

Restructuring the Engineering Activities in a Pre-college Summer Program

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Introducing College-level Laboratory Exercises in a Pre-college Summer Program

There are hundreds of pre-college summer programs that take place annually at colleges and universities in the United States. [1,2] Many are enrichment programs developed to expose middle and high school students to academic and research experiences in targeted fields such as Engineering and Sciences. [2] All are developed to include an experience of college life at that particular institution. [3, 4, 5] The United States Federal Service Academies all have pre-college programs that focus on the student experience at those institutions. This paper focuses on changes to Academy Introduction Mission, AIM, at the United States Coast Guard Academy, USCGA.

The Engineering majors have been highlighted as part of AIM at USCGA. Engineering majors and the department were represented through a robotics competition called ARoW- Academy Robotics on the Water. ARoW involved designing, building and testing a robotic design to complete as many of the eleven Coast Guard missions as could be completed in the allotted time. This involved teamwork, communications as well as creativity and the ability to use Radio-Controlled (RC) systems to control the robot. ARoW was designed to be a portable activity for recruiting events away for the Academy, as well as a key element in AIM.

After fourteen years, a small team took on the challenge of developing a new Engineering activity to represent the five majors during the summer program. This included the challenge of introducing a new major as well as finding a way to fit into the existing program structure. This Work-in-Progress paper describes the challenges and solutions for introducing change into an existing summer program.

Introduction

The United States Coast Guard Academy offers eight types of pre-college visits, ranging from day visits, overnight visits, to AIM. AIM is the primary tool for recruiting students. AIM is targeted towards rising high school seniors. USCGA accepts approximately 15% of rising high school seniors that apply for AIM.

AIM has been hosted annually since YEAR. Participants in this program represent approximately 48% of United States Coast Guard Academy's applicants annually, and on average, 45% of the accepted applicants. Student retention for the pre-college summer program is 95%, compared to an overall retention of 90%.

The United States Coast Guard Academy hosts three six-day sessions during July. Each session begins with participant arrival on Sunday. The formal program begins Monday morning and ends Friday afternoon. Engineering activities are scheduled for Mondays, Tuesdays, Wednesdays and Fridays. Monday's session is an introduction to United States Coast Guard Academy Engineering. Tuesday and Wednesday sessions were design and build sessions for Friday's ARoW competition. This past summer, the engineering team requested, planned and implemented a major change in activities.

In addition to the engineering team, two groups that help make AIM run. There is a training cadre assigned to AIM. The cadre is approximately 50 2/c cadets. These cadets conduct the majority of AIM activities under the command of a 1/c cadet, Summer Ensigns and Admissions Staff.

Admissions Partners are volunteers who are either alumni or parents of students/alumni, who come to AIM to help the engineering team with program. They are an exceptionally valuable resource as they augment USCGA's faculty and staff during each week of AIM. They also provide a different perspective for the participants and their families.

Restructuring the Engineering portion of AIM

Approximately 16 years ago, AIM introduced ARoW as it's Engineering activity. ARoW has been successful as both an outreach activity and Engineering component of AIM. There were several factors that influenced the decision to replace ARoW. This section will address those motivations.

ARoW was resource intensive. One team kit consisted of several hundred parts, including motors, a radio controller, mixer and receivers, as well as tools. Each kit was contained in four cases, stored in a 20 cubic foot bin. In addition to the kits used by participants, there were pool liners and lumber for the pools, tarps and rolls of carpet to place the pools on, pumps and other support materials. After every use, parts needed to be replaced and/or repaired. The size of the kits and support equipment meant special arrangements were required to ship kits for outreach activities. For AIM, there were only a couple of venues on campus that could host the Friday competitions because of the space required host nearly 200 students, 50 mentors, 10-20 Admissions Partners and hundreds of family members.

ARoW required a lot of people. Moving material for competition required 20 to 40 people to handle kits, carpet, lumber, tarps, tables and chairs. Typically, the cadre were

gathered Thursday mornings and Friday afternoons to help move everything from Engineering to the Student Union or one of the Gyms. Since there are usually only three courses offered during the Summer, the faculty are typically not on campus and staff are usually involved in other activities. Fewer faculty and staff have been assigned to ARoW- from a high of 10 down to two or three. The staff has been augmented by the assignment of a Summer Ensign, but at least one of the faculty is typically also assigned to other duties as well, and the Summer Ensign usually leaves before the last week of AIM to report to Flight School. Shorter staffing means means more work for the Admissions Partners and cadre. The cadre are also tasked with moving the participants from event to event throughout the day, so are often busy as well.

ARoW required a lot of space for both storage and competition. Storing all the ARoW materials required a large storage room. In a building in which space is a premium, giving up that storage room meant Civil Engineering was forced to use other rooms to store lab and course materials. As mentioned previously, ARoW requires a lot of space for competitions. There are currently seven rooms on campus where the competition could be held in one room. Since the competition requires Water, building managers were worried about the pools leaking or rupturing especially in Leamy Ballroom or on the Gym floors.

ARoW used skills that could be learned from robotics competitions. Some participating students were involved with FIRST Robotics Teams, and had a decided advantage over students that had not participated in FIRST. It was not uncommon for a team to have one or more FIRST participants put together the design and run the competition for the team. This was not the goal of ARoW, and in some ways, negatively affected team performance and development.

The main goal of ARoW was to encourage students to think about pursuing degrees in STEM, in particular at USCGA. Given the motivations to switch, the team wanted to create a new set of experiences that could replace ARoW, have fewer logistical challenges, better represent USCGA's five Engineering programs, and give participants a better idea of how Science and Engineering concepts are applied in technology, learned in college and used beyond graduation.

Moving beyond ARoW

In fourteen years, ARoW became a mainstay in AIM, but as the team prepared for Summer 2018, replacing ARoW with another challenge was not in dispute. United

States Coast Guard Academy Engineering needed a challenge that better represented the engineering student experience, and that led to deeper discussions about WHAT aspects of United States Coast Guard Academy Engineering the team wanted this new challenge to represent. The team settled on three main goals for a new challenge, or set of challenges- Authentic, Inclusive and Multidisciplinary. The team chose to replace ARoW with three challenges.

The new challenges should be authentic. Teams scored points in ARoW by completing any number of 11 Coast Guard missions in the time allotted. The team wanted the new challenges to authentically represent the types of academics pre-college students should expect to learn at USCGA. In addition, the challenges may represent applications of academic material that students could expect to see after graduation. So this goal is attempting to give participants an opportunity to see some short- and long-term expectations .

The new challenge should be inclusive. Some participants chose to sit back and let their teammates do most of the work. One reason given is they were not considering an engineering major, so ARoW was considered not interesting or applicable to some participants' chosen majors. The team wanted to address this by including aspects of other majors in these new challenges.

The three challenges were drawn mainly from Physics, Electrical Engineering and Cyber Systems. Elements of Civil Engineering, Mechanical Engineering and Management were incorporated into the challenges. Examples of how the main science and engineering concepts are manifest in work situations, beyond graduation, were incorporated into the either post-challenge discussions or in demonstrations performed during the challenges.

A fourth goal also became important- getting participants to thinking about how academics and teamwork can affect their ability to complete a task. AIM presents participants with plenty of opportunities to work in teams. The team wanted to continue that theme in the new challenges.

Constraints on change

The engineering team was working with tight constraints. Time, budget, facilities and training were the major constraints. The team also had to get USCGA Admissions and other stakeholders to agree to the change. The AIM summer assignment is usually five

weeks- one week of preparation time, one week to train the cadre and three weeks executing the program. Unofficially, the team forms two weeks prior to prep the ARoW kits.

There were three weeks to plan and prepare new challenges. The team had to design, plan and prepare new authentic, inclusive and multidisciplinary challenges, with handouts and coaching materials for the cadre. The team decided to plan three smaller challenges to replace ARoW. The smaller challenges allowed the team to focus on concepts with engineering applications. The team chose to use material and labs from actual engineering courses to cut down on cost and time to acquire materials.

The engineering team had to work within AIM's format by planning for 200 participants per week divided into eight platoons. The engineering team decided to divide the eight platoons into teams of four or five participants, and these teams would participate in each challenge.

For each challenge, the team needed to have materials for three sessions of 200 participants each. The team usually had a budget of \$6,000 per year for ARoW. This past summer, the team had the same budget. In addition to the \$6,000 from Admissions, the team was able to reuse materials from the various Engineering Majors. For example, the team was able to use 22 gauge Magnet Wire from the Electrical and Mechanical Engineering programs for one of the challenges. Other items, such as Multimeters and Salinity Meters were borrowed from the engineering programs.

Even though only three courses are offered during the summer, the campus has several Indoctrination, Cadet and Professional programs running concurrently. Room planning for the summer is usually done in January or February. Planning for AIM was done assuming ARoW would be the engineering activity for the summer. The engineering team was not assigned until after the room assignments and planning was done. The team had a second rationale for moving to three smaller challenges- it allowed the team to work in smaller spaces in the engineering building. There was an additional constraint on facilities with scheduled maintenance in the Hydrodynamics Lab and main gym. The team was able to work around both obstacles.

In addition to other constraints, the engineering team had to train the mentors on a new set of challenges as well as a new mentoring philosophy. In the past, mentors were content to drop off participants during engineering time, and do other things. The mentors who were not engineering students did not feel ownership because they were not engineering majors. These new challenges accompanied a new philosophy of

mentors mentoring. It does not take an engineering student to talk with participants about the expectations United States Coast Guard Academy has for its students. Since all the participants are not interested in engineering, this was seen as an opportunity for cadre and participants to learn about each other. Cadre could grab their peers when a participant had a major-specific question. It gave the participants an opportunity to see the cohesiveness that exists between cadre.

The team expected to introduce and instruct, with the cadre leading participants through the designing and building in the challenges. The cadre were walked through each challenge and the team led discussions after each to solicit questions and feedback. The cadre feedback was incorporated into each challenge. In addition to training the cadre, the team also had to train the Admissions Partners on the challenges. The engineering team trained the Admissions Partners when they arrive on campus the Saturday before their assigned week.

The last constraint the team faced was getting buy-in from both Admissions and United States Coast Guard Academy's leadership team. AIM is the premiere admissions activity of the year. ARoW had developed a great reputation over its 14 year run, so changing the engineering challenge was alarming to some members of the leadership team. The Director of Admissions trusted the engineering team would replace ARoW, and approved changes in advance, but Admissions still needed to see the final result. Once the Senior Leadership Team and Admissions heard about the new philosophy of authentic, inclusive and multidisciplinary challenges, saw the challenges and handouts, along with the finished designs, they were pleased with the changes.

New Authentic, Inclusive and Multidisciplinary Challenges

The team developed three challenges themed Land, Sea and Air/Cyber. Each challenge focused on a specific theme and scenario. For each theme, a four-page handout was supplied. The handout introduced a STEM-based concept, a real-life scenario, and a team-based activity. Detailed instructions were given for each challenge. Based on mentor feedback, some instructions were either included or removed. The mentors, admissions partners and engineering team interacted with all teams by answering questions, giving suggestions, and explaining theories and directions.

The Land challenge introduced the concept of directional antennas. The land scenario is recovering critical infrastructure in Puerto Rico after Hurricane Maria. The emphasis of the theme was infrastructure and how disaster recovery and how search and rescue operations are conducted post-disaster. In this challenge, teams of four to five

participants were tasked with building a Dipole Antenna that would be used to find a small radio transmitter. This exercise is called Direction Finding (DF). HAM Radio operators also call this Fox Hunting. This exercise was drawn from a Junior-level Electrical Engineering Antennas course. The team worked with Electrical Engineering faculty to develop a compact version of the DF lab. Instead of using expensive radio direction finding equipment, the team purchased hand-held scanners and HAM radio transmitters designed for Fox Hunting (Foxes).

Two areas were designated as search areas. The cadre hid the Foxes and made sure the teams stayed in the search area. They also timed each team and radioed back when a search area was available for a new team. The Admissions Partners acted as escorts for each team and completed a scoring sheet for each team. Each team had approximately ten minutes to find two Foxes.

The engineering team and Admissions Partners also conducted demonstrations of Soil Liquefaction and Water Filtration. These demonstrations were developed around the challenges faced in recovering infrastructure after a disaster. Several of the Admissions Partners involved in these demonstrations were Civil Engineers from the Providence, Rhode Island Coast Guard Engineering Unit, who were very happy to engage the participants.

The Sea challenge introduced the concept of wave energy convertors. The sea scenario was alternative energy generated by converting wave energy to electrical energy in Long Island Sound. In this challenge, the same teams were tasked with building a small wave energy convertor, and generating the greatest voltage potential in a wave tank. This exercise was drawn from a Sophomore-level Physics course. Physics II uses this exercise as a demonstration and lab. The exercise was developed at Pacific Marine Energy Center at Oregon State University. The teams were tasked with building scale model buoy that could generate electricity. Each team was given several items- a plastic test tube, 30 feet of 22 gage magnet wire, fishing line, fishing bobber and a rare earth magnet. Additional supplies such as scissors, hot glue, tape and rulers were available in each classroom. Each team had approximately 30 minutes to build a buoy. The mentors and admissions partners assisted by answering questions.

Regardless of the mentor's major, all had taken Physics II the previous Fall Semester. They were all familiar with Faraday's Law and had conducted the exercise previously. Once teams were ready to test their buoy, the mentors worked with team to anchor their buoys to the bottom of the wave tank, hook up a Multimeter and record the highest electrical potential the team's system generated. The mentors and Admissions partners

recorded the highest electrical reading for each team. This information was included on a score sheet.

The Air/Cyber challenge ran concurrently with the Sea challenge. This challenge required the most teamwork. Cyber Systems is the newest major at United States Coast Guard Academy. This class of pre-college summer program participants is the first admitted class to choose Cyber Systems as a major. The engineering team felt it was important to include one Cyber-based challenge. The air/cyber scenario was intercepting and decrypting a message so a smuggling operation could be stopped. To successfully complete this challenge, the teams had to communicate effectively to earn enough keys to decrypt the message.

Each team had to organize with a pilot, and three spotters. The pilot was tasked with flying a small drone through an obstacle course. The pilot could not move from a designated spot, so was forced to rely on instructions from the team's spotters. Each spotter had a FRS radio for communicating with the pilot. After the pilot navigated each obstacle, the spotter at that obstacle was allowed to collect a decryption key.

Once the team decrypted the message, the cadre or Admissions Partners recorded the team time for the course. As with the other challenges, each team received a score.

The team scores were tallied for each group. The teams were ranked for the Friday closing session. Each group had a one minute to present a topic or demonstrate one of the challenges they worked on during the week. In past years, Friday's morning session included the ARoW Competition, Admissions Brief and Lunch. The afternoon was a wrap-up and graduation ceremony. By changing AIM, the team had created an opportunity for a poster session of Capstone projects. This was billed as an opportunity to view the types of capstone projects their children could be engaged in as 1/c cadets. The new Friday morning agenda had become Engineering Debrief, Admissions Brief, Capstone Poster Session and Lunch.

Improvements

There was very positive feedback for this change in the program. In spite of that, there are a few improvements the engineering team is currently working on.

The most important improvement is generating new ideas from the five engineering majors. This would allow the engineering team several challenges to choose from. The team might choose to focus on one type of theme for that year or challenges that focus

on a particular major. More challenges will provide the team more flexibility in working around summer construction and improvement projects on campus.

The engineering team wants to avoid challenges running late. In particular, the Land challenge ran 30-45 minutes longer than anticipated every week. One way to improve timeliness would be to have a either another (fourth) challenge running concurrently, or have two land challenges running concurrently in different locations on campus.

The team also wants to explore new ideas for using new equipment and facilities. Physics and Engineering are currently in the second year of participating in Virginia Space's ThinSat Program. This program has opportunities to involve high school students in developing new instruments for space research, and analysis of data from instruments. [6] In addition, USCGA has a new satellite ground station installed, that may also provide opportunities for challenges, tours and demonstrations.

Conclusions

Changing an older, successful engineering challenge for AIM was an undertaking that could have ended poorly. The engineering team took a thoughtful approach to deciding how best to introduce new challenges that better represented the types of learning activities that rising high school seniors could expect to be engaged in at this academic institution.

This undertaking also gave the Engineering Department an opportunity to discuss how it can leverage its curriculum for outreach and recruitment. Given that most of the department's faculty is engaged in other activities throughout the summer, it was an important reminder that their work has benefits for people beyond the cadets we teach annually.

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