – helping students see STEM curriculums and careers as feasible and accessible for them.

Figure 3. Students test NetLogo Modules

Following completion of the NetLogo modules the teams were tasked with creating their own program. This goal of this code was to search for resources, virtually, using different search types and algorithms. Both teams came up with several approaches to this task. The Jack Britt team decided to have each member come up with a nonstandard search pattern. Each rover had a unique name and pattern.

Sanic, the name given to one of the robots, moves in a pattern that is like a square-shaped spiral. If a rock enters a radius of two while the robot is searching, then it will face the coordinates of the rock and then go pick it up. It will deposit the rocks at home base and then go back to the area it picked them up and continue the spiral. This was chosen after the mentors suggested more randomness might need to be incorporated. One of the problems the participants found was large clusters end up taking up most of the robot's time. Aside from that, robots that would share this programming are great for clearing out a large area. One idea for future study would be for it to leave trails at clusters and then skip them. This would free the rover up to only search while another rover could be assigned collection of marked nodes.

Another of the virtual rovers is named John. This particular rover will move randomly in the beginning and then after 2000 ticks it will start avoiding certain trails left by the other rovers. This is so that it can get the ones robots might have missed. However, it does not always avoid trails. It just has a *chance* to avoid trails. Through trial and error the team found that if the chance is close to 50% avoidance, it performs better.

Zen is another of the robots that the Jack Britt Team are working on. It has a very similar code to that of Sanic, described above, but it runs in reverse. Once again, it goes in a pattern that is similar to a square-shaped spiral, however the difference is it starts from the outside of the spiral and works inward. The robot moves to the outside corner first, then continues in a counterclockwise pattern, moving inward two units at every spiral. If a rock enters a radius of two elements while the robot is searching, then it will face the coordinates of the rock and then go pick it up. It will drop off the rocks then go back to the area it picked them up and continue the spiral.

Another robot is called Halley. This one is most similar to those in NetLogo Module One in that it just randomly goes to rocks and picks them up. Students were also planning on adding site fidelity to it. So far a good search angle for it seems to be 45 degrees. Becky is the fifth rover. It will move randomly to find single rocks and follow trails to rocks, but will also leave long trails to clusters. The members are still actively working on this algorithm. Sara is the final robot. It will move randomly, but targets clusters and follows trails to other clusters. Whenever it finds one, it leaves a short trail to the rocks.

The Terry Sanford team took the approach of working on one collective code. Their code consists of the rovers randomly searching. Upon locating a node by two separate rovers then the second rover would leave a trail back to home base and the remaining rovers would follow until the node has been fully exploited.

When planning Outreach for next year, we will approach other high schools in the area that provide greater diversity. The two schools chosen this year were primarily selected because of a pre-existing collaboration that was extended quite easily into the Swarmathon NetLogo project. However, when examining other high schools in the area, it became clear Terry Sanford and Jack Britt had much lower minority enrollment – as much as 30% in one case – than other area schools based on 2016 data collected.

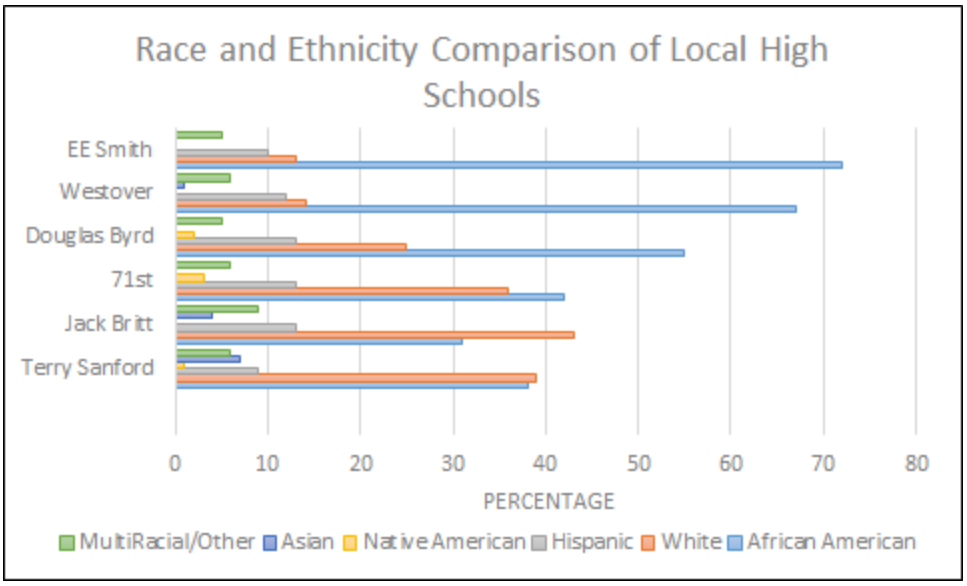

Figure 3. Diversity information from local high schools

For the future Outreach, we propose to request participation by one instructor and five students from three of the schools evidencing higher levels of racial and ethnic diversity. Westover High School will be one of the schools included in the program next year. Dr. Bhattacharya is on the advisory board of the Engineering Academy of Westover High School so there is already an existing connection. A team from the Academy participates in the For Inspiration & Recognition of Science & Technology (FIRST) robotics competition and it has several technology courses with a robotics orientation. They were not able to participate this year but they have indicated they would like to participate next year.

Approaching the other schools early will be vital in promoting involvement and allocating resources and time. Obviously, students already taking STEM-courses will serve as a pool to draw from, but recommendations from instructors will also be vital to reach students who may show potential but have not taken advantage of other opportunities. Working with robots, even virtual ones, may arouse sufficient interest to bring such a student into the program. Then it is our goal that they will become engaged and invested in the techniques and concepts presented to them and confidence in their ability to pursue such ideas outside the program will grow.