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Evaluation of miniGEMS 2015 – Engineering Summer Camp for Middle School Girls

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Abstract

miniGEMS (Girls in Engineering, Mathematics, and Science) was a free five-day Engineering Summer camp organized and run by the Autonomous Vehicle Systems (AVS) Research Laboratory at the University of the Incarnate Word for middle school girls during the week of July 6 to July 10, 2015. The primary goal of the camp was to introduce more females into the field of engineering through robotic projects and competitions, guest speakers, and field trips. The camp had an additional emphasis on providing learning and research opportunities for girls from underrepresented communities. miniGEMS was the first free camp in San Antonio, TX for middle school girls with a special focus on engineering. Despite being held for the first time, there were 25 middle school students from various school districts in San Antonio. The camp was planned, coordinated, and directed by the authors who were also the principal investigators of the program. Additionally, four engineering research assistants from the AVS Lab and three middle school teachers from the local school districts helped with the daily robotics projects and competition. The first half of the week focused on the EV3 Lego Mindstorms robots for the campers to learn about robotics, autonomous land navigation, and computer programming. The students also had the opportunity to build and compete using the SeaPerch underwater robots. This was the first time that the SeaPerch was used for a middle school girls' research competition in Texas. The campers had hands-on experience in building robots as a team which could be guided through an underwater obstacle course. The last day of the camp consisted of a field trip to a digital art and engineering studio and an awards presentation and banquet for outstanding research achievements. The individual and group interactions with the students and their parents reveal that the students had had a great time at the camp and many were motivated to consider engineering as a career.

We present the details of the miniGEMS summer camp including its objectives, plans, funding, daily activities, assessment, and evaluation. We will review the results of the evaluation of the miniGEMS camp including future work.

Introduction

The purpose of this paper is to discuss the planning, implementation, and evaluation of a middle school girl's robotics camp named miniGEMS which was planned by the authors and held last Summer 2015. We will present the details of the planning and development of the camp, budget and expenses, camp's daily activities, students' learning experiences, lessons learned, and future work. The camp was unique due to the fact that we had middle school science teachers actively help us plan the camp, develop the curriculum, and participate during the entire week of the camp. This paper will also review camp recruitment, middle school teachers' participation, program content, evaluation of effectiveness, and our plan to host future camps this coming summer.

The University of the Incarnate Word (UIW) is the fourth-largest private university in Texas. Even though the sixty percent of its students are female, the number of females enrolled in the

UIW Engineering Program is less than 5%. The same trend follows in several other STEM programs offered by the neighboring educational institutions in southwest Texas. There has been numerous studies in education that emphasize the importance of teaching and learning science in middle school classes.[1] By having an early exposure to the fundamental aspects of science at the elementary or middle school levels, the students and their parents can make an informed decision about pursuing a university education in STEM.[2,3] The authors' discussions with various funding agencies and many professionals in K-12 STEM education point to the fact that there needs to be more emphasis given to the students and their parents regarding the importance of studying science at the *elementary and middle school levels* .[4,5] In February 2015, the authors got an opportunity to present at the STEM Collaborative Super Saturday Technology Innovations, sponsored by COEHD Academy of Teacher Excellence, and held at UIW. The topic of the presentation was on the summer workshops and the camp opportunities available for middle school and high school students at the authors' AVS Lab. We met with and talked to several middle school teachers during the time and they inspired us to conduct a middle school camp exclusively for girls because of the need for more diversity and women in engineering. Furthermore, the UIW School of Mathematics, Science, and Engineering (SMSE) hosts an annual Summer Science camp named GEMS (Girls in Engineering, Mathematics, and Science) for selected high school girls in San Antonio. Therefore, it seemed natural to conduct a similar camp for middle school girls with an emphasis in Engineering and which included more active learning activities in Robotics. Additionally, miniGEMS integrated easily into the mission of UIW which emphasized access to education for all in our community. In April 2015, we applied for an 'Engineering Summer Program 2015' grant offered by the Texas Higher Education Coordinating Board. We received about $14,000 to run the one-week engineering summer camp for middle school girls. With the help of the three of the middle school teachers that we met during the Super Saturday event, we advertised the camp details to various schools and school districts throughout San Antonio. Within a short period of time, we got exciting responses and requests from the parents that they were extremely interested to send their daughters for the camp. The three middle school teachers, who were later hired to be our camp coordinating assistants, effectively participated to help us initiate the camp application process. They took care of receiving and securing the applications and the associated documents filled by the interested parents. Within a week or two, we received more than thirty applications from various school districts of San Antonio. We carefully studied the applications and verified the eligibility of the applicant since our plans were to give more opportunities to the students from underserved communities in San Antonio. Finally we selected a total of 27 students from Northside Independent School District (NISD), San Antonio Independent School District (SAISD), and Northeast Independent School District (NEISD).

We named the camp 'miniGEMS 2015: Roaches and Robots!'. Each day of the camp was designed to emphasize a particular theme in robotics: ground, air, and underwater robots. Our intention was to help the students to be accustomed to robots, computer programming, and most importantly, to introduce the field of engineering to the miniGEMS students. One of the main learning objectives was that the students would understand the field and career of Engineering by learning the importance of studying STEM courses, recognizing the levels of classes and the different courses that a student has to accomplish in order to get an Engineering degree, and also

by learning the professional responsibilities, recognitions, and challenges of engineers in society. Students would also learn the fundamentals of autonomous robots by understanding the mechanics and dynamics of robots through building them, learning the basics of computer programming through controlling robots, and also by exploring the concepts of feedback theory by learning the sensory and sensorimotor components of robots. Students also got an opportunity to build and control the EV3 LEGO Mindstorms Robots through an application installed in their smartphones. It also helped the students to learn more about the feedback and sensory mechanisms in the robots and also how to apply basic programming skills with the help of their smartphones. Other learning objectives were to introduce the students to the EV3 LEGO Mindstorms software, data visualization using iPads, and also to relate the significance of Physics, Geometry, and Algebra through the applications of Mathematics and Science to the control of robots.

Program Development of miniGEMS

The initial idea of creating a robotics camp for middle school girls occurred during an engineering presentation by the AVS Lab to middle and high school STEM teachers from the local school districts in February 2015. The purpose of this presentation was to talk about Engineering as a profession and discuss our undergraduate robotics research program. After the presentation, several middle school teachers suggested that we host a robotics summer camp for middle school students. We met with these middle school teachers over the next several months to discuss the objectives of such a camp and how best to recruit middle school students.

We all agreed that the primary requirement was to offer a STEM camp for middle school girls that was at no cost to the student and where all barriers to attending the camp were removed. There was to be no grade or course requirement to attend miniGEMS. We wanted to provide a camp for underserved and underrepresented female students with the objective of introducing the students to a career in Engineering. Finally, we agreed that it was important that middle school science teachers should be part of the planning of the camp and participate in the camp.

The biggest issue was finding funding to host such a camp. In April 2015, we located a funding opportunity through a Texas Higher Education Coordinating Board (THECB) work force development program to fund STEM summer camps. The authors spent the next month in developing camp educational objectives, program curriculum, and budget based on our discussions with the middle school teachers for the proposal. We received funding in May 2015 and began our recruitment plan and developing program content based on the educational objectives and program curriculum.

The authors spent significant amount of time in May and June 2015 in designing the camp curriculum based on the objectives and requirements of the proposal. We closely worked with the UIW Legal Office, Safety Office, Accounting Department, Payroll Department, Human Resources (HR) Office, and Mission Effectiveness Office in generating and developing the program. We were required to get approval from the University's Legal Office and thereby to understand the legal responsibilities of hosting a camp for minors. The Mission Effectiveness Office also assisted us in making sure that we were incorporating the mission objectives of our

University into the camp. We recruited and hired four undergraduate students to help with miniGEMS in early May so as to make everyone familiar and comfortable with each other to work as a team. The undergraduate students helped us in developing the robotics curriculum and testing the projects. We sought help from the HR Office to post the job descriptions and go through the formal hiring process for temporary camp employees which included a background check and the detailed application procedure. Additionally, once hired, all camp employees including the authors, were required to go through a formal training program provided by UIW prior to working with minors on campus. We also worked throughout Summer 2015 with the Accounting office in order to create Purchase Orders for paychecks, supplies, and vendors.

Program Budget for miniGEMS

The total cost for the one week miniGEMS camp was $19,000. We received $14,000 from THECB for miniGEMS which was the primary funding source. The camp could only be one week per the requirements from the funding source. Additionally, the agency did not pay for meals or drinks.

More than 60% of the budget went to salaries and stipends for the camp employees. We had two Camp Directors, three middle school science teachers, four undergraduate camp assists, and part-time clerical and program support. The Fringe Benefits were added to the salary budget and hence there was no indirect costs. We were required to keep a set ratio of employees to middle school students per UIW policy. Based on the salaries and supplies, we were able to host 27 middle school students for one week.

$5,000 of the $14,000 went to camp office supplies (notebook, pens, markers, post-it notes, etc.), handouts/copies, camp prizes, camp T-shirts, graphing calculators, field trip fees, and transportation for the field trip.

Meals and drinks were paid for by the Dean's office of SMSE and cost an additional $5,000 for snacks in the morning and afternoon and lunch. About $2,000 of the meal budget went to the Friday Banquet for 100 attendees and rental of the campus conference center.

Recruitment of Middle School Students

We recruited from five different middle schools from three different San Antonio school districts; NISD, SAISD, and NEISD. We first identified three science teachers from NISD and SAISD Middle Schools in April 2015 and received a commitment from them to assist in implementing the camp during the week of July 6. The three teachers participated in the week long camp, received a stipend, and 40 hours of CPE credit. In early May, we delivered the electronic and hardcopy versions of the camp brochures, applications, and parent releases forms for attending miniGEMS 2015 to participating schools. In late May, we visited Rawlinson Middle School in NISD during their Parents' Night event and provide an overview of miniGEMS 2015 to the parents and answer any questions. miniGEMS 2015 was open only to middle school girls; and we received 30 applications. Priority was given to low income students and students who are traditionally underrepresented in engineering. Additionally, priority was given to students who were entering high school next fall and then to 8^{th} grade, 7^{th} grade, and

finally to 6th grade students. Based on our program budget, we estimated that the maximum number of students that we could support would be 27 and selected the most eligible 27 miniGEMS students in early June with the help of the middle school teachers. We sent out announcements in mid-June by email and phone calls. 25 students arrived for the first day of miniGEMS on July 6.

Table 1 provides the school district demographics for NISD and SAISD. Table 2 below provides details of the miniGEMS student demographics.

Table 1: School Districts Demographics.

Demographics of School District		**NISD**	**SAISD**
Resident Population of School District		608,000	464,230
Student Enrollment of School District		104,539	53,811
Ethnicity (%)	American Indian	0.1	0.1
	Asian/Pacific Islander	3.2	0.2
	Native Hawaiian	0.3	0.0
	Black	6.4	6.3
	White	19	1.8
	Hispanic	68.2	91.2
	Two or more races	2.8	0.4

Table 2: Student Demographics.

Number of students accepted	27	**Grade Levels**	**# Students**
Number of students enrolled (1st Day)	25	**6th Grade**	10
White	3	**7th Grade**	8
Hispanic	20	**8th Grade**	7
African-American	2		

Perspective from Middle School Science Teachers

While attending a STEM Super Saturday event in February 2015 at the UIW we were introduced to the AVS Lab of the Engineering Department at UIW through a presentation on robotics given by the authors. At that time there were approximately 25 mathematics and science teachers in attendance from various school districts in San Antonio. We brainstormed and asked if the robotics research laboratory would be interested in hosting a family night at the Rawlinson Middle School campus. In March 2015, the AVS Lab team visited Rawlinson bringing undergraduate UIW students involved in robotic research and many facets of engineering to share with the middle school students. The students were exposed to the AVS Lab equipment and LEGO EV3 Mindstorms. It was a great way to introduce the different fields of engineering to the middle school students.

We began thinking of a way to introduce engineering to young girls. Knowing that the population of female engineers is low; a great way to make a change is to introduce the idea of engineering when they are younger. The camp was designed such that there would be no financial or educational barriers for the students to participate. We began by recruiting our students through our science classes and clubs. Once we received a large number of interest we created a registration packet and distributed them. Each student received a checklist, a registration form, and pre-survey form. The pre-survey was given asking the students if they knew of an engineer or what they do for our community. We made it very clear that academic standards and finances were not a criteria to attend our camp. Once the seats were filled it went to a lottery system.

It was critical to have had built a relationship with the students from our middle school campus. We felt that students who have a bond with their teachers grow and succeeded at the camp and are not shy or bashful with their ideas or creations. Including the camper's teachers as mentors in the program allowed the classroom environment to be a safe zone for our middle school students. In order for students to be willing to share, put an idea out and not be afraid of ridicule is a big concern at their level.

We also were in contact with the parents or the local guardians of the campers. It was important to have them understand what their child was learning during the camp. We invited them to the UIW campus and meet daily with their parents to provide an overview of each day's camp. This made the campers feel safer and more comfortable to participate effectively in the camp.

miniGEMS Program Content

Each day of the camp was different and fun-filled with interesting and engaging student activities that emphasize active learning with minimal lectures and extensive collaborative learning. The purpose was to encourage the students to actively participate in the camp and thereby to enhance their interest in learning STEM courses especially engineering. We started the first day of the camp with a 45 minutes 'Meet, Greet, Share' session which helped the students to meet and greet each other and also to share their information on name, grade, school, interests, and hobbies. This helped as a social icebreaker for the students so they could be familiar and comfortable with each other because team works were an inevitable part throughout the camp. Additionally, we had students from different school districts and it was important that we did not have school and district cliques.

The details of the program are given as the following:

Student team work: In order to promote team work and collaboration, groups were assigned with a maximum of four students per group except for one which had five. A major component of the camp was requiring the students to work together to complete their daily engineering projects and to discuss and solve problems. Daily projects included such activities as morning "ice breakers" which consisted of building marshmallow towers or air powered cars. Additionally, the afternoons were spent having the groups designing an EV3 robot for a daily challenge such as a sumo wrestling competition using their smartphones or a maze design challenge. Finally, on

SeaPerch Day, the student groups built an underwater robot and competed through a course at the UIW Natatorium.

Project presentations: Students attended daily seminars and, at the same time, they were asked to present their findings on selected topics (individual/group). A lab notebook was issued to each student. The authors and science teachers asked the students on the first day of camp about the importance of a lab notebook and how to identify what data to write. Moreover, on the last day, students were asked to conduct a final presentation based on the data they collected and experiences during the camp. Prizes were offered for exceptional work in presentation, lab notebooks, and data analysis.

Field trip: On the last day of the camp, as part of a field trip, students spent the morning at Pixel Savvi, a local digital painting studio, and learned about digital visualization and multimedia design using IPads. Additionally, on the topic of environmental sustainability, students had the opportunity to visit the university Solar House, a simulated home that operates on solar power and recycled water on the first day of the camp. Here, the students learned about the concept of photovoltaics and solar panels as well as how to build a house that is not on the electric power grid.

Panel or luncheon discussions with professional engineers and scientists: During lunch each day, a guest speaker from industry visited the miniGEMS camp and discussed their career in engineering. We had an Industrial Engineer from HEB Groceries, two Electrical Engineers from the Air Force Office of Scientific Research, an UIW Engineering Alumni getting her Civil Engineering Masters from Stanford University, and a Boeing Mechanical Engineer. We had a Keynote Speaker provided by the Local Section of the American Institute of Aerospace and Aeronautics to discuss Lunar Rocks during our Friday Lunch Banquet. All our guest speakers were Female Engineers.

The students spent the entire day of Thursday, July 9 at the UIW Natatorium working with the Navy on SeaPerch. The SeaPerch is a remote controlled underwater vehicle. The Navy provided five personnel to help us with our SeaPerch underwater competition for the entire day. These Navy personnel participated and talked with our miniGEMS students about the importance of Engineering. The miniGEMS student groups built, tested, and the competed in an underwater obstacle course. The local TV news stations visited, interviewed, and filmed the activities. miniGEMS was also in the local newspaper. Additionally, the campers had an opportunity with the university Missions Vice President for a campus tour of the university in order to learn more about college life in general and answer questions about the UIW campus. Finally, on Friday, July 10, miniGEMS hosted a Lunch Banquet for the miniGEMS students and their parents. Over 100 guests attended the banquet at the UIW Skyroom. We had a Keynote Address and then the students had the opportunity to present what they did during their week to their parents. We had an awards ceremony where the student received prizes. The UIW SMSE paid for the Lunch Banquet.

Program Evaluation, Effectiveness, and Results

A pre-survey was administered while the students were applying for the camp, shown in Table 3 below. Daily and final program surveys were conducted to assess the effectiveness of miniGEMS 2015. The daily surveys indicated the program execution efficiency and allowed immediate corrective actions, if necessary. The participant interest in engineering as a potential career increased considerably, partially due to popular, hands-on, robot projects and the daily guest speakers as were reflected in the post-survey results shown in Table 4. The final summative survey quantified program effectiveness and is shown in Table 5. The miniGEMS students' understanding of engineering greatly increased along with what courses to take in high school to prepare for a college engineering program. Analytical skills were developed through the robot design competition which required building and then programming the robots. An overall understanding of the skills needed to be an engineer were reflected in the answers on the daily surveys, the lab notebooks, the final essay and presentation, miniGEMS summative survey, and results from the post-survey data.

Additionally, several local San Antonio TV news organizations visited with the miniGEMS students on July 9. Several students and the middle school teachers had the opportunity to be on the evening news and their answers showed an increase understanding about what is an engineer. We feel that the interest of the local news also reflected the effectiveness of the program.

Table 3: Pre-Survey Aggregated Data.

		5	4	3	2	1	
	Check the best answer	**Strongly Agree**	**Agree**	**Unsure/ Neutral**	**Disagree**	**Strongly Disagree**	**AVG**
1	**I plan to go to college when I finish high school.**	**25**					**5**
2	**My parents/guardians are encouraging me to go to college.**	**25**					**5**
3	**My friends plan on going to college.**	**12**	**9**	**4**			**4.32**
4	**I enjoy school.**	**17**	**6**	**1**			**4.48**
5	**My teacher(s)/counselor(s) care if I go to college.**	**21**	**4**				**4.84**
6	**I am interested in a specific college(s).**	**13**	**3**	**8**	**1**		**4.12**

7	I have a specific career goal(s).	6	10	8	1		3.84
8	I am interested in a career in engineering.	9	8	8			4.04

Table 4: Post Camp Effectiveness Survey.

		5	4	3	2	1	
	Check the best answer.	Very great extent	Great extent	Some extent	Not at all	Not applicable	AVG
1	To what extent were you satisfied with this Engineering Recruitment Summer Program?	22	1				4.96
2	The student team work helped me to understand more about what it is like to be an engineer.	19	3	1			4.78
3	Working on a project presentation helped me to understand more about what it is like to be an engineer.	12	9	2			4.43
4	The field trips or industry site visits helped me to understand more about what it is like to be an engineer.	19	1	2	1		4.65
5	The discussions with professional engineers and scientists helped me to understand more about what it it's like to be an engineer.	22		1			4.91

Table 5: Post-Survey Aggregated Data.

	Check the best answer.	Strongly Agree	Agree	Not Sure/ Neutral	Disagree	Strongly Disagree	AVG
1	I plan to go to college when I finish high school.	23					5.00

2	**My parents/guardians are encouraging me to go to college.**	**23**					**5.00**
3	**My friends plan on going to college.**	**15**	**2**	**6**			**4.39**
4	**I enjoy school.**	**13**	**6**	**3**		**1**	**4.30**
5	**My teacher(s)/counselor(s) care if I go to college.**	**18**	**2**	**3**			**4.65**
6	**I am interested in a specific college(s).**	**13**	**3**	**4**		**1**	**3.91**
7	**I have a specific career goal(s).**	**10**	**8**	**4**		**1**	**4.13**
8	**I am interested in a career in engineering.**	**10**	**9**	**3**			**4.13**
9	**Participating in the Engineering Recruitment Summer Program has encouraged me to go to college.**	**20**	**2**	**1**			**4.83**
10	**Participating in the Engineering Recruitment Summer Program has encouraged me to become an engineer.**	**15**	**6**	**1**	**1**		**4.52**
11	**I would recommend the Engineering Recruitment Summer Program to my friends.**	**23**					**5.00**

Based on the results of Questions 9, 10, and 11, from the Post-Survey, we feel that the objectives of miniGEMS were met and that the week-long camp was a success.

- Question 8, “I am interested in a Career in Engineering” had 19 out of 23 student either “Strongly Agree” or “Agree” which was an improvement from the pre-survey.
- Question 9, “ESP has encouraged me to go to college” had 22 out of 23 students either “Strongly Agree” or “Agree”.
- Question 10, “ESP has encouraged me to become an engineer” had 21 out of 23 students either “Strongly Agree” or “Agree”.
- Question 11, “I would recommend ESP to my friends” had 23 out of 23 student “Strongly Agree”.

Lessons Learned from miniGEMS

One of the most important reasons that the miniGEMS camp was very successful was the involvement of the middle school science teachers throughout the camp. They worked very well with us from the very beginning of the initial planning, curriculum development, and camp development. They dedicated a tremendous amount of time in recruiting students, reaching out to follow up with the parents, and also to ensure the successful accomplishment of camp objectives. The middle school science teachers helped us feel more comfortable working with the students and their parents.

An important lesson from this first miniGEMS camp was the need to understand that we were not only Principal Investigators managing a Research project but also Supervisors of employees working on a camp for minors. Safety of the employees and the minors were an absolute must and that required all policies were followed, paperwork was filed, and approved early.

Working with the UIW Human Resources, Accounting Department, and Payroll was important for the success of miniGEMS. However, we were not aware of the policies and procedures of the department, which delayed some of our hiring and purchases. Next summer, we will work early with them to prepare for the camp. Additionally, salary was the largest portion of our miniGEMS budget. However, we felt that we had a highly motivated team that worked well together and was the key reason for the success of miniGEMS and the budget was well spent.

Transportation was an issue for some of our students especially those from underserved communities. In order to address this barrier to attending the miniGEMS camp, we will be providing free transportation for the students for next summer. We also plan to identify certain schools for centralized pick up and drop off for next summer.

We used email initially to communicate with the parents of the students attending miniGEMS. We quickly learned that about half of the parents did not have access to internet or email. The most effective way to communicate was through postal mail which was not initially planned in our schedule. For next summer, we will add a few more weeks for correspondence by postal mail. Additionally, with some parents we had a language barrier when speaking over the phone; for this summer we will have additional bilingual staff available to speak with parents.

We also want to provide breakfast in addition to lunch and snacks for the students next summer. Many of the students attending need not have the opportunity to eat breakfast prior to getting to the camp.

Additionally, miniGEMS is scalable and we plan to grow the number of camps. We feel that the number of sessions of the camp can be increased if we can get more funding. There will be an economy of scale as we expand the number of new camps.

Conclusion and Future Work

This paper provided an overview of miniGEMS, a free one week engineering camp for middle school girls, for summer 2015. This camp was a pilot project for the AVS Laboratory and had a total cost of about $19,000 for the one week camp. For the upcoming summer 2016 miniGEMS

camps, we plan to expand and host three separate camps in order to have a larger impact. We intend to conduct three session of our one week camp and to recruit 25 middle school girls per session from the various underrepresented and underserved local San Antonio school districts. Additionally, we plan to host at least three middle school science teachers for each week of the camp. The primary issue, at the writing of this paper, is funding for these camps. We are exploring various funding streams to help fund the camps. As we begin to host multiple camps, we expect to see cost savings due to the economy of scale. The intent will be to work with the middle school teachers to recruit a cohort from a particular school or district. We will be emphasizing more computer programming this coming summer. The miniGEMS camp will provide breakfast, snacks and lunch each day for the students. Additionally, we are investigating the possibility of transportation facilities to pick up and drop off students since it was an issue for some of our students last summer. Finally, we are exploring how to grow the number of camps that we can host in order to have a larger impact on the San Antonio community.

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