Aerospace Engineering Camp for Youth – Techniques Used and Lessons Learned

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Abstract – One of the best ways to spark interest in youth for Science, Technology, Engineering, and Mathematics (STEM) is to get them introduced to these subjects early in their lives. A decision made early in the life may help determine the future path for the youth. In this research, we explore the techniques that could be used to motivate middle and high school students to participate and learn about engineering in general and Aerospace engineering in particular. The techniques discussed are used in various Aerospace Engineering camps at Southern Polytechnic State University during the summer breaks. It is determined that some teaching techniques work better than others. A few teaching techniques are explored and lessons learned are described in this research.

Keywords: Aerospace, Camp, Teaching Techniques

INTRODUCTION

Aerospace Engineering (AE) is often thought of as 'Rocket Science' that is theoretical and difficult for an average student to understand. On the contrary AE is one of the special disciplines of Engineering in which theory is often developed based on the empirical results. There are several examples of both Aero and Space vehicles that were developed by trial and error. Aerospace Engineering in general is a discipline in which a lot of learning is done by hands-on, experimental, operational, observational, and exploratory techniques. These techniques can be taught and enjoyed by students of all ages (K-16) [1]. These techniques are explored in this study and their results are discussed.

One of the ways to motivate students to enter the field of engineering in general and AE in particular is through hands-on activities in educational camps. Two AE educational camps were held for middle and high school students at Southern Polytechnic State University (SPSU) in the summer of 2010, followed by three improved camps in the summer of 2011. Middle and high school students attended the camps at the same time but were separated in the room based on the age groups. The response was encouraging. A few field trips were arranged and guest lecturers were invited. Airplane, helicopter, and space shuttle models were used as training aids. Students participated in flight competitions including range and endurance competitions. Model rocket launch was one of the most well received activities. Model aircraft flights were enjoyed by students. The guest lecturer introduced students to Computer Aided Design (CAD) using state of the art software CATIA. A Few pictures from the camp are shown in Figure 1. The overall response from the participants was enthusiastic. Students enjoyed the hands-on activities and gave encouraging feedback. Several students expressed interest to return to the same camp the following year.

Hands-on, design, build, fly techniques, and visual and other tactile methods proved to be more educationally valuable than lecture-based sessions. Various techniques used to engage middle and high school students during the camp and the results obtained are discussed in this paper.

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RECRUITMENT STRATEGIES

The first step before recruitments begins is to have a set of clear goals and objectives for the camp. These are reflected in all the recruitment materials and communications. A detailed schedule was developed and camp dates were identified over six months in advance. A camp flyer was developed and published in the university pamphlet. An initial invitational email was sent to all the university employees. This generated a lot of interest. The word spread very quickly. Within a few weeks, there were several students enrolled in the camp. Students and parents were asked to sign waiver forms, and send in the registration fees to reserve their spots. A few weeks later, a similar email was sent to the principals of a number of local middle and high schools in the neighboring counties. Several principals responded favorably and supported the idea. A few schools posted the flyer on the school bulletin boards and school websites. This generated tremendous amount of interest. Several months before the camp start date, the camp was full. A second shorter camp was scheduled and that filled up very quickly. Each camp was limited to 30 students. Over a hundred students had to be turned away during the first summer these camps were offered. The following summer, three camps were organized, and the camp fee was raised. The camps were still limited to 30 students per camp. Similar recruiting strategies were used again. All the camps filled up quickly. It was determined that in today's electronic age, not a lot of resources need to be spent to get the word out. One of the best ways to recruit is through the word of mouth.

Figure 1: Aerospace Engineering Camp held in summer 2010 at SPSU, for middle and high school students

CAMP PREPARATION

The initial preparation includes finding the right time for the camps. Several items have to be considered including the middle and high school schedules, SPSU summer schedule, the camp director's schedule, the facility schedule etc. Flyers are put together and sent out to the local schools for the promotion of the camp information. The camp website [2] also helps generate interest. It also answers a lot of questions that parents and students have. Registrations are taken on first come first served basis. The camps are limited to 30 students. The camp fee is deposited in a university agency account. These funds are used to purchase equipment used in the camps.

The Aerospace camps at SPSU are primarily run by one camp director. A few student volunteers are recruited to help with camp activities. Parents are also encouraged to help with the camp. Children of the helping parents are given a discount in registration fee for helping with the activities.

CAMP ACTIVITIES

The camp preparation starts in the fall of the previous year. Parents start planning their and their children's vacations around the summer camps and other activities. They start seeking information about the camp months ahead of time. A simple approach for getting the information across is to put it all on a website. The SPSU Aerospace Engineering Camp information is available on its corresponding website [2]. The website is regularly monitored and updated. The camp is one week long. It runs from 9am to 4:30pm during the work week. Each day is broken down into several activities. The activities include short interactive lectures, use of props, educational aides, promotional videos etc.

1. **Introduction to Aerospace Engineering**

   The first and foremost concept that all students want to learn about is 'how airplanes fly.' The first hour of the camp is spent introducing students to the basics of aerodynamics and how lift is generated. Brief introduction to the history of Aerospace is given. A brief video of the early design concepts, failures and successes is shown. This typically excites students. Problems with early aircraft are discussed. This is followed by the fundamentals of bird flight and the concepts of flapping and feathering.

   Bernoulli's principle is used to explain the generation of lift. A variety of static and flying model aircraft are used to demonstrate the principles of flight. Students get to fly radio controlled model aircraft on a flight simulator. They are also introduced to the modeling and styling of aircraft using Computer Aided Design (CAD) software. Students are given projects to work on for the entire week – so they stay engaged and learning continues when they return home every night. Other activities include trips to the campus simulation lab, RC aircraft flight demonstration, rocket design-build-fly competitions, paper and balsa plane endurance and range flight competitions, and student presentations.

2. **Hands-on Activities**

   Aerospace engineering, like most of the other engineering disciplines, is an applied subject. This makes it easy to discover and use hands-on activities during the camps. Props of various sizes are used to engage students. Static and flying aircraft models are used. Students who perform well are rewarded with the opportunity to operate the model aircraft. A radio controlled Ornithopter is flown in the large lecture room to demonstrate how birds employ both flapping and feathering to generate lift and propulsion. Paper strip exercise is used to explain Bernoulli's principle. Bernoulli's principle is also emphasized with the hair dryer and ball experiments. When students visualize lift being created, and a ball levitating in the air because of the difference in pressure, they understand the concept of force and pressure. The difference of pressure on one surface of a body compared to another surface generates lift. Students are handed boomerangs. The demonstration of the fact that one surface of the boomerang is more curved than another helps them understand how lift is generated on an airfoil. It is a similar type of airfoil that is used in the wings of the airplanes. It is this particular curved shape of the wings that generates lift and keeps the heavy airplanes floating up in the sky. The Bernoulli's principle is also enforced by the ping pong experiment. It is emphasized that Bernoulli's equation is another form of Newton's second law of motion. A Frisbee is

also used to demonstrate that the curved surface on the top helps keep it in the air for a longer period of time.

3. Computer Aided Design (CAD)

Aerospace engineers often work as designers. The shaping, styling or modeling of airplanes, rockets, and other flying objects are initially done using Computer Aided Design. Students are introduced to a sophisticated CAD package called 'CATIA,' which is commonly used in several aerospace companies including Lockheed Martin, Boeing, Airbus etc. Rapid vehicle design is demonstrated live in class. SPSU has purchased student license for the Dassault System CAD package called 'Solid Works'. In the future camps, students will get hands-on experience with Solid Works. They will get to model an airplane or a rocket. Typically, engineering students are not exposed to engineering drawing or CAD until their first or second year in an engineering university. The campers get very excited when they realize that they can design aircraft that engineering students, who are much older than them, design at a later stage. This is a valuable learning experience for the students.

4. Flight Simulations

Three different flight simulators are used during the camps. These include radio controlled model aircraft flight simulator, a fixed wing aircraft flight simulator, and a rotary wing flight simulator. The fixed wing flight simulator is part of the visualization and simulation laboratory at SPSU. It provides an immersive environment for the students. They learn the basic flight controls, flight operations, maneuvers, and navigation and communication skills. Flight simulation has been one of the favorite activities for all campers.

5. Flight Competitions

Almost all group activities have student competition aspects. The paper and balsa plane activities consist of range, accuracy and endurance competitions. The flight simulation consists of accuracy landing competitions. Rocket launch has esthetic, flight and spot landing competitions.

6. Rocket Design-Build-Fly Competition

Students are given rocket kits. They are also given the building steps and instructions. All the building material is provided. If they do not finish building the rocket during the day, students are allowed to take the kits back home and get help from an adult. They are encouraged to come up with innovative ideas in terms of painting and naming their rockets. The rocket engines are not provided for safety reasons. On the day of the competition, students are given a chance to adjust the launch pad. Depending on the launch angle, and wind direction and speed, they can estimate which direction the rocket is going to fly in. Rockets have parachutes or streamers. The goal is to have the rocket land as close as possible to a target spot.

7. Student Presentations

The paper plane competition gives students lots of room to think outside the box. Campers are given the entire week to think and play with different ideas. They are encouraged to apply the concepts learned during the camp to improve their designs. They are allowed to design two different airplanes, one for range and another for endurance. They are required to do research and record flight data from their flight tests. Based on these findings, they are required to do group presentations on the last day of the camp. The group presentation is a great way to encourage and prepare them for public speaking. Students are judged based on their performance in the flight competitions and presentations.

8. Awards Ceremony

At the end of the camp, certificates and awards are distributed to the students. Parents are invited to attend the graduation ceremony. The vice president of the university delivers a short speech, where he enforces the fact that it is important to get the students excited and determine their inclination at an early stage. Attending summer camp is a great way to motivate students to join STEM careers. Often times, these students decide to study a STEM field because they got inspired by an activity or a statement during the

camp. At least one of the camp alum informed the camp director that they wanted to enroll in the Aerospace Engineering program after their high school. Students who perform well at various activities throughout the camp get medals and trophies. All the participants are awarded participation certificates.

A lot of students and their parents are very appreciative of the camp efforts. When they shake hand and thank the camp organizers before leaving – that is usually the most rewarding part of the camp for the director.

STUDENT FEEDBACK

Student feedback is collected at the end of the camps based on carefully designed evaluation forms [3]. The feedback is usually constructive and positive. But it also helps better the camp. Some of the positive qualitative feedback received from the first camp surveys is as follows.

In response to the question 'What did you find valuable during the Aerospace Engineering Camp at SPSU?,' we received the following:

"You did a great job of knowledge balance and hands-on activities"

"Learning how airplanes fly, learning about airfoils, learning how spaceship flies"

"CATIA (CAD) Demonstration"

Some of the feedback that helped improve the second round of camps is given as follows. This feedback was received in response to the question 'What can be done to improve the future camps?'

"Do more hands-on activities"

"Add more field trips"

"Add more engineering and building of stuff"

Based on the above feedback, some of the lectures are cut shorter and more student-centered active learning techniques are introduced. These activities include the wind tunnel experiments, balsa plane competitions, radio controlled aircraft operations, CAD, and others. As we learn more from these experiences, we will continue to improve these camps.

DEALING WITH DIFFICULT STUDENTS

Teaching and effectively controlling any group of students, especially students of early teen ages, is a challenging task. Several techniques have been used effectively in all the camps to control mischievous students. If a student is distractive, or not interested in the activities, or if their actions cause others to suffer, the student is isolated from the rest of the campers. The camp director keeps a special eye on such a student. Such a student may be asked to work on one-on-one basis with the instructor. They are also asked to sit separately from the rest of the group. They may be asked to pay attention to the activity and then demonstrate the activity to the class. Sometimes small punishments like making them stand in the corner or not allowing them to participate might work. If none of the methods work, they are asked to bring their parent to the camp. The parent is informed about the situation. The situation typically gets better after that. If the problem persists, the difficult student may be asked to not return to the camp. In all the camps conducted, none of the students had to be asked to drop out. Middle and high school students attend the camp at the same time but are separated in the room based on the age groups. The two different groups work and compete in activities separately and independent of each other.

FOLLOW-UP CAMPS

A Radio Controlled (RC) Pilot camp is planned for the summer of 2012. The previous camp alumni are invited to attend the RC pilot camp. It is a flight training camp where students will be taught how to operate Radio Controlled aircraft. The age requirement to participate is 15-18 years. The minimum age requirement is governed by the American Model Association (AMA) and the flying club requirements. The large scale Radio Controlled aircraft need large spaces to fly. The local Radio Controlled flying club has graciously welcomed the camp director to host the flying day at the club site. The idea of the camp is to teach students how to fly, operate, and maintain RC aircraft

models. The camp includes introduction to RC systems, parts of the aircraft, aircraft controls, coordinated turns, other flight maneuvers, and flight simulations. The next advanced camp under planning is an Aviation camp, where students will be taught the basics of General Aviation (GA) aircraft. The camp director holds a private pilot license. The Aviation camp will include discovery flights in Cessna 172 aircraft for the campers.

PROGRAM COST

The cost to run the camps can be broken down into non-recurring program cost, capital investment, recurring, and miscellaneous costs [4]. The capital cost is minimized by holding all the camp activities at the state institution and using the institutions facilities. An effort is made to reuse as much of the camp material as possible. The reusable items include the model aircraft, flight vehicles, flight simulators, all the software and computer hardware, and miscellaneous hardware. There are several consumable items that are purchased for every camp that account for the recurring costs. These include the flight model rockets, balsa planes, T-shirts, awards etc. There are costs associated with hiring student assistants and other help. In addition, there are some non-tangible costs e.g. the operation of the buildings, electricity usage, wind tunnel operations, flight simulation operations etc. All the camp cost is covered by the registration fee that students pay. There are additional activities that could be added to the camp to further enrich the experience e.g. field trips to Lockheed Martin manufacturing facility, field trip to a local airport and the control tower, field trip to aerospace museum etc. However, to keep the registration cost low, these activities will not be executed until further funds are secured. The goal is to keep the cost to the students at a minimum. For that reason, the camp is run on a non-profit basis. It is the camp director's desire to acquire state, federal or other sources of funding to augment the increasing cost of running the camps.

CONCLUSION

Aerospace engineering is an exciting discipline and it is here to stay. Youth are encouraged to join the field by introducing them to the field in their teen years. Several Aerospace Engineering summer camps were conducted at the Southern Polytechnic State University. In this paper, the author has described the camp activities, what works and what does not work. In the past two years, the camps have been run successfully and have generated significant interest amongst the local middle and high school students. Student feedback is collected after each camp. Camps are further improved with this feedback. Several students showed interest in pursuing the STEM fields and one student decided to become Aerospace Engineering after attending the camp. In this paper, a few effective teaching techniques are outlined including the use of hands-on activities, flight demonstrations, site visits, and student competitions. The lessons learned and potential areas of improvements are highlighted.

ACKNOWLEDGEMENTS

The author would like to thank several parents and student assistants who worked as chaperons on volunteer basis in all the camps. The author would also like to acknowledge the Southern Polytechnic State University and all the personnel who helped with the setup, organization, and operations of the camps.

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