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An Initial Perspective on the Implementation of an Engineering Ambassador Program

Dr. Priya T Goeser, Georgia Southern University, Armstrong Campus

Priya T. Goeser is a Professor in the Department of Mechanical Engineering at the Georgia Southern University's Armstrong Campus, Savannah GA. She received her Ph.D. in Mechanical Engineering from the University of Delaware and her B. Tech in Mechanical Engineering from the Indian Institute of Technology, Chennai, India. Her current research interests are in innovative teaching methods in engineering education. She is the program director for the Eagle Engineering Ambassador Program.

Dr. Thomas Murphy, Georgia Southern University

Dr. Thomas Murphy is an Associate Professor of Electrical and Computer Engineering at Georgia Southern University-Armstrong Campus. He received his PhD and M.E. in Electrical and Computer Engineering from the University of Florida and his B.S. in Electric

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Abstract

The Eagle Engineering Ambassadors (EEA) Program was first developed in Fall 2022 and launched in Spring 2023. The EEA Program is a mentorship based program involving Georgia Southern University's Armstrong campus and local high schools. The program exposes a diverse group of high school students and teachers to engineering concepts and careers through engineering projects within a mentoring framework. Seven high schools participated in the first year of the EEA program. The participating high schools included one private, one charter, and five public with two of the public schools having a high percentage of students in underrepresented groups.

The high school teams completed one or more engineering projects in Spring depending on the project length. Projects included: design prototyping using CAD and 3D printing, automatic watering system, autonomous robots, digital music keyboard, and DC motor/fan control. The high school teams were mentored by Georgia Southern engineering students (Ambassadors). The Ambassadors supervised and coordinated the high school teams and visited the teams weekly while projects were being performed. The Ambassadors were predominantly mechanical engineering students with one computer engineering student. Seven high school STEM teachers, 62 high school students, and 10 Georgia Southern engineering students participated in the EEA program in Spring 2023.

This paper will discuss the development, implementation, and evaluation of the EEA Program.

Introduction

An ambassador is an authorized person who acts as a representative, messenger or promoter of a specified activity or organization. Using this definition of an ambassador, engineering students would serve as excellent ambassadors for engineering programs. This is a main premise upon which engineering and other ambassador programs have been established. One of the objectives of these programs is to develop diverse leaders by equipping and empowering university students (the ambassadors) with advanced communication and leadership training, so that they may share their passion and excitement about engineering and STEM with K-12 youth, the engineers of tomorrow [1], [2].

There are several STEM ambassador programs in Georgia and beyond that have trained students to represent the university and college at on-campus events. The student ambassador program at the University of Georgia is a program that has students who are trained and help promote the college of engineering at special events on campus [3]. A similar program at the University of Arizona, Engineering Ambassadors have student representatives at college recruitment events and information sessions [4]. Another unique STEM Ambassador program, STEMAP launched by a team from the University of Utah is dedicated to training faculty, postdoctoral and graduate students in STEM departments at colleges and universities who wish to carry out public

engagement in nontraditional settings (e.g., outside schools, museums, science centers) [5]. The GOT Space Ambassadors program is a successful program supported by the Georgia Space Grant Consortium with affiliate participation from Georgia Institute of Technology, Georgia State University, and Kennesaw State University [6]. This program recruits and trains undergraduate students who serve as STEM Ambassadors and bring STEM focused presentations and activities to K-12 classrooms and other programs in the community.

The Engineering Ambassador Network has established several engineering ambassador programs at universities throughout the United States, with each program incorporating outreach to middle and high schools as one of its goals. The program also focuses on developing the communication and leadership skills of engineering students who serve as the ambassadors [7]. The Hometown Ambassadors program developed at Ohio State University aims to effectively connect undergraduate engineering students and university alumni in engineering careers to high school students [8]. The ambassadors in this program serve as the team leaders for their high school teams and serve to plan and organize outreach events. The University of Connecticut School of Engineering in partnership with the Neag School of Education and local schools districts have developed the Galileo Project which includes the training of engineering graduate students (Galileo Ambassadors) to assist high school teachers in delivering and implementing pre-engineering course models for high school students [9], [10]. A similar program at Manhattan College includes engineering and education undergraduate students and faculty members who work together to improve STEM education by partnering with middle and high school students [11]. The engineering ambassadors program at the University of Utah was initially designed to recruit prospective students into the engineering majors [12]. After a few iterations, the program has evolved to one that aims to educate the community about opportunities in engineering by providing hands-on activities for high school students and classroom resources for teachers to use in the curriculum. The engineering ambassadors themselves have also benefited by increasing their interest in engineering, learning how to take their classroom concepts into teaching high school students and overall an increased retention within the engineering programs.

While recruiting and outreach is the main goal of many ambassador programs, the one at Texas A & M University also has student-led, peer-to-peer mentoring with both current and prospective students [13]. While this has resulted in increased on-campus recruiting efforts, it also provides mentors for newly admitted students. Overall, engineering ambassador programs have a positive impact on student development as shown by a study done on students from two universities: Oregon State University and Howard University [14].

This paper presents the development of the Eagle Engineering Ambassadors program at Georgia Southern University's Armstrong Campus. This program is similar to the GOT Space Ambassadors and the program at the University of Utah mentioned above. The program trains undergraduate students to bring hands-on activities to high school students and classroom resources for teachers in the STEM fields, with the primary objective to educate the local community about opportunities in engineering. The following sections outline the program overview, the details as implemented in Spring 2023, preliminary assessments, conclusions and acknowledgements.

EEA Program Overview

The first Eagle Engineering Ambassadors (EEA) Program was successfully developed in Fall 2022 and launched in Spring 2023. The EEA Program is a mentorship based program involving Georgia Southern University's Armstrong Campus and local high schools. The program exposed a diverse group of high school students and teachers to engineering concepts and careers through engineering projects within a mentoring framework. One of the main objectives of the program is to reinforce and strengthen student STEM knowledge and develop a pipeline of students for Georgia Southern University STEM majors and the next generation of scientists, technicians, engineers and mathematicians.

The program works with several high schools in the greater Savannah area including a high school from Richmond Hill. The program pairs a trained undergraduate engineering student (ambassador) with a host team consisting of the STEM teacher and 6–8 students from each school. Teachers are recruited from the STEM teachers at the school and help identify the high school students that participate, coordinate ambassador visits, and help supervise projects. The ambassadors visit the host team 2-3 times in the Fall and 2-3 times in the Spring with the option of additional video conferences or visits. Mini engineering projects are performed during the visits under the mentorship of the ambassador and teacher. The projects, developed by engineering faculty, ambassadors and teachers, highlight topics of interest such as robotics, embedded systems, and rapid prototyping using 3D printing.

Through this program, students gain a deeper understanding of STEM concepts and how they are applied to solve problems. Students and ambassadors gain opportunities to improve their soft skills, and the awareness of schools and the community of Georgia Southern University STEM education opportunities and NASA programs and opportunities are enhanced. The projects also provide engineering, management, teaching in STEM fields, and leadership training experience for the EEAs.

There are no other Engineering Ambassador programs in this region of Southeast Georgia at this time. While there is currently a STEM Ambassador program at Georgia Southern University's Statesboro Campus, it is purely a volunteer based program, is focused on STEM events at local K-12 schools in the Savannah area and does not have a significant public impact. It is envisioned that the Eagle Engineering Ambassador program at the Armstrong Campus of Georgia Southern University (i) impacts high schools in the greater Savannah area which have a large economically disadvantaged and underrepresented minority enrollment, (ii) builds mentorship relationships between the ambassadors and high school student teams, and (iii) provides STEM teachers with a larger repertoire of engineering projects and activities. The Savannah-Chatham County Public School System is the 10th largest school district in Georgia and serves about 36,000 students of whom 58% are African American, 13.5% are Hispanic and 42% are economically disadvantaged (eligible for free and reduced lunch plans).

EEA 2022 - 2023 Program Details

Seven area high schools participated in the EEA program including six high schools from Chatham County and one high school from Bryan County. The participating high schools

included one private, one charter, and five public with two of the public schools having a high percentage of students in underrepresented groups.

The teams completed one or more engineering projects in Spring 2023 depending on the project length. Projects included: design prototyping using CAD and 3D printing, automatic watering system, autonomous robots, DC motor/fan control (shown in Figure 1) and digital music keyboard (shown in Figure 2). The high school teams were mentored by Georgia Southern engineering students (Ambassadors). The ambassadors supervised and coordinated the high school teams and visited the teams weekly while projects were being performed. Seven high school STEM teachers, 62 high school students, and 10 Georgia Southern engineering students participated in the EEA program in Spring 2023.

The ambassadors aimed to help the teachers and students where they needed it most. For example, at one school the STEM teacher was working on a MARS Rover project for her class. She asked for assistance with a portion of the project that involved 3D printing some parts. The ambassador assigned worked with her and the students to teach them how to use a 3D printer and then print these parts. In another school, the teacher asked the ambassadors to speak to groups of students about the college application process and their college experiences. The ambassadors assigned spoke to several students about these including information on financial aid and scholarships. One of the ambassadors was a non-traditional student returning to school after serving in the military. He was able to share his experiences and the advantage of gaining such military experience before enrolling in an engineering program.

The mini engineering projects were developed modularly, so that they could be performed in one to four visits. For example, the DC motor control project consists of three modules: circuit design using CAD software, circuit prototyping and testing, and program development. For the circuit design module, the teams create the motor control circuit using Tinkercad, a CAD modeling software [15] and test the design using Tinkercad Arduino emulation and a provided test program. For the circuit prototyping, the teams are provided with a parts kit and they construct the circuit from their Tinkercad schematic or a provided schematic. The teams connect their circuit to a provided Arduino UNO and test the circuit using a provided program. For the program development, the teams use their circuit constructed previously or a provided circuit and modify the provided program to control the motor/fan.

All of the teams performed the DC motor control activity as shown in Figure 1. This was the first project that was developed (outside of CAD and 3D printing) and the easiest to create parts kits for. The project could be performed over one to three visits. Parts including an Arduino Uno, DC hobby motor, motor driver integrated circuit (IC), solderless protoboard, 9V battery and connector, LEDs, pushbutton, and resistors were provided. Later versions also had a switch for disconnecting power from the motor if they were using a small fan. With the exception of the Arduino Uno, all the parts for the kit cost less than $10. Arduino Uno R3s cost approximately $25 with third party versions costing around $10.

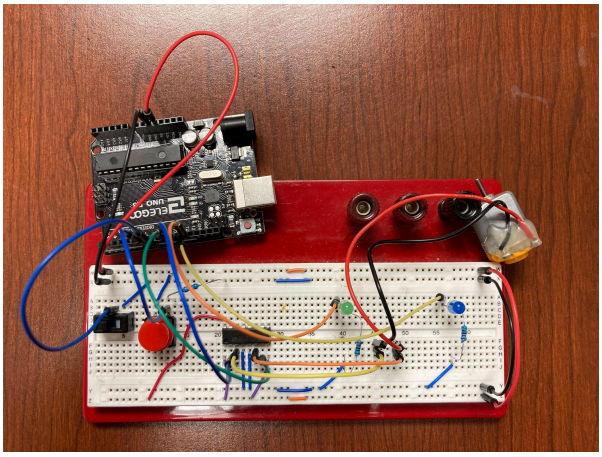

Figure 1: DC Motor Control Circuit

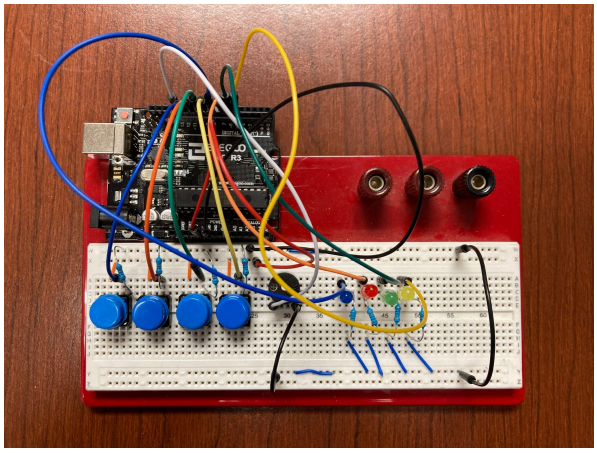

Figure 2: Digital Music KeyBoard Circuit (single buzzer)

One team designed and constructed an automatic water system for indoor plants. This project was proposed by the team as they wanted to design something for their teacher/mentor. The project was successful and the working project was given to the mentor at the end of the project. The project was performed over multiple visits with the team also working independently between visits. Parts including an Arduino Mega, moisture sensors, pumps, tubing, and relays were provided. With the exception of the Arduino Mega, all the parts cost less than $20 to support four watering zones. The Arduino Mega was used as it has a much larger number of I/O pins than the Arduino Uno. Arduino Megas cost approximately $45 with third party versions costing around $20.

A more involved robotics project was performed by one team over three visits with the team also working independently between visits. The project was proposed by the team and the ambassador. The team designed and 3D printed the chassis. Parts including an Arduino Nano, wheels, DC hobby motors with gearbox, motor driver ICs, IR and Ultrasonic sensors, and a Nano terminal block were provided. They were also provided with resistors, wire, LEDs, and soldering equipment. With the exception of the Arduino Nano, sensors, motor drivers, and soldering equipment, all the parts were obtained from a parts kit that cost less than $20. The project was successful, but this project was possible because the ambassador for the school had extensive robotics, circuit construction, and Arduino programming experience and some members of the team had prior robotics experience. Arduino Nanos cost approximately $25 with third party versions costing around $6.

Another team designed an innovative popcorn holder using Tinkercad and then learned how to use a 3D printer to create a 3D printed model. Figure 3 shows one of these models - a popcorn bowl with a tail that serves as a phone holder. All high school teams were provided with a portable 3D printer, costing between $200-$400 and were trained appropriately to use them.

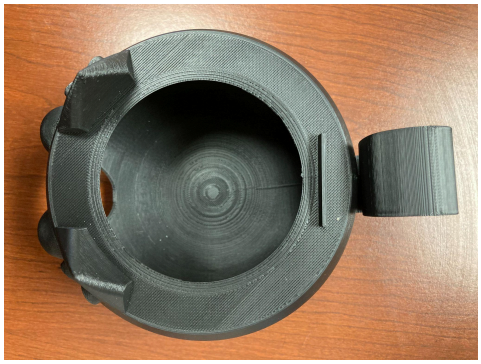

Figure 3: 3D Printed Popcorn Bowl

Three high school field trips were also hosted as part of the program. The high school student groups and their teachers participated in half day engineering activities on Georgia Southern University's Armstrong campus and toured the campus engineering labs. A sample agenda for these trips was as follows:

- Introductions - 10 minutes
- 'What does a Computer Scientist do?' - A motivational talk by a faculty member, Department of Computer Science, Georgia Southern University, Armstrong Campus - 30 minutes
- Arduino based project - 60 to 90 minutes
- Tour of Engineering Labs - 30 minutes

A total of 85 students and three teachers participated in these field trips. One of the group visits was co-organized with Engineering Explorer Post, Savannah. This group includes high school students and teachers from multiple schools in the area. The Arduino based project used for the field trips was the circuit prototyping and testing module from the DC motor control project.

All high school teachers and ambassadors received a stipend for their time and efforts in making this a successful program.

EEA Program Assessments

To assess the effectiveness of the EEA program, two sets of anonymous questionnaires were sent via Google Forms to the Georgia Southern University's engineering students who served as the ambassadors and the high school teachers. In addition, the program director also conducted informal interviews with the teachers during the last week of the program to get their feedback. The program director also met with the student teams periodically to assess their progress and address any concerns.

Post program comments from the ambassadors included:

- Liked the opportunity to expose students to new subjects.
- Liked giving high school students an engineering project to be passionate about and learn from.
- Program has excellent potential and is really only limited to the mentors project scope/time.

Post program comments from teachers (summarized) included:

- The focus on Arduino boards and wiring circuits was a great lesson in the necessity to be meticulous in their work.
- The articulating 3D print was also a great lesson; students had to think about how their design would print, not just the way to model it in the CAD system.
- I appreciate the thought that goes into the projects every year to give students valuable, relevant experience.
- The opportunity for high school students to interact and learn from college students whom they can relate to due to the fact they are close in age and experiences was one of the best aspects of the EEA program.
- I truly appreciate all of the effort you put into helping us build excitement for STEM careers.

Some teachers were involved in past NASA supported programs such as the Engineering Design Challenge (EDC). One commented (summarized): over the past several years, my students have learned how to use 3D CAD systems, 3D printing, and now how to wire the Arduino boards.

One of the long term goals of ambassador programs is to establish a pipeline: high school students who participate in the program, to undergraduate students at the university, to undergraduate students who mentor high school students. Several of the ambassadors mentored teams from high schools they graduated from and some had participated in the EDC program in the past. These ambassadors were familiar with the student ability and school culture and offered valuable suggestions for tailoring projects to those particular teams.

In the future, high school students will be given pre and post tests to assess the increase in understanding of engineering concepts. Similarly, the Ambassadors will also be assessed on the improvement of leadership, time management and other soft skills.

Conclusions

The Eagle Engineering Ambassadors Program was first developed in Fall 2022 and then implemented in Spring 2023. While the initial plan was to offer high school visits in both Fall and Spring semesters, due to a combination of the grant funds coming in late and problems getting timely responses from the school teachers and staff, there were no visits in the Fall. It is anticipated that in the future the program will be opened to schools earlier in the Fall. In future offerings, the program can also be extended to select Middle Schools with a STEM emphasis. Most of the projects can be modified to be used by Middle School students.

Overall, the program was successful in achieving its primary objective of developing a mentorship program between Georgia Southern University's engineering students and local high school students. The teachers at these high schools also benefited by being exposed to several engineering projects that many of them now feel competent to incorporate into their curriculum. Generating a specific increase in the pipeline of students attending the engineering program at Georgia Southern University, Armstrong Campus is a long term goal of the program. It is anticipated that it will take a few cycles of implementation of the EEA program to see any results in this goal.

Acknowledgements

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