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Introduction to STEM Fields Through Robotics: A Synergetic Learning Experience for Students and Their Parents

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Abstract

This work demonstrates the success of an initiative to promote Science, Technology, Engineering and Mathematics (STEM) in 19 school districts that are predominantly Hispanic and have high numbers of students who come from low income households. An innovative method of community involvement as part of the program's Community Engagement strand, this program provided a unique opportunity for both students and parents while developing STEM awareness. Through a synergetic summer learning experience, students and parents spent an entire weekend learning about STEM fields and participating in prepared exercises while bonding in the experience of post-secondary life as they stayed in the university dormitories.

This program was funded by the Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP), a federal discretionary grant awarded by the U. S. Department of Education. It was designed to increase the enrollment of low-income students — simultaneously preparing them for success in post-secondary education — through a partnership grant between Texas A&M International University (TAMIU) and 19 school districts throughout the southern part of Texas, covering approximately 14,972 square miles.

To enhance skills, motivation, and preparation, the TAMIU GEAR UP program brought over 225 rising 9th grade students and one of their parents — for a total of 450 participants — over 4 weekend periods to participate in a Friday-Sunday STEM camp with an emphasis on robotics. The highlights of the STEM workshop ranged from hardware and software programming of a LEGO robot to astronomy and additional STEM hands on activities.

The program's evaluation demonstrated that nearly all participants agree or strongly agree that they gained knowledge, increased interest in secondary education, increased interest in post-secondary education, believe the learning goals of the program are important, and are eager to attend future GEAR UP events like the one hosted. It is strongly recommended that follow-up of students that attended the camp are followed-up and tracked to maintain record of their status. Also, based on evaluations recommendations from parents, it is recommended to include more sessions to parents on how to encourage kids earning a higher education degree. Nonetheless, the positive results encourage development of STEM programs within the community which will reciprocally benefit from its young members' advancement in these fields.

I. Introduction

STEM, which stands for Science, Technology, Engineering and Mathematics, has become the buzz word in education due to an emphasis on increasing the competitive edge in the global economy. In 2005, President Bush introduced a bill as an initiative to revisit the factors that would help the United States successfully compete, prosper and ensure its place in the global economy. One of these highlighted measures was to improve STEM education [1]. This initiative has shown great success, to the extent that it was re-enforced in 2010 by President Obama. Significant investments have been made to increase the interest in STEM education, including funding not just for high school levels but as early as kindergarten (the K-12 initiative). This way, every U.S. child will have to get involved.

However, the population in the U.S. is changing rapidly. Thirty-seven percent of people under age 18 in the U.S. are persons of color, and this percentage will continue to increase [2]. Unfortunately, though it is hard to believe, even today, that the color of someone's skin can determine the success of their future [3], it appears that minorities are less likely to succeed in college. This is not because they are not entering college but because either they are dropping out of college or are disillusioned and change majors because they are not well-prepared and/or lack financial or parental support[4,5,6,7,8,9,10, 11].

Most minorities are first time college students and lack parental support while in college. Often, their parents have never attended this level of higher education and lack understanding of the demands of college attendance[11]. Thus, for minorities, the value of earning a higher education degree is more likely to be transmitted in the form of knowledge-based resources such as guidance counselors and others who assist with college entrance exams or have adequate college preparedness [7, 12, 13, 14, 11]. Furthermore, whenever there is involvement of either parent in the student's overall college life — such as extracurricular activities and educational development — studies have shown a positive impact on the student's college success[15]. Entering college for the first time can have many challenges, but support from their family can be a great asset [16]. Not only can it be beneficial in their academic success but it could also mitigate the negative impacts of their social status and prevent them from dropping out of school [17, 18, 19, 20, 21, 22, 23, 24].

In answer to the challenges faced by these students, Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) is a federal discretionary grant awarded by the U.S. Department of Education. The program is designed to increase the number of low-income students by preparing them to enter and succeed in postsecondary education.

TAMIU was first awarded the grant and began its first cohort of students from a pool of 921 middle schoolers from Laredo, Texas schools only in 2005. The intent of the first GEAR-UP program was to maintain and follow this cohort group from middle school through graduation from high school and into college. The program involved weekly tutoring sessions and Saturday mentoring of the students, plus workshops throughout the year, including summers. TAMIU GEAR-UP is now working on its fourth cohort and in their current grant; they are serving approximately 10,000 students who are currently in 9th grade. The students will be afforded college awareness and readiness activities in addition to the services provided by the grant through high school graduation and up to one year into their postsecondary education.

GEAR UP IV implemented the "Creating A Vision" project, which is a partnership grant between TAMIU and 19 school districts throughout the southern part of Texas, covering approximately 14,792 square miles. The grant is designed to provide low-income students with the skills, motivation, and preparation needed to successfully pursue a postsecondary education. The focus of the project is to provide direct services to students through four strands: academia, assessment, college readiness and parental/community involvement. Each campus site has a College Access Team that provides direct services to students. The College Access Team is made-up of a Site Coordinator and College Access Coach.

II. The Program

The purpose of this summer program was to address the lack of family support among the GEAR UP IV students by providing a synergetic summer learning experience to not only the students but their corresponding parents by spending an entire weekend together. During this

weekend, both, the students and their parents, had the opportunity to engage in learning about STEM fields and participate in prepared exercises. In addition, the participants boarded in the university dormitories for the weekend. The projects and facilities served to familiarize the parents with the studies, activities, and lifestyle changes that their children will encounter upon entering the university.

There were four workshops over four different weekends starting on Friday afternoon and ending on Sunday. The four weekends were as follows:

- Weekend I - June 21-23, 2013
- Weekend II - July 12-14, 2013
- Weekend III - July 19-21, 2013
- Weekend IV - August 2-4, 2013

The student/parent pairs were divided into three different groups since there were three different activities going on simultaneously. Each weekend began with registration at 10:00 am on Friday morning at the Residential Learning Community (dormitories). A welcome session kicked off the program with a keynote from US Army Lieutenant Colonel (Retired) Consuelo Castillo Kickbusch who put her Cybernetics advanced degree to use in the US Army. After the opening keynote, parents and students participated in a variety of relationship- and team-building activities so that the students and parents from the different communities could get to know one another and feel comfortable sharing in the learning process throughout the weekend. Dinner was provided and Friday evening concluded with telescope viewing where parents and students observed Saturn and the Moon as an intro to the field of Astronomy.

Throughout Saturday, there were three sessions, of three hours each, wherein the student/parent groups engaged in a robotic competition, a rocket building with launching activity, and a College Rocks! Session, which consisted of avatar creation activities and a college knowledge presentation by the GEAR-UP staff. These three stations operated simultaneously in repeated shifts, so the participants, who were divided into subgroups, could rotate through each activity over the course of the day.

Robotic Competition:

For the robotic competition, the participants were broken into teams of two, each consisting of one student with his/her respective parent. The competition entailed building a LEGO robot (see below for robot model) and programming it to function in a soccer shoot-out in a 3-foot field with a goal. Each group worked with both the hardware and software. They were given a complete set of LEGOs with instructions for building and programming the robot, plus a laptop with MINDSTORM software. To monitor the activity, there were seven TAMIU engineering students that had been previously trained with building and programming the LEGO robots moving around the room, answering questions and providing tips to improve their teams' designs.

Items used during this robotic competition are as follows:

1. 9797 LEGO MINDSTORM Education Base Set
2. LEGO MINDSTORM Education NXT Software V.2.1.6
3. Laptop with Windows XP

4. Set of step-by-step instructions.
5. Goal made from LEGO parts and balls included within the Education Base Set.

Each team had approximately 1 ½ hours to build the robot and 1 subsequent hour to program it. If the team completed the robot before schedule, they were given an opportunity to practice in the soccer field to familiarize themselves with the robot's handling. At that time, the team was given challenge questions to motivate modifications to their robot to improve chances of better maneuverability. For instance, some teams added extra sensors and modified their program for better arm handling. At the end of the practice runs, there was a round robin competition, allowing each team a chance to compete in the championship round.

This soccer championship provided the groups not only hardware and software exercises but critical thinking by exploring different components throughout the competition. Interestingly, most of these students or parents had never had any experience with this type of software — much less robotic experience — but, by the end of the competition, all of the teams in all sessions were able to make the robot work and compete in the soccer shoot-out.

Rocket Building & Launching

During the rocket launching session, each student/parent team was paired up with another student/parent team to build a rocket from recyclable materials, which were provided by TAMIU Planetarium Department. They had an opportunity to not only build it but decorate it as well. The decoration not only included aesthetics but aerodynamic techniques that would help improve their capability to make their rocket launch farther. They also were tasked with including a parachute so that the rocket could land appropriately once it was launched. They had to ignite a fuse to launch the rocket.

College Rocks!

The College Rocks! Session of the program was two-fold. The students and parents participated in a college knowledge presentation where STEM degrees were highlighted along with other pertinent information about college life. The second part of the session was aimed at students creating avatars by dressing up a miniature avatar with the uniform/dress of the career that they hope to obtain once they graduate from high school and from college. Parents were asked to also create an avatar of their choice with the career that they are currently in and/or the career that they would have liked to have chosen. Parents and students then introduced their avatars to the group, and many meaningful conversations took place among students and parents.

The day ended with three simultaneous sessions that focused on astronomy in the evening. They were able to watch an astronomy show at the Planetarium, participate in a space trivia game and were able to have an interactive Skype chat with an Astronomer from the McDonald Observatory located in East Texas.

The program ended on Sunday morning with a breakfast where a slide show presentation with student and parent photographs was shown, and the culminating activity was provided by Drum Café showcasing the science of music through an interactive team-building grand finale. Students and parents shared their thoughts about the weekend at that time and completed the evaluation for the STEM program.

III. Workshop evaluation results

At the end of the program, both the students and the parents were issued an evaluation survey to provide feedback. They were given a form with five questions that needed to be ranked from strongly disagree, disagree, agree, and strongly agree. As indicated in the following graphs, the completed surveys show the impressive results, demonstrating positive responses wherein "strongly agree" and "agree" totaled in the 90th percentile. This feedback has played a major role for planning future programs. The complete results are shown in the following graphs:

	Student	Parent
1. I have learned a lot of during this GEAR UP event		
Strongly Disagree	0%	0%
Disagree	0%	0%
Agree	25%	27%
Strongly Agree	76%	72%
2. This GEAR UP event has: increased my interest in school / provided me with information to be able to motivate my son/daughter to be interested in school		
Strongly Disagree	1%	1%
Disagree	3%	0%
Agree	18%	7%
Strongly Agree	78%	92%
3. This GEAR UP event has increased my interest in going to college / provided me with information to be able to motivate my son/daughter to be interested in attending college		
Strongly Disagree	0%	1%
Disagree	0%	0%
Agree	10%	43%
Strongly Agree	90%	56%
4. I believe that what I was being asked to learn at this GEAR UP event is important		
Strongly Disagree	0%	1%
Disagree	0%	0%
Agree	23%	11%
Strongly Agree	77%	88%
5. I want to attend more GEAR UP events like this one		
Strongly Disagree	0%	10%
Disagree	0%	0%
Agree	10%	6%
Strongly Agree	90%	93%

Table 1 – Post-Camp Responses

IX. Summary and Conclusions

This program provided a unique opportunity for both students and parents. The main goal was to develop STEM awareness and foster an appreciation for higher education through dynamic learning activities. Students were given the opportunity to explore and develop their

skills alongside their parents who will now have a better understanding of their children's STEM pursuits. In addition, boarding and dining on the university campus afforded both students and parents a sneak peek at the future, allowing them to envision and prepare for the lifestyle of a college student. By involving the parents, the workshop has laid a foundation for family support and understanding when the student is ready to enroll in the university.

The program's evaluation demonstrated that nearly all participants agree or strongly agree that they have gained knowledge, increased interest in secondary education, increased interest in post-secondary education, believe the learning goals of the program are important, and were eager to attend future GEAR UP events. Based on some parent responses, it was recommended that more emphasis be placed in providing them with more information to be able to motivate their son/daughter to be interested in attending college. In the future, possibly a session on techniques or mentors with more direct emphasis will be incorporated into the parent sessions. Nonetheless, the positive results do encourage development of STEM programs within the community which will reciprocally benefit from its young members' advancement in these fields.

V. Acknowledgements

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