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Robotics Competition and Family Science Fair for Grades 4-8 Sponsored by the Latino-STEM Alliance

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Robotics Competition and Family Science Fair for grades 4-8 sponsored by the Latino Stem Alliance

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A robotics competition and family science fair was held in June 2015 in an inner city neighborhood in Boston sponsored by the Latino STEM Alliance (LSA), for students in grades 4-8 and their families to promote engineering to students from underrepresented groups.

The LSA partners with schools, private industry, community groups, and academia to bring STEM experiences to underserved youth who otherwise would not have such an opportunity. The LSA saw that existing robotics competitions were not available to underserved youth and therefore decided to hold a year-end competition to motivate the participants. The robotics competition was the culmination of the students' year-long effort in the designing, building, programming, and debugging their teams' robots.

Alongside the competition, a family science fair was used to make families aware of the many STEM resources in Boston as well as to pique their interest in STEM. Engaging families is a priority of the LSA in order to encourage parents to advocate for STEM offerings in schools, as well as to encourage the parents, who are often very young, to consider STEM education and career pathways for themselves.

Another key feature of this event was the participation of NSF S-STEM electrical engineering scholars from Suffolk University, who are graduates of Boston Public High Schools and who are predominantly students of color themselves. These students engaged the fair participants in hands-on experiments about energy and electricity and served as role models for the participants and their families. Surveys of the student attendees as well as some of the presenters were performed to assess various measures of self-efficacy. Surveys indicated that the event was successful in promoting self-efficacy.

Introduction

This paper discusses the Robotics Competition and Family Science Fair for grades 4-8 sponsored by the Latino STEM Alliance, which was held at the end of the school year in an inner city neighborhood in Boston.. In it, we will discuss the motivation for this event, its planning, its execution, its assessment, and next steps in the partnership between Latino STEM Alliance and Suffolk University.

Background

Evidence has shown that robotics programs can encourage interest among underrepresented groups and others in studying STEM [1, 2, 3, 4, 5, 6, 7, 8, 9, 10] but that funding issues and a lack of trained personnel can be a problem[11]. It was also recommended that parents of these students be given support to motivate their children to pursue higher education[12]. In Boston, Northeastern University and Boston Public Schools partnered to integrate a robotics curriculum into Boston Public Schools[13]. In Philadelphia, University of Pennsylvania and the School District of Philadelphia established a similar partnership to increase student performance in robotics competitions[14]. None of these robotics programs though were geared only toward students of color and this shortcoming may be critical-- studies have shown that role models and a sense of community are key for success of minority students[15, 16. 17, 18]. The robotics competition and science fair sponsored by the Latino-STEM Alliance (LSA) addresses this shortcoming and is described in this paper.

The Latino STEM Alliance was founded in 2010 by three Latino engineers Raul Porras, Roman Jaquez and Reinier Moquete who were stunned by the paucity of engineers of color in their work, and desired to encourage young people of color to study engineering. LSA has done the following:

- School Year 2011-2012 – LSA held career days where engineering affiliations such as Society for Hispanic Professional Engineers (SHPE) spoke to middle school students about careers in engineering. A pilot using content from the Verizon Foundation's Thinkfinity program ran at the Lawrence Boys and Girls Club.

- Summer 2012 – Robotics camps at two sites in inner-city Boston and Worcester.

- Summer 2013 – Robotics camps in five community organizations in inner-city Boston, Lawrence and Chelsea, Massachusetts.

- School Year 2013-2014 – Year-long after-school Robotics programs for boys in five middle schools in inner-city Boston as well two programs at the Lawrence (MA – a city north of Boston with an 80% Latino population) Boys and Girls Club. The five programs in Boston were part of a grant from The Boston Foundation for boys ages 8-15 in the heart of the inner-city of Boston.

- Summer 2014 – Summer Robotics camps in six community organizations in inner-city Boston and Lowell, MA. Under the sponsorship of LSA, a gaming class was offered by Emerson College at a community organization in Boston.

- School Year 2014-2015 – Year-long Robotics programs in 11 elementary and middle schools and community organizations in Boston. Two of these programs were funded by the American Association of University Women and were for girls only. The remaining programs were co-ed. A pilot Early Childhood Robotics program was developed and started in spring, 2015.

- Summer 2015 – Continued Robotics programming plus the addition of Design Squad Global, a program developed by the Boston educational television affiliate, WGBH.

- School Year 2015-2016 – Year-long Robotics programs in 16 schools and community organizations in Boston and Lawrence, MA; expansion of early childhood programs.

In June 2014, the first LSA Robotics Competition and Family Science Fair was held. This competition had about 30 middle school competitors, 11 tables of exhibits, and 50 family attendees. In comparison, the recent competition held in June 2015, which is the subject of this paper, had 70 middle school competitors, 15 tables of exhibits, and 250 attendees. It should be noted that three of the competitor teams comprised *Students with Interrupted Formal Education* (SIFE). These students had recently come to the US from Haiti without having had formal education in their own countries. One SIFE team came in second in the competition.

It is important to note that while LSA locates its programs in cities with significant Latino populations, any young person, regardless of race, who lives in that city is welcome to participate. The racial breakout of participants is approximately 40% Latino, 55% African-American (including Cape Verdean and Haitian), and 5% Asian or White.

In addition to teaching age-appropriate technology, LSA focuses on key 21st century skills in its curriculum: Leadership (each team is required to present to one or more school events such as parent nights and assemblies); teamwork (students work in teams of three and learn to work with each other's strengths and areas for growth throughout the year); problem-solving/tenacity (as they build and program their robots, students constantly make and test hypotheses, and rebuild or reprogram accordingly--students learn to see errors as opportunities, not failures); communication (as mentioned above students are asked to present at school-wide or parent events. In addition, they write about their progress and challenges in a blog or on-line worksheet.)

A key aspect of this program is to engage parents substantively. Working with the schools, LSA prepares events which guide parents to understand education and career paths for their children in STEM and STEM-related professions. LSA does this with the hope that in addition to being better able to advocate for their children, parents (many of whom are young themselves and un- or under-employed) will see STEM in their own education or career path.

While the founders continue to be the driving force behind LSA, additional board members contribute expertise in education and in robotics educational programs. Heavily-engaged board members include: a retired inner-city school principal and coach of principals who decried the lack of substantive STEM instruction in Boston's middle and high schools; a retired head of the science department in a large, affluent suburb of Boston and an IT executive in a local company.

Planning

Through researching existing STEM programs, LSA contracted with a doctoral student who is a coach of the NUtrons, a robotics high school team sponsored by Northeastern University, to develop curriculum and training materials. Working with LSA, he developed a curriculum to be taught to the teacher/facilitators in each school/community organization in three segments throughout the school year as follows:

- Mid-October – Introduction to LEGO kits and basic programming using LEGO software along with basic challenges which the students can accomplish
- Late January –The trainer and his high school team present the challenge which they have designed for the year-end competition. They provide each facilitator with the challenge field and all of the necessary materials. Facilitators return to their sites to have students begin building and programming their robots to meet the challenge.
- Mid-late April – Half of the last training session is devoted to the trainer and his students answering specific questions which the facilitators have regarding the challenge. Many of the facilitators face the same obstacles in working with their students, so this session addresses common needs at one time. The second half of the session is devoted to facilitators summarizing their experience over the year and making suggestions for the next year.

In addition to these trainings, LSA provides on-site support monthly by the trainer, his students, Boston Public School instructional technology staff, and former robotics teachers. LSA has developed webinars and maintains on-line e-mail support and an online collaboration site for facilitators as well.

Execution

The Robotics Competition and Science Fair was held on a Saturday in June, 2015 (Figure 1 and Figure 2). Eleven teams of students took the robots they had designed and continued to tweak their programs in a pit that LSA provided. The task which students had to accomplish was for their robot to knock balls into a goal either on the challenge floor or from a see-saw attached to the floor and to prevent the opposing team from doing the same. Each team participated in three rounds of two minutes each to move to the next round. Teams were judged by the number of points they scored by getting the balls into the goal. In addition, a team of professional engineers and educators judged teams on creativity of design and level of teamwork.

In addition, STEM-related organizations from the Boston area, such as New England Aquarium, Franklin Park Zoo, Science Club for Girls, Suffolk University and the Museum of Science had tables where attendees (students, siblings, parents, et al) could participate in hands-on activities.

Figure 1 June 2015 Robotics Competition and Science Fair: the robotics competition

Figure 2 June 2015 Robotics Competition and Science Fair: the science fair

Please see a short video of the event: https://vimeo.com/134637558 .

Participation of Suffolk University's NSF S-STEM Electrical Engineering Scholars

A new feature of the 2015 Robotics Competition and Science Fair was the participation of *Suffolk University's NSF S-STEM Electrical Engineering Scholars*[1], who come from Boston, and who had studied at several of the same elementary and middle schools as the participants. Moreover, they are almost all engineering students of color and as such can be excellent role models to the elementary and middle school attendees and their families. The students manned a table (Figure 3) where they demonstrated cool electrical gadgets that illustrated fascinating electrical concepts such as a shake generator, a Lego Mindstorms projectile gun, a wind turbine, a Mendocino Motor, and photovoltaic cells. This activity not only allowed the elementary and middle school attendees to envision themselves as future engineering students but also afforded the NSF S-STEM students an opportunity to improve their leadership and communication skills, and to improve their own self-efficacy. Moreover, it gave them an opportunity to give back to the community.

[1] Suffolk's *NSF S-STEM Electrical Engineering Scholars awards full scholarships for Boston students with financial need to study EE at Suffolk University.*

Figure 3 Suffolk University EE scholars demoing cool electrical gadgets to the events young participants.

Challenges

Implementation of the program had numerous challenges, many (but not all) of which we successfully managed. Understanding these in advance of replicating this program will reduce pitfalls in a new program.

1. **Facilitator on staff of school –** LSA pays a stipend to a teacher from each school to run the Robotics team. The benefits of such an arrangement include the fact that teachers know the school and students well, thus facilitating recruitment of students and access with the principal. However, teachers may have to attend unscheduled professional development on team day, may be asked to coach another club, or have other conflicts in scheduling. As a result Robotics class sometimes is canceled or shortened on a given day and/or facilitators are unable to attend an LSA training after school.

   An alternative to hiring teachers from the school as facilitators is to hire part-time facilitators who work directly for LSA. The main advantage to this approach is that LSA is their priority. In addition, they may be able to teach Robotics classes at several

schools, thus improving quality and consistency of instruction among sites. The disadvantages are that the investment of the school in the program is reduced. Another disadvantage is that external facilitators can be students; as such, when their schedule changes mid-year, they may not be able to continue teaching on the same day the following semester.

While LSA primarily hires faculty from the school, we have occasionally hired external facilitators. Next year we are thinking of piloting the hiring of one external facilitator to work at 3-4 schools and will assess which structure is more effective.

2. **Late Hours of Class** – Boston Public Schools (BPS) engages in "school choice," which means that students are often bused to schools across the city. Robotics classes typically run for 90 minutes after school. The first year of the program BPS operated "late buses," so that students could attend after-school events. In School Year 2014-2015, because of budget cuts, BPS canceled "late buses." Since many of our students live far from the school, this prevented some of them from attending the Robotics program. The neighborhoods where our students live and attend school are often high-crime. Parents are reluctant, especially in winter when days are shorter, to have them go home on public transportation and then walk home in the dark. Thus students electing to study Robotics were either walkers, or those whose parents committed to picking them up after school. This affected attendance, because when a parent could not pick up a student, the student would miss Robotics class.

   We have not yet figured out a way to effectively address this problem.

3. **Educational Director**- Our educational director is a doctoral student. He had competing priorities around availability for training and site visits. Plus, although extremely grounded in Robotics (having both participated in and coached FIRST teams), he is not a teacher. Because of that, occasionally both the curriculum and the training sessions lacked coherence. As a result, facilitators did not take attending the trainings as a priority. This meant that they struggled alone to have students build and program their robots.

   In the next school year, LSA hopes to rely more heavily on the BPS Robotics coordinator both for curriculum development and training. Our educational director, who will graduate in May, plans to stay on with LSA, possibly on a more limited basis.

4. **Competing Priorities for Students** – Other school activities occasionally competed for our students' attention at times during the year. Specifically, many of our students wanted to be on the basketball team, which occasionally met on Robotics days. Basketball took place in the winter, which meant that after several months studying Robotics, some students would temporarily absent themselves from Robotics.

In late summer, LSA will meet with the principal of each school to ensure that basketball and other desired activities will be held on different days from Robotics.

5. **Parents -** Parents have been both an asset and a challenge. As was mentioned above, many parents have taken on the responsibility to pick their children up, often from other parts of the city, during rush hour at the end of Robotics class. We are grateful for the seriousness with which they take Robotics.

   Occasionally the exigencies of inner-city life require that parents need to ask their child not to attend a class on a particular day, so that they can take care of a younger sibling or translate for an older relative at the hospital or court. This is a problem that the schools face every day; neither they nor LSA has found a suitable solution.

6. **Providing Opportunities for Students to Continue to Study STEM in High School**

   Meaningful STEM opportunities in Boston high schools are either non-existent or inconsistent. LSA has worked with facilitators and guidance counselors to channel eighth grade students to apply to high schools which have solid STEM course offerings.

Recommendations for Replicating This Program

This Robotics program is eminently replicable. The paper describes how the program was created and how it has been modified each year. Some quick recommendations for replicating the program are:

1. **Identify and recruit board members with different strengths.** As has been mentioned, LSA was founded by engineers. Subsequent board members have represented education and business. Still lacking are those with access to financial and legal resources, whose presence would enable further programming. At the early stages in any non-profit, board members should be willing to tackle planning and management of the organization until fundraising can yield to hiring an Executive Director (which LSA finally did this past February).

2. **Identify and recruit stakeholders**. Several partnerships which LSA has are critical to its success. These include:

   a. BPS Office of Instructional Technology – This is a symbiotic relationship. BPS' Robotics Coordinator knows which schools should be included in programming. Her knowledge of curriculum, instruction, and latest resources and training possibilities are enabling not only LSA to expand existing programs, but also to branch out to Early Childhood Coding and Robotics. Because she lacks a budget to do the work

necessary across schools, LSA supports her efforts by writing grant proposals to provide instruction at schools which she identifies.

b. Suffolk University Electrical Education Program (N-STEM Program). This program is unique; many of the students are themselves BPS graduates, who are first generation college students. They have backgrounds similar to those of the students LSA serves. They serve as mentors as well as participants in the Robotics competition. In addition, Suffolk staff have analyzed our end-of-year student surveys. The partnership with Professor Lisa Shatz and graduate student Kerrie Pieloch has been invaluable.
c. BPS Principals - While all principals have been supportive of having Robotics instruction in their schools, several have distinguished themselves by the intensity of that support. They stand out for attending events, holding parent events, and providing opportunities, such as pep rallies before the competition, to enable our students to be seen as leaders in their school community. In addition, especially in K-8 schools, they have created a pipeline for younger students to become aware of and choose to participate in Robotics instruction.

Method

Participants

The participants in the LSA Robotics Competition and Family Science Fair included approximately 70 elementary and middle school students who were involved in a robotics club at their schools and eight Suffolk NSF S-STEM EE Scholars. When surveyed, 37 elementary and middle school students and all the EE scholars responded. The elementary and middle school students were in 4^{th}-8^{th} grade (mode = 5^{th} grade).

Measures

Following the robotics competition, the elementary and middle school students were given a 33-question survey assessing the impact of the robotics club overall. The EE Scholars were given a 5-question survey assessing their impressions of the event and of the younger students at the event.

Results

Robotics Club

Elementary and middle school students were asked how their robotics club impacted other aspects of their life (academics, social, etc.). Over 50% of respondents agreed that robotics clubs helped them feel more comfortable asking questions or asking for help in the classroom (see Table 1). For those who answered, yes most students wrote that they felt more comfortable because they knew their peers and teachers better, while other students wrote that they knew it was important to ask questions in order to learn. Those who answered no wrote that they already felt comfortable asking questions so this did not change over time. Many students also reported that robotics club helped them communicate better in school. One student reported, "In robotics you have to communicate with one another and doing this every week helped me communicate better."

Approximately 65% of students said that robotics club helped them become a better leader in school (see Table 1). Students said that robotics helped them become better leaders because it increased their levels of commitment to a project, involved them in a club that made them look like "the most advanced kids in school", helped them understand different people, helped them learn to respect other people's ideas, and helped them learn to keep calm under pressure.

The majority of the students also said that robotics club helped them become better team members (80.7% said yes). When asked how robotics helped them become better teammates, students said because they learned how to work with other people and delegate tasks to others, learned to be more responsible, learned to listen to those in charge, learned to help others as well as accept help from others, and improved their communication skills.

Participating in robotics club also helped students become better at solving problems (65.6% said yes) and helped them to spend more time solving difficult problems (44.8% said yes). When asked how robotics club helped build their problem-solving skills students said it taught them how to tackle problems step by step, how to slow down and not give up, how to check their work, and how to "see problems in different ways."

Students also endorsed that robotics club helped them understand more about technology (79.5% agreed) and they felt that knowing more about technology would help them get a better job in the future (91% agreed, see Table 1). After students went on a field trip with the robotics club, they were asked how the trip showed them more about technology. One student said, "the field trip showed how engineers improve on each other's ideas to make things better."

Suffolk NSF S-STEM EE Scholars

All EE scholars agreed that participating in the robotics competition was worth their time. When asked on a 5-point scale (5 being the highest) about the engagement of the elementary and middle school students they interacted with, the EE Scholars gave an average rating of 4.5. All of them agreed that if they had attended this event when they were younger, it would have made them more likely to become an engineer. When given an open-ended question about their impressions of the event, EE Scholars expressed that they enjoyed exposing the younger children to different engineering technologies and they were inspired by the children's enthusiasm and their involvement in engineering from an early age.

Table 1.

How Robotics Impacted Students' Lives

	Yes	No	Don't Know
Felt more comfortable asking questions/ asking for help in school	60.8%	34.8%	.04%
Helped them communicate better in school	37.5%	18.8%	43.8%
Helped them become better leaders (in robotics, school, or other teams)	64.5%	35.5%	0%
Helped them become better team members (in robotics, class or sports)	80.7%	19.4%	0%

Helped them become better at solving problems (in robotics or class)	65.6%	34.4%	0%
Helped them to spend more time trying to solve a difficult problem (in robotics or class)	44.8%	10.3%	44.8%

	Agree	Disagree	Neither Agree or Disagree
Helped them understand what technology is	79.5%	8.8%	11.8%
Felt that knowing technology would help them get a better job	91.0%	3.0%	6.1%

Future Plans

The partnership between Latino STEM Alliance and Suffolk University, which began by Suffolk students having a table at the Robotics Competition and Science Fair in June 2015, has grown during School Year 2015-2016. This year the NSF-funded students will serve as formal mentors to the LSA teams. Each Suffolk student will be assigned to a school team. They will be responsible for checking in with the team members periodically during the year, questioning them about their projects, the upcoming competition challenge, and supporting them in-person and on-line. An unusual aspect of the mentorship will be that each mentor will participate in one evening STEM-related event at the school for parents, so that parents can see that students who look like their own children and are first-generation college students are successfully studying engineering. This will make the educational path for LSA's participants and their families more accessible. One further unique aspect is that a parent of one of the college students, himself Latino and Spanish-speaking, will attend the parent event with his son, so that parents can ask specific questions about the college application process and college life in general.

In addition, our students will go on field trips to Suffolk University, to see the college experience and to attend demonstrations of electrical engineering phenomena such as high voltage Tesla coils.

Conclusion

Overall, the robotics club and the robotics competition and family science fair were great successes both for the elementary and middle school students as well as the university students who helped out at the event. The questionnaires showed that all of the students involved had positive experiences at the robotics competition and appeared to have learned from each other as well as inspired each other. According to the students surveyed, the robotics club was successful at teaching students about technology as well as providing them with such self-efficacy skills as communication, leadership, and problem solving skills that they can use both in and out of the classroom. Although these surveys were brief, they indicate that future collaborations between university and grade school STEM programs are integral to expanding the field and inspiring new generations to join the STEM fields.

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