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miniGEMS STEAM and Programming Camp for Middle School Girls

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miniGEMS STEAM and Programming Camp for Middle School Girls

This paper provides an overview of a STEAM Camp for middle school girls from Title I school districts and schools in San Antonio, TX. The paper will provide details on hosting a STEAM camp that is dedicated to recruiting from underserved and underrepresented communities. miniGEMS was a free two-week summer STEAM (Science, Technology, Engineering, Arts, and Mathematics) and Programming camp for middle school girls in grades 6 to 8 held at the University of the Incarnate Word (UIW) in San Antonio, Texas. miniGEMS was hosted by the Autonomous Vehicle Systems (AVS) Research and Education Laboratory.

This is the third year that miniGEMS is being held at UIW. Four two-week miniGEMS camps were hosted at UIW for a total of eight weeks starting June 5 till August 4 this summer. The primary goal of the camp was to introduce more female students to the field of Engineering through robotic projects, computer programming, graphic design, and guest speakers. Project Based Learning curriculum was introduced over the two-week camp culminating with a final presentation and skit. miniGEMS was the first free camp in San Antonio for middle school girls that had a special focus on autonomous ground, air, and underwater robots. miniGEMS camps was led by undergraduate and graduate students from various UIW STEAM programs including Engineering and Biomedical Sciences. Middle school teachers were hired to participate in the camp and they helped recruit the middle school students from their respective schools. miniGEMS high school student alumni came back as peer mentors for the camp. An End of Summer Conference and Banquet was held for all campers, their parents, and teachers on August 4. miniGEMS clubs are now being formed in some of the middle schools in San Antonio to continue some of the miniGEMS curriculum throughout the academic year.

Introduction and Motivation

The University of the Incarnate Word (UIW) is the fourth-largest private university in the state of Texas. Even though the sixty percent of its students are female, the number of females enrolled in UIW's Engineering Program is less than 5% and trending downwards. The same trend follows in several other STEAM programs offered by the neighboring educational institutions in 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 STEAM [2,3]. The authors' discussions with various funding agencies and many professionals in K-12 STEAM 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* [4-6].

An additional motivation was the passing of State House Bill 5 (HB5). The bill made substantial changes to the state's curriculum and high school graduation requirements since it was passed by the state legislature in 2013. HB5 came into effect in Fall 2016 and has three major components:

- 1) A core set of courses each student must complete for a total of 22 credits;

- 2) The requirement that each graduating eighth grader select one of five Endorsements (listed below), which are broad categories of career related courses; and
- 3) A Distinguished Level of Achievement for outstanding performance within the chosen endorsement.

The five endorsements are:

- 1) STEAM (Science, Technology, Engineering, and Mathematics),
- 2) Business and Industry (including vocational training),
- 3) Public Services,
- 4) Arts and Humanities, and
- 5) Multidisciplinary Studies.

A consequence of the law is that career conversations and decisions that used to occur in mid to late-high school must now take place in middle school. Middle school teachers are effectively tasked with being knowledgeable advocates who encourage students to pursue STEAM careers and inform them of college curriculum requirements. The problem, however, is that middle school teachers often do not understand various STEAM disciplines, such as engineering, well enough to describe the field in detail, talk about job opportunities, or list course requirements for college.

Based on school improvement literature, teachers are the most important school-based factor impacting student achievement [7]. Though not a direct objective of miniGEMS, the literature suggests that improvement to teacher quality is most affected by *long term* professional development as opposed to a one-time workshop [8].

Based on this information and conversations with local school leaders, the authors began hosting the miniGEMS STEAM camp for the first time in Summer 2015. miniGEMS initially started as a free five-day long STEAM summer camp for middle school girls from various local school districts. The camp was planned and directed by the authors, Dr. Michael Frye and Dr. Sreerenjini Nair, and involves university undergraduate lab research assistants and middle school STEAM teachers. The camp was conducted for the third consecutive summer at the AVS Lab last year and was expanded to a two-week camp. Additionally, four separate camps were held last summer. This paper will present the details of planning and implementation of the miniGEMS camp. The paper has an additional focus on the funding details, camp's budget and expenses, students' learning experiences and survey results, experience gathered by the authors, and also the future plans to conduct more miniGEMS camps.

An Overview of miniGEMS

miniGEMS is a free ten-day long middle school (grades 6th to 8th) girl's summer STEAM and Programming camp held at the main campus of the University of the Incarnate Word (UIW) in San Antonio, TX. The miniGEMS camp, which has been funded by the Texas Higher Education Coordinating Board (THECB) Engineering Summer Program and the Texas Workforce Commission Camp Code for Girls, has had a multidisciplinary STEAM focus with a special emphasis in engineering and computer programming. The primary goal of the camp was to introduce more females into STEM, especially the field of engineering, through robotics

projects and competitions, computer programming, guest speakers, and STEM based field trips. Campers were recruited from the underrepresented communities of San Antonio with an emphasis on providing learning and research opportunities for them. The miniGEMS Program is unique in that the former campers are invited back next summer to attend as alumni or as a group leader. This allows the authors to perform a longitudinal study of why female students in San Antonio lose interest or drop out of STEM programs in middle school and high school. The miniGEMS camp started with 25 female students in middle school and now have over 160 alumni as of this August 2017 with many already in High School.

The authors developed the curriculum, recruited the middle school students and the camp assistants, and managed the day-to-day activities of the miniGEMS camp. Additionally, five undergraduate research assistants from the AVS Lab and *12 middle and high school teachers* from the local school districts helped with the prior planning and the entire coordination of the daily camp activities. An additional unique feature of miniGEMS is the participation of middle and high school teachers during the camps. The first five days of the miniGEMS camp focused on exploring the STEM fields and introducing the campers to the field of computer programming. Additionally, during this time, miniGEMS began to prepare the campers for the programming curriculum used during the second week. During the second half of the camp, the campers spent five days using the MATLAB programming language with applications to the control of autonomous ground robots.

The camp was enriched by various project-based learning activities including environmental sustainability, biologically inspired robots, machine learning, EV3 Lego Mindstorms robots, control of robots, and computer programming. The campers also had the opportunity to build and compete using the SeaPerch underwater robots. The PIs have been awarded two SeaPerch equipment grants from the ONR and currently have 10 SeaPerches. Naval Recruiting District (NRD) San Antonio has supported miniGEMS the last three summers as part of its STEM outreach. For Summer 2017, miniGEMS hosted four SeaPerch Days at the UIW Natatorium. All four SeaPerch Days were supported by NRD San Antonio who provided active duty guest speakers to talk with the miniGEMS campers about STEM fields in the Navy. NRD San Antonio will be supporting miniGEMS again next summer. On the last day of the camp, as part of a field trip, students spent the morning at the 'science museum on wheels' named STEM Trailblazer operated by a Texas-based organization, Texas Alliance for Minorities in Engineering (TAME). During the field trip, the students learned numerous interesting concepts in STEM including resonance, hurricanes, motors and engines, electricity, and light. The PIs had the University's admissions and financial department present on the last day of the camp to answer student parent's questions regarding how a university admissions department works. Also, an End of Summer Conference and Banquet was held for the campers and their parents on the last day of the camp. Congressman Will Hurd was the keynote speaker for the Summer 2017 Conference and Banquet.

The miniGEMS alumni are now entering High School and the authors would like to create a miniGEMS program which supports both middle and high school students. The purpose is to continue to provide STEM support for the miniGEMS alumni as they progress through high school and begin to prepare for postsecondary education. Additionally, the authors would like to begin to provide year around miniGEMS activities at select middle school and high schools. To accomplish this, the authors will need a fulltime Project Coordinator to help organize and plan

the advanced STEAM curriculum in robotics and programming. Additionally, the PIs would like to create curriculum which will help encourage the miniGEMS high school students and their parents to start thinking about their postsecondary education at university, community college, or trade school in the field of STEAM. Finally, the miniGEMS program will now include a camp dedicated to the local military school districts in San Antonio.

The PIs are already working with the local school districts to measure the following performance outcomes:

- 1) Graduates of the miniGEMS program from the previous years will select the STEM Endorsement in High School increasing the number of female students from underserved communities entering the STEM track. The STEM Endorsement in high school is critically important if the student plans to go into a STEM major at the university-level.
- 2) Graduates of the miniGEMS program will have increased attendance in Middle School and High School.
- 3) Graduates of the miniGEMS program will exhibit increased persistence in Middle School and High School. miniGEMS students will show persistence in their studies and learn to handle both classroom and STEM coursework challenges by providing them with miniGEMS resources and a network.

miniGEMS Campers Recruitment

The miniGEMS 2017 camp recruited from three different middle schools from three different city school districts of San Antonio; NISD, SAISD, and SWISD. The schools participated in miniGEMS 2017 were Rawlinson from NISD, McNair from SWISD, and Mission Academy from SAISD. Both SWISD and SAISD are considered Title I economically underserved school districts. As mentioned earlier, it was the three teachers from the corresponding school districts who committed to work as camp chaperons and program assistant, who tremendously helped us to identify the students.

In early May, the authors delivered the electronic and hardcopy versions of the camp brochures, applications, and parent releases forms for attending miniGEMS 2017 to participating schools. 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 8th grade, 7th 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 114 and selected the most eligible 114 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.

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

Table 1: School Districts Demographics.

Demographics of School District	NISD	SAISD	SWISD
Resident Population of School District	608,000	464,230	54,631
Student Enrollment of School District	104,539	53,811	13,500

Ethnicity (%)	American Indian	0.1	0.1	0.1
	Asian/Pacific Islander	3.2	0.2	0.3
	Native Hawaiian	0.3	0.0	0.0
	Black	6.4	6.3	2.9
	White	19	1.8	5.3
	Hispanic	68.2	91.2	90.4
	Two or more races	2.8	0.4	0.9

Table 2: Student Demographics.

Number of students accepted	27	Grade Levels	# Students
Number of students enrolled (1st Day)	26	6th Grade	1
White	1	7th Grade	7
Hispanic	21	8th Grade	12
African-American	2	9th Grade	6
Asian	2		

For 2017, the ninth graders shown in Table 2 were miniGEMS Peer Mentors. All the peer mentors participated in the 2015 miniGEMS camp and had the opportunity to share their experiences and, acting as group leaders, provided further assistance to the 2016 campers for the duration of 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 STEAM courses especially engineering. The authors' 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, since the students were from different school districts it was important that we did not have school and district cliques.

The details of the program are given as following:

Student team work: In order to promote team work and collaboration, groups were assigned with a maximum of four students with an additional Group Peer Mentor to assist with the projects. 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 University 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 the middle school 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 the ‘science museum on the wheels’ named STEAM Trailblazer operated by TAME. Students learned numerous interesting concepts in STEAM including resonance, hurricanes, motors and engines, electricity, and light through posters, videos, and practical demonstrations provided by the trained experts of TAME and the University undergraduate students who were present at the trailblazer to give tour to the students. 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. The miniGEMS had an Industrial Engineer from HEB Groceries, four Electrical, Mechanical and Industrial Engineers from CPS Power Energy, a female UIW Engineering Alumni working as an engineer in a local company in town, and two University female professors in Biology and Engineering. On Thursday, June 23, the Navy provided five personnel to help us with our SeaPerch underwater competition for the entire day. These Navy personnel participated and talked with the miniGEMS students about the importance of Engineering.

Thursday SeaPerch and Friday Banquet: The students spent the entire day of Thursday, June 23 at the University Natatorium working with the Navy on SeaPerch. The SeaPerch is a remote controlled underwater vehicle. The Navy provided five personnel to help with the 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. 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 University’s campus. Finally, on Friday, June 24, miniGEMS hosted a Lunch Banquet for the miniGEMS students and their parents. The students presented their research and overall camp experiences through posters that they prepared as groups. The exhibited and presented their posters to the banquet guest which included their parents, teachers, relatives, female engineers and other key personnel from the CPS Power Energy, and several University’s administrators, faculty, and undergraduate research students. Over 100 guests attended the banquet at the UIW Skyroom. The authors hosted an awards ceremony where the student received prizes. The University SMSE paid for the Lunch Banquet.

Campus Tour and University Admission and Financial Aid Expo: The students had a campus tour of the University on Tuesday, June 21 led the Vice President of the Campus Mission and Ministry. The purpose of the tour was give the campers an idea about history and grandeur of the campus and also to let them visualize college life in general. On Friday, June 24, University Admissions Office representatives came over to meet with the students and parents to explain them the admission procedure and the financial aid opportunities for eligible students.

Program Evaluation, Effectiveness, and Survey Results

Daily and program surveys were conducted to assess the effectiveness of miniGEMS 2016. 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.

The daily surveys provided quality control daily and allowed immediate corrective actions, if necessary. An interesting outcome from the daily surveys was the importance of having lunches that the students would eat. Pizza with olives were very unpopular and there was an expectation for healthy options from the campers. The authors learned about the importance of providing breakfast from the daily surveys since some of the campers were mentioning they were hungry in the morning.

A pre-survey was filled out while the students were applying for the camp in April or May and is shown in Table 3 below. The purpose of the pre-survey was to determine if the student plan to go to college, their perception of their peers and school, and if they were interested in engineering. The pre-survey was not used to select students for the miniGEMS camp but to develop a baseline on attitudes about themselves, school, their friends, and engineering. Overall, the pre-survey reflected a confident and positive outlook about going to college and about their school environment. The only notably lower result was the answer to Question 8, “I am interested in a career in engineering” which had a score of 4.00. Most of the students who attended miniGEMS 2016 belonged to a STEAM club or had an interest in STEAM.

Table 3: Pre-Survey Results from April/May.

		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	2				4.93
2	My parents/guardians are encouraging me to go to college.	23	4				4.85
3	My friends plan on going to college.	18	6	2			4.80
4	I enjoy school.	18	6	2			4.80

5	My teacher(s)/counselor(s) care if I go to college.	23	2	1			4.85
6	I am interested in a specific college(s).	14	18	4	1		4.64
7	I have a specific career goal(s).	16	8	3			4.84
8	I am interested in a career in engineering.	7	5	15			4.00

Table 4 evaluates the miniGEMS goal of increasing the knowledge and interest in a career in engineering. Overall, the miniGEMS students feel that they left with a better understanding about engineering. The authors did note that the project presentation from Question 3 had a little lower score and will work on improving the group prompts and working on presentation skills. Some of the campers were very hesitate to present in front of an audience. On the other hand, the campers enjoyed the daily guest speakers during lunch. The authors feel that this is due to the speakers discussing their own personal stories which the students could easily relate to. Finally, the campers overall enjoyed the camp as reflected in Question 1.

Table 4: Post Camp Outcome Survey.

#	Check the best answer.	5	4	3	2	1	Avg
		Very great extent	Great extent	Some extent	Not at all	Not applicable	
1	To what extent were you satisfied with this Engineering Recruitment Summer Program?	19	4				4.83
2	The <u>student team work</u> helped me to understand more about what it is like to be an engineer.	17	5	1			4.70
3	Working on a <u>project presentation</u> helped me to understand more about what it is like to be an engineer.	16	3	4			4.52
4	The <u>field trips or industry site visits</u> helped me to understand more about what it is like to be an engineer.	19	2	2			4.74
5	The <u>discussions with professional engineers and scientists</u> helped me to understand more about what it it's like to be an engineer.	20	1	2			4.78

The final summative post-survey quantified program effectiveness and the results are shown in Table 5. What is interesting is the overall decrease in average results from the Pre-Survey results in Table 3. The authors feel that the student attitudes had changed since they have been out of school for about one month by the time miniGEMS camp started. The post-survey was done during the late Spring Semester. The only two Questions that showed an improvement where

Questions 2 and 5. The authors found this interesting since there was parent and middle school teacher involvement in the miniGEMS camp and this increase may reflect that involvement. Additionally, these results may indicate the importance of constant parent and teacher encouragement to student attitudes toward school, especially during the time the students are out of school for break. The authors will investigate this question further next summer.

Question 8, “I am interested in a Career in Engineering” had 15 out of 23 students either “Strongly Agree” or “Agree”. While the overall average had decreased from the Pre-Survey, the student’s responses increased around “Agree” and decreased from “Not Sure.” The authors feel that the campers left with a positive image about engineering and the confidence that they too could become an engineer.

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

Question 9, “ESP has encouraged me to go to college” had 22 out of 23 students either “Strongly Agree” or “Agree”. One aspect reflected in this result was the University Admission’s Department presenting to both the campers and their parents on the process of applying for admissions, scholarship, and financial aid. The authors feel that this helped in increasing this result.

Question 10, “ESP has encouraged me to become an engineer” had 21 out of 23 students either “Strongly Agree” or “Agree”. Again, the authors felt that the miniGEMS campers left with a positive image of the engineering field.

Question 11, “I would recommend ESP to my friends” had 22 out of 23 students “Strongly Agree”. The authors were very happy with this successful result which was comparable to the Summer 2015 results. The authors feel that this is an indicator of the willingness of miniGEMS alumni to return as Peer Mentors for Summer 2017 which is an extremely important aspect of the success of the camp.

Table 5: Post-Survey Results.

		5	4	3	2	1	
#	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.	21	1	1			4.87
2	My parents/guardians are encouraging me to go to college.	22	1				4.96
3	My friends plan on going to college.	16	5	2			4.61
4	I enjoy school.	17	5	1			4.70
5	My teacher(s)/counselor(s) care if I go to college.	22	1				4.91

6	I am interested in a specific college(s).	15	3	2	3		4.30
7	I have a specific career goal(s).	15	4	4			4.48
8	I am interested in a career in engineering.	6	9	7		1	3.83
9	Participating in the Engineering Recruitment Summer Program has encouraged me to <u>go</u> to college.	20	2	1			4.83
10	Participating in the Engineering Recruitment Summer Program has encouraged me to become an engineer.	14	7	1	1		4.48
11	I would recommend the Engineering Recruitment Summer Program to my friends.	22				1	4.83

Lessons Learned and Future Direction of 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 closely with the authors 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. We plan to recruit more teachers for our upcoming camps especially from the same schools the students come from.

The use of miniGEMS student alumni as peer mentors and group leaders helped with the facilitating of the daily exercises and activities. The daily surveys suggested that the group leaders helped with the camp learning process and additionally the concepts were reinforced with the group leaders since they needed to help explain those concepts. The authors will continue to use the peer mentoring model for next summer.

Safety of the employees and the minors were an absolute must and that required all policies were followed, paperwork was filed, and approved early. We conducted campus-wide training and awareness for the all the chaperons including students and teachers on the legal aspects and policies when dealing with minor students. It tremendously helped us in hosting the camp very efficiently and professionally.

Working with the University Human Resources, Accounting Department, and Payroll was important for the success of miniGEMS. Next summer, the authors' will work early with them to prepare for the camp. Additionally, salary was the largest portion of our miniGEMS budget. However, the authors 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 miniGEMS students, especially those from underserved communities. In order to address this barrier to attending the miniGEMS camps, the camps will provide free transportation for the students for next summer. The authors also plan to identify certain schools for centralized pick up and drop off for next summer.

The authors initially used email to communicate with the parents of the students attending miniGEMS. However, it was 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, a few more weeks will be added for correspondence by postal mail. Additionally, with some parents, the authors had a language barrier when speaking over the phone; for next summer additional bilingual staff available to speak with parents will be added. We will also make sure that we have more bilingual chaperons for the upcoming miniGEMS camps.

The miniGEMS camp will provide a hot breakfast in addition to lunch and snacks for the students next summer. Our prior experiences show that many of the student participants need not have the opportunity to eat breakfast prior to getting to the camp.

Conclusion

This paper provided an overview of miniGEMS, a free two-week engineering camp for middle school female students, for summer 2017. This camp has been hosted twice now by the AVS Lab and had a total cost of about \$130,000 for the four camps. For the upcoming summer 2018 miniGEMS camps, the authors' plan to expand and host a new high school camp in order to have a longer impact. 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, transportation will be provided to pick up and drop off students since it was an issue for some of our students last summer.

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