



Overview of the megaGEMS AEOP Summer 2021 Research Apprenticeship Camp

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Abstract

GEMS (Girls in Engineering, Math, and Science) is a free STEAM and programming summer camp and after-school robotics club that focuses on educating girls about the fields of STEM. GEMS is divided into two main programs: miniGEMS for rising fifth through eighth middle school students and megaGEMS for rising ninth through twelfth-grade high school students.

This paper will provide an overview of a new program within megaGEMS called megaGEMS AEOP (Army Education Outreach Program) for rising eleventh and twelfth-grade high school girls. The camp was initially piloted in the Summer of 2020 during the COVID-19 pandemic as a virtual four-week research camp. For Summer 2021, megaGEMS hosted the inaugural eight-week in-person Apprenticeship Research Camp from June 7-August 6, 2021, for eight rising juniors or seniors. This Apprenticeship Research Camp was held at the Autonomous Vehicle Systems (AVS) Research Laboratories located at the University of the Incarnate Word provided the students with an experiential research camp mentored by both faculty and graduate students in the science of autonomy. The camp was funded through two grants provided by the Army Education Outreach Program.

Examples of projects included brain-computer interfacing, virtual reality, and Infrared and LIDAR sensor collection. One apprentice was able to obtain her FAA Part 107 UAS Operator license to collect images using a drone. The camp provided opportunities to expand soft skills, explore college-level research, and community outreach. The apprenticeship curriculum was implemented by undergraduate and graduate students which included: daily Python coding classes, developing quality research skills, improving public speaking, and introducing careers in STEAM. Local female STEM leaders were guest speakers and provided career advice. The program concluded with a research symposium where they presented their research in poster and presentation format.

This paper will provide details about recruiting, lessons learned working with students and parents under COVID-19 restrictions and developing research agendas for high school students.

Introduction

The purpose of this paper is to discuss the megaGEMS Apprenticeship research 8-week program held in the summer of 2021. The details of the paper will include the evolution of the GEMS program which sculpted the megaGEMS AEOP Apprenticeship model. The grant

funding resource, recruiting for the program, developing the curriculum, lessons learned, and future work.

GEMS or Girls in Engineering, Mathematics, and Science is a free all-girls STEAM (Science, Technology, Engineering, Art, and Mathematics) and Programming summer camp that focuses on educating young girls about the fields of STEAM and the careers in each field. GEMS is divided into two sections: miniGEMS is for rising fifth grade through rising eighth-grade girls, and megaGEMS is for rising ninth grade through rising twelfth-grade girls. miniGEMS after-school clubs meet weekly to learn block coding using EV3 LEGO Mindstorm robots to compete in FIRST LEGO competitions each spring.

The mission statement of GEMS is to inspire and empower young girls to be innovative with their future in the fields of STEAM. GEMS covers diverse topics of education that the students would not normally be exposed to, supporting each other, developing teamwork skills, learning how to better the community with their knowledge, being creative, and developing self-efficacy [1]. GEMS is unique because it targets girls from under-resourced, underserved, underrepresented communities giving low-income areas of San Antonio, Texas an opportunity to gain experience and their knowledge in STEAM. The long-term objective of GEMS is to increase the number of females in STEM [2], [3].

GEMS was established in 2015, as miniGEMS, a one-week summer STEM (Science, Technology, Engineering, and Mathematics) camp for twenty-seven middle school-aged girls to explore robotics, coding, and hands-on experiments [2]. The summer camp's success continued year after year, increasing in 2017 to four 2-week camps, allowing over one hundred girls into the camp experience. As the girls graduated from the miniGEMS program, megaGEMS was created, adding two new high school programs. The 2-week megaGEMS camp consisted of girls from the Girls Inc. Eureka program, which is one of the community partnerships working with GEMS, and the 8-week megaGEMS Research Camp (megaRC). In 2019 GEMS transitioned to STEAM, with the addition of the Arts to encourage a larger range of learning opportunities within the program.

The megaGEMS AEOP apprenticeship was hosted by the University of the Incarnate Word Autonomous Vehicle Systems (AVS) Research Laboratories in San Antonio, Texas. The University is the fourth-largest private university in Texas. Even though sixty percent of its students are female, the number of enrolled females in the university Engineering program is less than 5% [1]. This is a similar trend for other STEM programs offered by the neighboring education institutions in south Texas and is seen in numerous studies [1], [3]. The lack of female representation inspired the creation and implementation of the GEMS summer camps and after-school clubs.

Developing the Model

The establishment of the megaGEMS programs in 2019 shaped the programs available today for the rising ninth through rising twelfth-grade girls. The megaGEMS 2-week camp had a similar curriculum as the miniGEMS camps but was created at a high school level. If the experiment for the day was to make slime, then the megaGEMS would make slime, as well as learn about the chemical reaction and balance the chemical equation. They would explore if changing predetermined amounts of the ingredients used would alter the outcome. Another example of the GEMS' advancing curriculum is introducing the megaGEMS to Python programming language instead of block coding for the EV3 LEGO Mindstorms obstacles and games [4]. Providing the girls with multiple coding languages creates a wider foundation of programming for STEM careers [2].

GEMS was fortunate to have a community partner with a similar mission to inspire and empower young girls to be successful in their futures such as Girls Inc. The Girls Inc. Eureka cohort of twenty high school-aged students was the initial 2-week megaGEMS camp.

The megaGEMS second program was an 8-week research camp that was a mix of the traditional miniGEMS programs with a research component. This unique camp was a wonderful way to evaluate and assess the idea that GEMS could initiate and implement a higher level of educational experience. The fifteen girls selected for the research program were instructed by a science teacher who had been a part of previous miniGEMS summer programs. An interesting feature of this camp was allowing the girls to explore and develop a STEM-related research project of their interest with guidance and mentorship from the counselors. The success of the projects and lessons learned assisted in the decision to fully implement the megaGEMS research camp.

The model of the megaGEMS Research camp (megaRC) was initially piloted in the Summer of 2020 during the COVID-19 pandemic as a virtual four-week research camp. The collaboration of the lessons learned from megaRC and the megaGEMS camps in 2019 created an outline for the program. With a small, contained group the implementation of megaGEMS Virtual Research Camp (megaVRC) was conducted safely through multiple zoom meetings per week. The girls conducted college-level research to produce a 5-page scientific research paper and a PowerPoint presentation for the End-of-Summer Showcase. The girls had weekly guest speakers from local female STEM advocates from HEB, Valero, and Intercultural Development Research Association (IDRA). During the 4-week program, the girls developed a Curriculum Vitae (CV), an "elevator speech", and enhance their soft skills. The camp was led by the GEMS Head Counselor/Curriculum Coordinator and the GEMS Project Manager/Coordinator.

For the summer of 2021, megaGEMS hosted the inaugural eight-week in-person

Apprenticeship Research Camp from June 7-August 6, 2021, for eight rising juniors and seniors. The apprenticeship was held Monday through Friday from 8-4:30 pm with one week off for July 4th holiday. The goal of this program was to provide hands-on scientific research at a college level for high school-age students. The outcomes were the submission of an abstract to the AEOP as well as a 5-page scientific paper, poster, and presentation of their research. The apprentice began with an official onboarding simulating a work environment on day one. The apprentices were given access to the daily and weekly schedules which included daily tasks, deadlines, and unique events. More explained curriculum in section Curriculum Development. The pandemic influenced GEMS in-person and virtual events for 2020 and 2021. Based on current cases and safety protocol GEMS decided to only host the megaGEMS AEOP Apprenticeship and not host the miniGEMS programs for the summer of 2021. This allowed GEMS to maintain high safety standards to ensure the safety of the apprentices and the GEMS staff.

Funding

The megaGEMS AEOP Apprenticeship was funded by two funding sources the Army Education Outreach Program (AEOP), the High School Apprenticeship Program (HSAP), and the AEOP REAP from the Rochester Institute of Technology.

The funding supplied each apprentice with a stipend that was distributed through multiple payments. This stipend reinforced the work environment and supplemented transportation and food cost. Each stipend was based on the apprentice's time researching and daily attendance. As GEMS focuses on reaching underserved and under-resourced communities the stipend reduced the financial burden to attend an 8-week summer research program. GEMS received a stipend based on the number of apprentices to provide support as needed to conduct the program.

Recruiting

The Army Education Outreach Program (AEOP), mission is to provide both students and teachers with a collaborative, cohesive, portfolio of U.S. Army-sponsored STEM programs that effectively engage, inspire, and attract the next generation of STEM talent through K through graduate programs and expose them to Department of Defense STEM careers [5]. The AEOP website contained information about all the opportunities including the inaugural apprenticeship held at the University of for the summer of 2021. Applications were submitted through the AEOP website and then supplied to the GEMS staff for review. AEOP utilized social media platforms to present information to students and parents alike.

GEMS used social media platforms along with emailing GEMS parents and students from previous summers and after-school clubs about the opportunity. GEMS leadership presented the

opportunity to community partners to expand the bandwidth of exposure.

AEOP provided GEMS staff with a list of 102 applications and then narrowed it down to fifteen for a first interview. Applicants' selection is based on criteria set by the AVS lab to conduct the predetermined experiments. The applicants needed to live locally and be available to attend the full 8-week program. Once the fifteen applicants were selected, initial interviews were conducted by the GEMS leadership through Zoom meetings. Each applicant was asked a series of questions relating to STEM, such as STEM interests, and goals. The top eight applicants were selected and informed through the AEOP and GEMS.

Curriculum Development

The curriculum and the daily agenda for each GEMS program were developed by the GEMS Head Counselor/Curriculum Coordinator. The apprentices began their day by checking their emails and reviewing upcoming deadlines and team activities. The team activities included STEM scavenger hunts with brain-teasing riddles, word games, and morning walks. These activities provided the apprentices to work on soft skills like teamwork, communication, leadership, self-efficacy, and public speaking skills.

Guided activities/lessons, not lectures, were opportunities for the apprentices to learn the newest APA format, how to find quality references, literature reviews, and locating quality resources. To keep the apprentices engaged the counselors relied on discussions and activities, rarely using PowerPoints, making the camp feel less like a summer school. Literature reviews created discussions and feedback for the apprentices to analyze other papers within their research and assess the quality of the paper.

Daily schedules had embedded "brain breaks" to give the apprentices time away from screens and research. "Brain breaks" included team activities, games, experiments, and giving back to the community. As previously stated, the pandemic did not allow for the in-person miniGEMS summer camps, so the apprentices created YouTube videos for the GEMS channel. Each two-person group found experiments, created a script, and filmed and edited the video. The groups worked together to assist one another in the video editing process as some of the apprentices did not have prior experience. Teamwork and communication were key to ensuring that the miniGEMS were able to understand and conduct the experiments safely at home.

Computer Information Systems (CIS) students and professors conducted daily coding Academy or Python coding classes. The apprentices' goal was to complete a coding project by building upon the previous lessons. The implementation gave the apprentices deeper knowledge of their research projects.

Each day ended with a journal entry with prompted questions, to allow for continued communication between the counselors and apprentices. The questions provided daily feedback regarding how they felt about their research if they needed additional time with advisors, and fun questions that allowed the counselors to get to know them more. These writing samples created a rolling dialogue, allowing the counselors to analyze the writing levels of the apprentices.

Each morning and afternoon had one to two hours dedicated to research time. Research time included researching their topics, drafting their papers, and creating their posters and presentations. Three to five times a week the apprentices were able to meet with their lab advisors. The lab advisors consisted of members of the AVS lab that were working on similar ongoing research projects, allowing the apprentices to have mentorship and guidance for their research. Meeting with their advisors also allowed the apprentices to insight into various STEAM careers.

Examples of the research topics for the megaGEMS AEOP Apprenticeship program included:

One Apprentice will help support the ongoing research in the use of Unmanned Air Systems (UAS) for autonomous inspections within the Guidance, Navigation, and Controls Lab. The goal of the research project is to learn about UAS applications and the use of artificial intelligence for inspections. The Apprentice will focus on the operation of the UAS platform and its sensors and, with help from the AVS Labs research assistant, learn to develop and deploy autonomous control software to the UAS platform. Additionally, the Apprentice will work with the Computational Intelligence Lab and will acquire basic artificial intelligence programming skills in Deep Learning techniques for image and video classifications. By the end of the summer, the Apprentice will learn to fly a drone and how to program AI applications using Python programming.

One Apprentice will help support the ongoing research in the autonomous control and sensor fusion of an autonomous ground vehicle within the Computational Intelligence Lab. The ground vehicle uses multiple sensors, including a 2D LiDAR, and has a GPU processor. The Apprentice will learn the basics of autonomous controls for ground vehicles using Python and ROS along with using sensor data to make autonomous decisions, such as avoiding an obstacle. The Apprentice will gain experience working with a 2D LiDAR sensor mounted on the ground vehicle, processing LiDAR point cloud data, and generating 3D LiDAR images. By the end of the summer, the Apprentice will learn about autonomous ground vehicle control and utilization of Python in sensor fusion.

The research topics were presented to the apprentices, and they each were given an opportunity to answer several questions to assist the GEMS leadership in assigning the topics. The AVS

labs PI, lab advisors, and GEMS staff worked together to match the research topics with apprentices. Other topics included brain-computer interfacing, virtual reality, and Infrared and LIDAR sensor collection. The AVS Labs Flight Team collaborated with an apprentice to learn Federal Aviation Administration (FAA), state, and local regulations to obtain her Part 107 UAS Operator license at the age of sixteen. The apprentice witnessed UAS flight missions with the AVS Flight Team.

Additionally, weekly guest speakers from female STEM advocates presented in person or on zoom to describe their path, educational path, their experience within a STEM career, and networking. Guest speakers included a female Ph.D. mathematician, HEB Education & Workforce Program Manager, and an Amazon Cloud Technology Manager. The University of the Incarnate Word also provided guest speakers to speak on the university's history and discuss the importance of etiquette for interviews and business attire.

The AEOP End of Summer Symposium was held for family and friends, following the end of the eight weeks. The event assimilated a conference in which the apprentices each presented their research in poster format to the guest. As the presentation commenced two guest speakers, Ms. Kimberly Toney, and Ms. Shandra Bates, from Air Force Civilian Service working at the Air Force Personnel Center (AFPC) shared their inspirational pathways and careers within the STEM fields. The main portion of the event was the presentations led by each apprentice, including a PowerPoint presentation of their eight weeks of research. As the symposium concluded the apprentices were able to retain their posters and were encouraged to submit them to local educational conferences. The apprentices also submitted an abstract to the Army Education Outreach Program (AEOP).

Lessons Learned

Each program's lessons learned, or insights allowed for the GEMS leadership to evaluate and assess to make necessary changes or improvements year after year. This section will look specifically at the megaGEMS lessons learned from the inaugural megaGEMS AEOP Apprenticeship in the summer of 2021.

COVID-19 - GEMS decision to host a summer program during the COVID-19 pandemic created additional obstacles for the GEMS leadership. Imposing extra safety protocol based on fluid guidelines from the Centers for Disease Control and Prevention (CDC) for PPE and sanitizing surfaces. The GEMS leadership created individual workspaces for each apprentice with plexiglass dividing workspaces. Each workspace contained office supplies, hand sanitizer, and a face mask as needed by the apprentice. Daily sanitizing of workspaces was led by GEMS leadership at the end of each day, including cleaning all surfaces. Daily health checks were done as the apprentices began each day as well as asked to not come in if they were currently

having any symptoms related to COVID-19. Temperature checks were done twice daily and recorded. The parents of the apprentices were given COVID-19 protocol before the apprenticeship held during a GEMS Parent's Night and throughout if changes arose.

Collaborating with parents during this unprecedented time was also challenging. Parents were frustrated with indoor mask policies and challenged the GEMS leadership when implementing policy. The AEOP's position was to follow policies set by locations hosting events. The University of the Incarnate Word had COVID-19 safety protocol as well as camp safety protocol to be upheld by all faculty, staff, and students.

The added safety precautions increased the workload for the GEMS leadership. The leadership tracked the daily health checks and checked in on those who were absent due to COVID-19-like symptoms. The AVS Lab was very vigilant as well to ensure all lab advisors were meeting the same safety requirements as they were spending in-person time with the apprentices.

Lab advisors - Early on changes to the daily schedules were made to allow for more time with lab advisors. GEMS leadership listened as the apprentices expressed to have more time with advisors. Aligning subject matter experts to mentor research elevates the apprentice's work. The additional time was implemented in week two and continued through week eight.

Curriculum Development – GEMS Leadership conducted activities in the first several weeks to discuss APA formatting and useful online resources. A lesson learned from previous megaGEMS programs, as each apprentice attended different high schools receiving different educational backgrounds. It was important to establish a consistency of expectations for the daily writing samples and outcomes early within the apprenticeship.

Research Project Selection – Allowing the apprentices to assist in choosing the research topic of their interest increased their enthusiasm for their projects. Matching the research projects and lab advisor to an apprentice was achieved, as the apprentices each had various interests in multiple research topics conducted within the lab.

Python Coding - Establishment of Coding Academy for daily Python coding classes. Initially, the apprentices faced struggles due to various levels of experience in coding skills, however, within a brief time the apprentices not only gained coding skills they gained confidence in their work. Each apprentice would work with others in the class to help with those who were not seeing successful results as well as comparing codes to see how the outcomes would vary. The apprentices stated on several occasions that they looked forward to Coding Academy during the later weeks of the program. They also liked that the Coding Academy was taught by several AVS lab staff, each having their style and skill set.

Feedback – GEMS leadership had one-on-one meetings with each apprentice to discuss assignments, questions about research if they needed additional assistance with any task, and to create an open dialogue. The apprentices asked to receive one-on-ones earlier in the program instead of halfway through, and the apprentices stated that they enjoyed various aspects of the program. Other feedback included: enjoying the variety of guest speakers, extending the camp to longer than eight weeks, enjoying creating YouTube videos for the miniGEMS, and challenging them daily with new experiences.

A notable change based on feedback will be to conduct future apprenticeships beginning at nine in the morning instead of eight in the morning. GEMS leadership will try to align the apprenticeship daily times closer to local high schools' start times.

Evaluation and Outcomes

As this was a smaller group to obtain data the outcome evaluation process was adjusted accordingly. The megaGEMS AEOP Apprenticeship began the evaluation process first with the selection of candidates for interview. The AEOP application requirements asked for a resume and school transcripts as supplemental documents. This equipped the GEMS staff to filter out students who did not align with the guidelines for the predetermined experiments. Each of the fifteen candidates was asked the same series of questions during their initial interview to allow the GEMS staff to evaluate according to standards set by the AVS labs.

The first questionnaire, located in the GEMS application, was taken before the camp start date and another was conducted on day one to assess levels of interest and areas of comfort with computer skills. As stated in the Curriculum Development section, each camper answered prompted questions in the daily journal entries. All entries were saved and logged to follow the growth and development of the apprentice. The questions provided daily feedback regarding how they felt about their research if they needed additional time with advisors, and fun questions that allowed the counselors to get to know them more.

The outcomes were (1) to maintain and/or increase the apprentice's interest in STEM [1],[3], (2) to provide hands-on experiences, and (3) to expand research/writing techniques. The outcomes were measured based on the apprentices' final presentations, the journal entries, follow-up questionnaires, and willingness to complete a second year as an apprentice. Currently, multiple apprentices have applied to return for a second year during the AEOP Apprenticeship for summer 2022.

Conclusion and Future Work

The progression of GEMS since 2015 has continued to evolve as the program expanded to

multiple programs, reaching rising fifth grade through rising twelfth-grade girls from under-resourced communities [1]. GEMS strives to maintain a presence for the girls, acting as a foundation as they create their STEM pathway in high school and/or post-secondary school. GEMS is not a recruiting tool but rather a support system for students and schools

The megaGEMS AEOP Apprenticeship summer of 2021 provided not only hands-on research experience, the further development of soft skills but also the ability to build on their Curriculum Vitae (CV). The megaGEMS AEOP apprenticeship for the summer of 2021 created the model for future programs. Future work will include a delay in morning start times to align more with current high school start times, increasing one-on-one opportunities starting in week two, and creating a daily schedule with more time allotted for lab advisors. Providing a stable schedule dedicated to working with a subject matter expert will build time management skills for the apprentices as well as increase the quality of the research conducted by the apprentices. Additionally, Coding Academy will continue as a staple in the megaGEMS curriculum.

GEMS currently is scheduled to host megaGEMS AEOP Unite 4-week research camp for rising ninth grade and rising tenth-grade students and a megaGEMS AEOP Apprenticeship 8-week research program for rising eleventh and twelfth-grade students for the summer of 2022.

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