Outreach Program Using Swarm Robotics at The University of Puerto Rico at Arecibo

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Introduction

The public and private education system of Puerto Rico had limited to no access to computer science during our K-12 education given restrictions on the local curriculum. Being a computer scientist is such a relevant field on STEM, and it is imperative to take initiatives in the local communities and expose students to a whole new world of essential concepts. The final goal of this project was to encourage the impacted young people to pursue a college education STEM and particularly in computer science area using the Swarm Robotics concepts **(Dorigo, 2014)** and tools.

NASA Swarmathon **(The Moses Biological Computation Lab., 2015)** is a competition, that allows to undergraduate students to do research, creating, designing and modifying swarm robotic algorithms to make advancements in space exploration and also required to do outreach activities with students in the communities to build the skills and generate interest in computing and robotics. UPRA Swarmathon Team has been part of this initiative since 2016.

On the other hand, The UPRA Swarmathon initiative is part of the Robotics Development Lab "RoDeL" **(Robotics Development Lab, 2014)** RoDeL is a research and creative laboratory that works with ISMuL (Integrated Science Multi-purpose Laboratory sponsored by NASA Puerto Rico Space Grant Consortium) and the CIC (Research and Creative Endeavor Center) that brings together students of programs related to STEM areas of UPRA (mainly Computer Science and Engineering) in a dynamic and cooperative learning environment. The Laboratory provides the necessary facilities for the development of projects of research, creation and professional practices pertinent to the area of robotics and artificial intelligence to the students of UPRA especially those of the program of Computer Science.

In order to bring project information to the community, UPRA team worked mainly in two types of activities: 1. General outreach activities, wherein a general way and with the help of the Swarmies (robot used in the college competition), presenting the project, impacting a large number of people in small periods and 2. I have specialized academic activities where groups of students learned and practiced the basic concepts of swarm robotics and Swarmathon in using hands-on workshops.

The general outreach workshop was designed expecting teenagers have fun while learning about computer science and swarm robotics. This strategy would ensure the complete attention of students, especially if they are uninterest on any STEM field. The workshop consists fundamentally of three segments:

1. Introduction to swarm robotics, basic concepts as solving problem strategies, heuristics, swarming, and swarm robotics.
2. Learning basic concepts of programming, coding with NetLogo Software.

3. Do physical activities that mimic the Swarmathon Challenge.

To evaluate and to improve the activities, we collected data that allow us to describe our participants demographically. The workshop evaluation technique is defined in the two key points. The first, being a formative evaluation, is aimed squarely at improving the workshop and its instructors. It centers on one specific question: "Are our instructors/approaching strategies effective?

The second key point emphasizes the accountability of effectiveness, which is aimed squarely at compiling data in percentage about the student improvements. It centers on one specific statement: "To measure "Basic NASA/CS knowledge before and after the workshop."

This document presents the summary of all the outreach activities that UPRA Swarmathon TEAM developed and implemented during the academic year 2017-2018. (see video at **NASA Swarmathon UPRA Outreach Video 2017**).

Thanks to NASA Swarmathon and the different activities we participated, we accomplished our goal, and we've been able to pass on the passion for computer science to a good group of students.

Purpose of the Outreach Activities

At Puerto Rico, K-12 Students do not have the opportunity to learn about CS basics since this topic is not included in the curriculum, as a consequence we could see how year to year that a big group of freshmen change of major after the first year of college. The reason? A good group of the High Schoolers that enter the university having a vague idea of what the majors have to offer, they ditch STEM field majors because the lack of knowledge and exposure and usually thinking they're either complicated or hard to graduate. It is crucial to provide Puerto Rican students experiences about what computer science and engineering field are about before entering university.

The main goals of this outreach program are:

- Accomplish the objective proposed by the NASA Swarmathon Project at UPR-Arecibo.
- Bring UPR-Arecibo, RoDeL, and NASA Swarmathon project information to our community, to arouse them, and to engage more young people in STEM areas at present and future times.
- Provide CS basic concepts that are not provide for the K-12 curriculum to a group of students using the Swarmathon challenge as reference and NetLogo and Vex Robotics platforms as tools.

Description of Activities

General Outreach Activities

Expo UPR 2016: The University of Puerto Rico (UPR) presented its diverse academic offerings to more than 20,000 high school students of Puerto Rico at the UPR Expo on October 27th and 28th, 2016. *UPRA Swarmathon Team* was invited to participate, representing the Computer Science Program at UPR-Arecibo. At this event, we had the opportunity to interact with a good number of high school students and explain what is NASA Swarmathon. (more info Expo UPR 2016).

NASA GSDO Visit: As part of ISMuL (NASA-PRSGC center at UPRA) activities, we receive at UPR-Arecibo a group of Puerto Ricans that works at NASA-GDSO program and *UPRA Swarmathon Team* was invited to participate. At this event we impact approximately 300 high school students in an informative boot. (more info: NASA-PRSGC ISMuL)

Also, we had part of two local tv interviews that allows us talking about NASA Swarmathon project and the Swarmies (see more info at: WAPA Interview and WOLE Documental)

STEM UP! Challenge Activity: On March 8th and 9th, 2017 we had the opportunity to participate at this event, that intends to collect and present to high school students of PR, the programs related to STEM that the Universities of Puerto Rico offer to them. At the event, at the UPR-Arecibo boot, UPRA Swarmathon Team provided information about NASA Swarmathon, behind other projects. Also, we offer two presentations to science and math teachers about basic concepts of Swarm Robotics and the possibilities of participation of the Puerto Rican schools in the outreach program using NetLogo.

Academic Activities

We did three main outreach activities, one workshop during CS4Girls Summer Camp, and two workshops on second semester 2016-17 called "Approaching Space Exploration using Swarm Robotics". We selected one public and one private school, near to UPR-Arecibo. Two of our team members were former students at these schools, since we wanted to promote the identification of participants with the presenters. Next, we will present details of each one.

CS4Girls'16 Summer Camp Activity:

On the summer RoDeL and ISMuL offered a summer camp at UPR-Arecibo to twenty-one (21) girls from 13 to 16 years from all Puerto Rico. The main goal of this summer camp was to engage girls in STEM Careers, with special emphasis on Computing For two weeks, between 9:00 am to 3:00 pm the participants learn about basic concepts of Computer Science, 3D animation using Alice and robotics using VEX and Lego Mindstorms platforms. Also, we implement our pilot event for NASA Swarmathon outreach, that consist in a workshop of six hours where explain NASA Swarmathon Challenge, a hands-on activity based on the adapted NASA Swarmathon Outreach material and a robotics activity that used VEX proto-bots that mimics the Swarmathon challenge.

We included a couple of NASA Swarmathon related question on the pre and post-test of the summer camp and applied a survey to measure the overall satisfaction with the initiative.

On first semester of the 2016-2017 academic year UPRA Swarmathon Team, based on the experience and feedback obtained from CS4Girls pilot workshop, planned and improved a new one we called "Approaching Space Exploration using Swarm Robotics", that includes a brief introduction to swarm robotics, basic concepts as solving problem strategies, heuristics, swarming and swarm robotics. Also, it included the NASA Swarmathon Challenge, offering information about the tools and strategies that we used at UPRA.

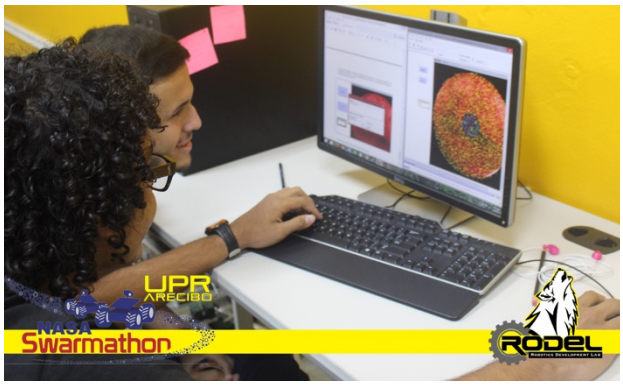
Employing NASA Swarmathon Challenge as reference, our workshop provides the opportunity to work with NetLogo Programming Language and learn about the project and computer sciences basics topics at the same time in a hands-on experience programming a group of Swarmies collecting meteorites on Mars.

Finally, the students will be able to mimic the NASA Swarmathon challenge by using the VEX Swarmies that have been crafted by our outreach team. This activity consists of dividing the students into groups, whom have to create a strategy and test it on a field 12'X12' by driving our VEX Swarmies and collecting the cubes just like the original challenge, but in this case, one of the member will be blindfolded and the other one will provide instructions to accomplish the goal. For evaluation purposes we designed a pre-test and post-test, also a form to collect demographic data and prepared a survey to evaluate the workshops.

Workshop to Vocational School Antonio Luchetti at Arecibo, PR:

We implemented the designed workshop to 29 high school students of industrial electronics class, using the RoDeL facilities, with the sponsor and help of ISMuL. This groups of students receive training in a well-equipped, modern electronic laboratory while studying a broad spectrum of electronic and engineering theory and application of basic electronics, communications and digital circuits, as part of their curriculum. We applied the designed pre and post-test and also ask for the evaluation of the event. (See Video1 and Video2)

Workshop to Colegio San Rafael at Quebradillas, PR.



We implemented the designed workshop to 29 high school students 23 high school students of industrial electronics workshop using the RoDeL facilities, with the sponsor and help of ISMuL. Those students had few experiences on computer science of programming topics. We applied the designed pre a post test and also ask for the evaluation of the event. (See Video3).

Analysis of Results

General Outreach Activities

Swarm robotics and NASA Swarmathon projects were a topic that caught the attention of young people and adults in our community, they show excitement and enthusiasm during our presentations. It is important to mention that the team always had the support of the administration of UPRA and CS department, and it allowed us to participate in all the institutional activities.

We visited several places on the island (different from those explicit on this paper), where we were invited to present our CS program and NASA Swarmathon project. It was very revitalizing to see the interest of high school students and teacher on the project. We impact more than 5000 students across the island.

Academic Activities

CS4Girls'16 Summer Camp Activity: For the summer camp, we collected the following demographic characteristics: All of them were females, between 12 and 16 years old, from eleven municipalities of Puerto Rico, 43% attend to public school, 52% to private school and 5% were homeschoolers. In terms of satisfaction, on average 90% of the participants consider that every evaluated dimension was excellent.

The summer camp also was evaluated by using pre-and post-tests (with some Swarmathon questions), that were taken by all participants (21 students). When comparing pre-test and post-test class point scores for the whole group, the average pre-test % was 52% and the average post-test % was 74, yielding a % difference of +23%. While this % difference is positive, it was also found to be statistically significant. When a correlation was performed, the pre-test and post-test were significantly correlated at the 0.01 level (p=.01), meaning that the tests measure the same concepts.

Workshop to Vocational School Antonio Lucchetti at Arecibo, PR: For this workshop, we collected the following demographic characteristics: We had 29 participants, whom 66% were males and 34% were females from grade 10th and 11th, between 15 and 17 years old, from five (5) municipalities of the North of Puerto Rico. Also, 88% of the participants have interest in pursuing STEM careers. In terms of satisfaction, on average 95% of the participants consider that every evaluated dimension was excellent.

This workshop also was evaluated by using pre-and post-tests (all Swarmathon related question), that were taken by all participants (29 students). When comparing pre-test and post-test class point scores for the whole group, the average pre-test % was 67% and the average post-test % was 86, yielding a % difference of +19%. While this % difference is positive, it was also found to be statistically significant. When a correlation was performed, the pre-test and post-test were significantly correlated at the 0.01 level (p=.01).

Workshop to Colegio San Rafael at Quebradillas, PR: For this workshop, we collected the following demographic characteristics: We had 23 participants, whom 56.5% were males and 43.5% were females from 9th, 10th and 11th grade, between 14 and 17 years old, from four (4) municipalities of the North of Puerto Rico. Also, 79% of the participants have interest in pursuing STEM careers. In terms of satisfaction, on average 88% of the participants consider that every evaluated dimension was excellent.

This workshop also was evaluated by using pre-and post-tests (all Swarmathon related question), that were taken by all participants (23 students). When comparing pre-test and post-test class point scores for the whole group, the average pre-test % was 55% and the average post-test % was 87, yielding a % difference of +32%. While this % difference is positive, it was also found to be statistically significant. When a correlation was performed, the pre-test and post-test were significantly correlated at the 0.01 level (p=.01).

Conclusions

Without a doubt, we could state categorically, the outreach experience was excellent for the UPR Arecibo team. We can say this activity became a learning experience for the whole group. Our team had to invest many hours, in which we all worked together, obtaining a successful result and also proving to be a learning experience for the participants.

In the workshops of this semester we had groups with different profiles, one group with more exposure to technology than another, a public school and a private school, but beyond the differences, we were astonished by the enthusiasm and commitment that showed the majority of the students in the proposed activities.

We were surprised how the participants advanced in the workshops of NetLogo having so little experience in the area of programming. We were also motivated by the interest of teachers in receiving the invitation for these workshops. Swarm Robotics helps us to motivate the participants to learn more about computing and STEM areas in general.

This document allows us to evaluate the initiative and also, disseminate the results with the Robotics Community.

Future Work

After those experience, we know that we need work hard in outreach initiatives to motivate young people from Puerto Rico to pursue careers in STEM, since a majority of the K-12 do not have the opportunities to be in contact with those topics during the school, specifically computer science and robotics. Also, those activities are very important for our college students because help them to provide the opportunity to be role moles of the future generations. Finally, for the mentors, is a very good way to enrich the K-12 education of the region.

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