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## **AC 2011-273: MEASURING THE EFFECTIVENESS OF ROBOTICS ACTIVITIES IN UNDERSERVED K-12 COMMUNITIES OUTSIDE THE CLASSROOM**

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Rayshun Dorsey is currently the Founder and President of WizKidz Science and Technology Centers, an organization that works in conjunction with the Georgia Institute of Technology and currently offers an extensive in-formal education collaboration through various outreach projects to include AroPability, a federally funded initiative in conjunction with California Institute of Technology, Center for the Visually Impaired, National Federation of the Blind and Children's Healthcare of Atlanta at Scottish Rite that seeks to stimulate STEM interest, primarily robotics and computing for disabled Middle and High School students; Rayshun and his organization currently hosts PC2Main (Popularizing Computing to the Mainstream) in conjunction with Notre Dame University. This initiative targets middle school students interested in computing and programming by introducing them to story board computing and visual computing technologies. Rayshun is also the creator of The Shadow for a Day (SFAD) Summer Program which provides a unique opportunity for Middle and High School students to assist undergraduates from Spelman College and Georgia Tech's School of Computer and Electrical Engineering. Rayshun Dorsey and WizKidz Science and Technology Centers also works with the (HumAnS) Laboratory and participate in investigative strategies for human interaction with tele-operated assistive robots in home environments; In conjunction with ExxonMobil, Rayshun Dorsey and WizKidz Science and Technology Centers and GA. Tech hosted the 2009 ExxonMobil Bernard Harris Science Summer Camp, a two week residential camp that gives aspiring middle school students the opportunity to experience college life while being introduced to concepts in Lunar Robotics and Colonization.

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Ayanna Howard is an Associate Professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology. She received her B.S. from Brown University, her M.S.E.E. from the University of Southern California, and her Ph.D. in Electrical Engineering from the University of Southern California in 1999. Her area of research is centered around the concept of humanized intelligence, the process of embedding human cognitive capability into the control path of autonomous systems. This work, which addresses issues of autonomous control as well as aspects of interaction with humans and the surrounding environment, has resulted in over 100 peer-reviewed publications in a number of projects from scientific rover navigation in glacier environments to assistive robots for the home. To date, her unique accomplishments have been highlighted through a number of awards and articles, including highlights in USA Today, Upscale, and TIME Magazine, as well as being named a MIT Technology Review top young innovator of 2003, receiving the Georgia-Tech Faculty women of distinction award in 2008, and recognized as NSBE educator of the year in 2009. From 1993-2005, Dr. Howard was at NASA's Jet Propulsion Laboratory, California Institute of Technology. Following this, she joined Georgia Tech in July 2005 and founded the Human-Automation Systems Lab.

# Measuring the Effectiveness of Robotics Activities in Underserved K-12 Communities outside the Classroom

## Abstract

Students from at risk or underserved communities need exposure to real world situations and should be given such opportunities early in their education, to stay competitive in the world arena of science, technology, engineering and math (STEM). New and exciting challenges must be made available that brings these students closer to careers in science and technology. Today, scientific research and exploration within underserved K-12 schools consists of old fashioned methods of students gathered into classrooms and taught with curricula that keep the children informed, yet isolated from the reality of true scientific processes. Teachers from these areas try their best to bring in real life problems and hands-on experiences into the classrooms, however, things such as legal issues and low budgets can pose a problem for certain types of field trips and educational activities. The high demand placed on standardized test preparation requires most of the year's class time leaving teachers discouraged from going beyond the confines of the school walls. Underserved students need more informal education opportunities for the sciences and technology to challenge these children and young adults in science and connect them with the scientific and technology community.

In this paper, we discuss our approach to meet the needs of underserved communities using a process that connects young people to passionate educators and professional engineers and scientists. By offering an academic enrichment initiative that places science and technology within an after school robotics program, we can develop a model for a sustainable phase driven K-12 program that offers a creative and safe out-of-school learning environment where young people from underserved communities work with university mentors and industry professionals to explore ideas, build confidence, develop skills, and find pathways into college and careers that are science and technology driven. These after school programs are designed to tackle the needs of underserved or at risk elementary, middle, and high school students who have expressed or demonstrated interest in STEM. The after school programs are implemented by combining hands-on robotics applications and university professionals in a safe and engaging learning environment. A three-year effort was conducted to determine the effect of these robotics activities for at-risk middle school students outside the classroom. The purpose of these activities was to determine if in fact, programs such as these help to put young adults on pathways toward college degrees and finally, careers in science and technology fields. There were three key focus areas: Retention, Pathways to College, and Decrease in exposure to activities that could result in deviant behavior. Discussion on the approach is presented in this paper and validated through implementation with student populations to provide supportive evidence of the observed benefits.

## 1. Process to engage underserved communities in STEM activities

Low-income students grow up in poverty and usually attend resource-poor schools. Many grow up in environments where nobody they know has attended college. In schools, low expectations are usually set for this class of students. They are normally tracked into a less demanding high school curriculum that does not lead to college [1]. A great deal of research has been conducted to identify the characteristics of low-income, first-generation students and the issues they deal with as they interact with college and university social and learning environments [2,3]. Only

47% of low-income high school graduates immediately enroll in college or trade school, compared to 82% of high-income students [4]. Only 18% of African-American and 19% of Hispanic high school graduates in their late 20s have earned a bachelor's degree, compared to 35% of whites [4]. The opportunity gap persists regardless of academic preparation: 22% of college-qualified high school graduates with low family incomes don't pursue postsecondary education, compared to only 4% of high-income graduates. [5]

There is some belief expressed among some educators that students from poverty fail to achieve because they lack motivation [6]. An offshoot of this "deficit model" is that teachers have low expectations for students who they believe are simply unable to meet high expectations. They tend to demand less academically and behaviorally, which translates into fewer opportunities to achieve and a decreased chance of graduating and going on to higher education. As an example of this belief system, one teacher at a low-income school once said of her students [6]: "We need to tell them, 'You're not all going to college.' Some are not college material and we should tell them that. They should set lower goals and follow them."

To combat this issue found in many underserved communities, we designed and implemented a number of after school programs for at-risk elementary, middle, and high school students who have expressed or demonstrated interest in any aspect of science, technology, engineering and/or math (STEM). The after school programs are implemented by combining hands-on robotics applications and university professionals in a safe and engaging learning environment with a focus on three key areas: Retention, Pathways to College, and Decrease in exposure to activities that could result in deviant behavior.

## **2. Experimental Design**

Quality after-school programs can provide safe, engaging environments that motivate and inspire learning outside of the regular school day. While there is no one single formula for success in after-school programs, both practitioners and researchers have found that effective programs should combine academic, enrichment, cultural, and recreational activities to guide learning and engage children and youths in meaningful activities [20]. In this section, we discuss specific modules used in the after-school robotics programs, namely Assistive Robotics, Mars Robotics and Space Robotics. We employed an after-school and Saturday program that explored various STEM research areas such as robotic hardware, planetary space exploration, astrobiology, flight simulations, and engineering design challenges. The program connected students with science and robotics experts and offered an exciting hands-on experience that reflected true scientific processes. Using various activities, our students used their science and technology skills, teamwork, and their imaginations to help create solutions for real world issues. Postsecondary engineering and science students also interacted with students through classroom visits, university tours, and project mentoring.

Using a team of university educators, industry professionals and master school teachers to facilitate the classes, the project developed, field-tested, and disseminated classroom-ready, STEM integrated lessons that were specifically designed to address the national standards in math and science; specifically designed to highlight the national standards in astronomy (NSES); and integrated mathematics and science by making unique use of existing resources at our technology center. The program was administered in two 10 week module blocks. Every 2-3 weeks for 1 day out of the week, students met during after school hours and Saturday during the morning and afternoon. Our current partnerships allowed speakers from various science and technology industries to participate. Our list of participants included speakers from NASA,

Georgia Institute of Technology, Georgia Bureau of Investigation, Lockheed Martin and more. The program was centered on “college preparedness” and sought to increase the local school district ratings in math and science for students in middle school. Using technology tools and resources of the professional community, the after school program added significance and cultural value to current school initiatives.

### 2.1. Assistive Robotics

Real life scenarios were presented to the middle and high school students from beginner to advanced in the form of robotic problem solving challenges and activities. Laboratory exercises that provide hands-on activities that enforce the learning concepts by coupling them with a robotics application [21]. For each scenario, exercises were distributed in the class and students were broken down in teams to design and build a robot capable of solving each scenario. Each activity was designed to help students learn to apply engineering processes to real life scenarios. Students designed robots intended for law enforcement that performed mock bomb removal missions as well as robots used in the medical field such as a medical image processing robot using Image-Guided Therapy (IGT) capable of performing a mock needle biopsy using a grape suspended in Jell-O that simulated a biopsy on a prostate tumor. This project was modeled after a National Science Foundation sponsored robotics competition held at Carnegie Mellon University 2001. Students also designed and built mock planetary exploration robots equipped with a solar panel and wireless VEX robotic camera designed to scout specific areas of a simulated lunar terrain. The program itself, focused on a more curriculum based learning model where students learned how feedback from sensors and motors manage the functional properties that control the world they live in. They learned about systems, resource allocation, and time management. At the same time students developed work related competencies as they learned to work in teams and manage their projects. Team sizes were determined based on the complexity of the project. Teams consisted of a project manager, a programmer, an engineer, and a communications specialist. Students were encouraged to work together and exchange roles so they are able to experience each role in its entirety. They were immersed in activities that required them to effectively manage time and materials to complete their project in a successful manner. After participation in the robotics modules, more advanced students were provided an opportunity to participate in Shadow-for-a-Day (SFAD) where students had the opportunity to assist undergraduates from a local University and participate in investigative strategies for human interaction with tele-operated assistive robots in home environments. For one day, participants conduct research and assist the undergraduates on transplanting human-like reasoning powers into robotic systems and investigate approaches for encoding task knowledge so that teleoperation can be achieved at higher levels of abstraction.



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### 2.2 Mars Robotics

By combining the efforts of the Solar System Ambassador initiative (<http://www2.jpl.nasa.gov/ambassador/>), we conducted a 10 week workshop series that incorporated the Mars Student Imaging Project (MSIP) where 9 middle school students were selected based on merit, STEM interest and past participation in our programs. Students worked

to uncover the mystery of life on other planets, namely Mars. Student teams consisted of various roles needed to conduct a successful research operation. Students studied microscopic life forms that exist in extreme conditions and their possible existence on other planets, types of minerals that could be found in their research areas, as well as how robotics are used to search for life and explore extreme environments on other planets. Students studied the Phoenix Mars Lander and tuned in to live webinars and accessed authentic Mars photos that helped them determine their research site. Students also incorporated NASA's "Seeds in Space" project; Materials International Space Station Experiment or MISSE-3. MISSE was a series of suitcase-sized test beds containing many different materials, including seeds that were placed outside the station to test how they withstood the harsh environment of space [22]. Student teams had to design, build and evaluate plant growth chambers that contained space exposed basil seeds that were flown upon the shuttle mission STS-118 and compared them to earth based basil seeds. Students also recreated a mars terrain to run robotic vehicle exploration missions on their determined research site.



### 2.3 Space Robotics

Our space robotics module provided 15 middle school students with the opportunity to learn hands on skills in aerospace technology and the challenge of human aviation and spaceflight through the usage of a real live Space Shuttle Launch Control Center Simulator. Classes were instructed by a retired NASA engineer as students were exposed to the same Orbital Simulations used in NASA astronaut training. Students were engaged in simulations that involved working as a team and solving real-world astronaut problems. Students worked in teams to complete payload retrieval missions operating a simulation of the shuttle robotic arm. Aviation classes consisted of professional pilot instructors using Microsoft simulatorX and a DreamFlyer flight simulator that included activities such as how to read flight charts and maps, flight planning, airplane inspection, landing procedures, airplane safety, mission completion and more. Each module ended with a trip to Lawrenceville Airport at Briscoe Field where students participated in one on one flights with pilots as the students had the opportunity to control the plane while in flight. Students also took a field trip to Tuskegee University and experienced flight simulations, instructor lead meet and greets, and finally the opportunity to control a real Unmanned Aerial Vehicle(UAV).



## 3. Pedagogical Focus Areas

Implementation of the after school programs, as discussed above, also involved implementation of three key practices to ensure success: Retention, Pathways to College, and Decrease in exposure to activities that could result in deviant behavior.

### 3.1 Retention

Policies and practices that affect the general populace of students generally can benefit at-risk students as well. These practices include a focus on student retention and graduation, rather than

just on enrollment; well-aligned and proactive student support services; experimentation with ways to improve student success; and use of data on students to improve programs and services [7]. In addition, five factors that have been shown to increase retention [8-11] focus on financial support, helping to build a foundation in academic skills, instruction and academic support, and ensuring an inclusive and welcoming institutional environment. Based on adherence to these factors, we designed a number of practices for contributing to increases in retention. We found that follow-up activities and constant communication between instructors and students yielded the best retention results. Instructors initiated follow up visit to students' schools and continued to involve past participants in activities that kept the students engaged. 15 students received scholarships and grants for future summer camps and after school programs and were distributed to students based on a financial sliding scale, past participation and grade improvement. Parent consultation and involvement also assisted in the retention of student participants. Teacher training workshops were implemented to assist teachers in continuing the STEM based efforts as well.

### **3.2 Pathways to college**

It has been shown that activities designed to increase college awareness in students at the elementary, junior high and high school levels have the potential of enlarging the pool of college-bound minority students. Some of these current outreach activities focus on mentoring highly talented students in fields such as math, science, or teacher preparation and in providing public education activities aimed at increasing the awareness of minority families or communities about the importance of college and on how to best prepare their children for postsecondary success [13-15]. Following these example programs, we determined that summer activities and after school programs that included partnering Universities and Colleges were key in creating real world learning scenarios for the students interested in pursuing STEM related degrees. As such, a Shadow for a Day (SFAD) program was implemented for advanced High school students that participated in our Robotic camps and were provided an opportunity to assist undergraduates from local Universities. 48 middle school students also had the opportunity to participate in a residential 2 week long camp on the campus of the Georgia Institute of Technology that involved Lunar Robotics and Colonization. High school and middle school students enrolled in Morehouse Colleges "Project Identity" had the opportunity participate in a 3 week residential camp that included, Robotics, Forensic Science, Game design and more. Middle school students had the opportunity to take field trips to other areas on the Morehouse campus as well as take a one day field trip to Tuskegee University.

### **3.3 Decrease in exposure to activities that lead to deviant behavior**

In America today, between 7 and 15 million young people are alone and unsupervised in the hours after school, before parents return home from work. This situation places children and teens at grave risk for juvenile crime, substance abuse, teen pregnancy, and other problems. The hours between 3-6 p.m. on school days (referred to by law enforcement officials as a "danger zone") are the prime time for violent juvenile crime; this is also the time period during which kids are most likely to become victims of violent crime, be involved in all kinds of accidents, experiment with drugs or alcohol, and become pregnant [16, 19]. As such, the after school hours are the peak time for juvenile crime and experimentation with drugs, alcohol, cigarettes and sex [17,18]. There is growing evidence that quality out of school opportunities matter [16]. Our summer and after school programs therefore offer activities that are stimulating and fun, yet

isolate student participants from the possibility of being involved in an act of crime. Our goal is to make activities accessible in underserved communities that are not just centered on recreational sports, but are academically benefiting as well.

#### 4. Discussion and Future Work

The academic support teachers provide within the classroom is also related to their expectations of students and often differentiated based on beliefs and expectations related to race, ethnicity, and socioeconomic class. In the classroom, teachers tend to call on those students whom they perceive to be more able learners and engage them more actively in the learning process. They are more likely to provide extra time and help to these students, because they expect them to learn, grow, and succeed. On the other hand, teachers tend to become impatient and ignore students whom they believe are unable to achieve to the level of the others in the classroom [24]. Through the implementation of our programs, we sought to determine the effectiveness, and change in student perspective, on their ability and interest in STEM-related activities. We focused on evaluating whether the programs:

- Developed student awareness to quantitative approaches to decision making scenarios in engineering.
- Helped the students understand different kinds of analytical procedures for determining problems as well as problem solutions.
- Helped students to look upon team decision making processes in terms of analytical models with state variables, decision variables and exogenous variables.
- Encouraged the students to be able to use science and technology to arrive at solutions of analytical models.
- Impressed upon the students the importance of Science, Technology, Math and Engineering in different functional areas

During the three years in which the activities were conducted, both new and continuing students became involved in the program. There was a noted increase in interest in math and science and an increased desire to attend a technical based university.

#### References

- [1] L. Rendon “Reconceptualizing Success for Underserved Students in Higher Education” Oct. 2006
- [2] Rendón, L. I., García, M. and Person, Dawn (Eds.) (2004) *Transforming the First Year of College for Students of Color* The National Resource Center for The First-Year Experience & Students in Transition, University of South Carolina: Columbia, South Carolina: (Monograph #38)
- [3] Terenzini, P.T. Rendon, L.I., Upcraft, M.L., Millar, S.B., Allison, K.W., Gregg, P.L., & Jalomo, R. (1994). The transition to college: Diverse students, diverse stories. *Research in Higher Education*, 35, 57-73.
- [4] National Center for Education Statistics [NCES], 1999
- [5] National Center for Education Statistics [NCES], 1997
- [6] Lipman, P. (1998). *Race, class, and power in school restructuring*. Albany, NY: State University of New York Press.
- [7] Jenkins, Davis. (2006). *What community college management practices are effective in promoting student success? A study of high- and low-impact institutions*. New York: Community College Research Center, Institute on Education and the Economy, Teachers College, Columbia University.
- [8] Muraskin, Lana; Lee, John; Wilner, Abigail; Swail, Watson Scott. (2004). *Raising the graduation rates of low-income college students*. Washington, DC: Pell Institute for the Study of Opportunity in Higher Education.

- [9] Seidman, A. (2005). Minority student retention: Resources for practitioners. In G. H. Gather (Ed.), *Minority retention: What works?* San Francisco, CA: Jossey-Bass.
- [10] Brahmia, Suzanne, & Etkina, Eugenia. (2001, July). Emphasizing the social aspects of learning to foster success of students at risk. Paper presented at the Physics Education Research Conference: Research at the Interface, Rochester, New York, July 25-26, 2001.
- [11] White-Brahmia, Suzanne, & Etkina, Eugenia (2004, spring). *Recruiting and retaining underrepresented populations. How we can help: The Rutgers Story*. APS/AAPT Joint NY State Section Meeting.
- [12] Carter, Deborah Faye. (2006, Summer). Key issues in the persistence of underrepresented minority students. *New Directions for Institutional Research*, Issue 130, 33-46.
- [13] Nestor-Baker and N. Kerka, S. "Recruitment and Retention of Underrepresented Students in STEM Fields", the Ohio State University, Oct. 2009
- [14] Yelamarthi, Kumar, and Mawasha, P. Ruby. (2008, July-December). A pre-engineering program for the under-represented, low-income and/or first generation college students to pursue higher education. *Journal of STEM Education*, 9(3-4), 5-15
- [15] Lam, Paul C., Srivatsan, Tirumalai; Doverspike, Dennis; Vesalo, John, and Mawasha, P. Ruby. (2005, July-December). A ten-year assessment of the pre-engineering program for under-represented, low income and/or first generation college students at The University of Akron. *Journal of STEM Education*, 6(3-4), 14-20
- [16] AFTER-SCHOOL ALL-STARS Three Hours Can Change a Life "Factoids, Facts about After School Programs & At Risk Youth" [www.afterschoolallstars.org](http://www.afterschoolallstars.org) 2010
- [17] U.S. Department of Labor; U.S. Census Bureau, Urban Institute Estimate. 2000
- [18] Fight Crime: Invest in Kids, 2002; [www.fightcrime.org](http://www.fightcrime.org)
- [19] Grossman, Jean Baldwin and Joseph P. Tierney. "Does Mentoring Work? An Impact Study of the Big Brothers Big Sisters Program." *Evaluation Review*, Vol. 22, No. 3, June 1998, pp 403-426.
- [20] Gold, M., & Mann, D. (1984). *The Contribution of Alternative School Programs to the Safety of American Schools*. Eric Document Reproduction Service No. ED 218551
- [21] D.Kumar and L. Meeden, "Robots in the Undergraduate Curriculum," Proceedings of the Third Annual Consortium for Computing in Small Colleges Northeastern Conference, Journal of Computing in Small Colleges, John G. Meinke (editor), Volume 13(5), 1998
- [22] NASA engineering design Challenge "Lunar Plant Growth Chamber" (2008 <http://www.nasa.gov/audience/foreducators/plantgrowth/home/index.html>)
- [23] P. Rao, Master in Business Administration "Quantitative Analysis Course Syllabus"; W.SyCip Graduate School of Business, 2005
- [24] Brophy, G., & Good, T. (1974). *Teacher-student relationships: Causes and consequences*. New York: Reinhart and Winston.)