AC 2012-3642: INTRODUCING AEROSPACE ENGINEERING TO MIDDLE AND HIGH SCHOOL STUDENTS: TECHNIQUES THAT HELP THEM LEARN WHILE HAVING FUN

Dr. Adeel Khalid, Southern Polytechnic State University

Adeel Khalid, Ph.D., is Assistant Professor, Systems Engineering, Southern Polytechnic State University; Office: 678-915-7241; Fax: 678-915-5527; Web: http://www.spsu.edu/akhalid.

Introducing Aerospace Engineering to Middle and High School Students – Techniques that help them Learn while having Fun

Abstract

Aerospace engineering camps are held during the summers of every year at Southern Polytechnic State University. The camps are designed for middle and high school students. In this paper, we outline the benefits, challenges of starting the camp, recruitment strategies, camp activities and some feedback. Conducting AE camps has proven fruitful for the students, the university, and the camp director. Some of the effective teaching techniques and potential areas of improvement are highlighted.

Introduction

Aerospace Engineering (AE) is often thought of as 'Rocket Science' that is theoretical and extremely difficult for a common 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 including middle and high school students (K-12). These techniques are explored in this study and their results are identified.

One of the ideal ways to spark interest in students in 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 in the summer of 2010, followed by three improved camps in the summer of 2011. 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 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. 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. At-least one of the campers has since graduated from high school and has joined the undergraduate AE program. Several others have promised to study AE and expressed interest in working in the AE industry.

Recruitment Strategies

The first step before recruitment 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 for each camp. A camp flyer was developed and published in the university pamphlet. An initial invitational email was sent to all the university employees. This typically generates a lot of

interest. The word spreads very quickly. Within a few weeks, for each session, there were several students enrolled in the camps. Students and parents were asked to sign waiver forms, and send in the registration fee to reserve a spot. 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 start date, the first 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 that these camps were offered. The following summer, three camps were organized, and the camp fee was raised to help offset the costs. 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 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[1] also helps generate interest. It also answers a lot of questions that parents and students have. Registrations were taken on first come first served basis. The camps were limited to 30 students. The camp fee was deposited in a university agency account. These funds were 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[1]. 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 and 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 flight of principles. 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 hall 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 applied to fluid particles. 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 competition consists of range, accuracy and endurance competitions. The flight simulation has 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. The building material is provided. If they do not finish building the rocket, 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[4]. Often times, these students decide to study a STEM field because they got inspired by an activity or a statement during the camp. 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 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 student. Such a student may be asked to work one-on-one 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. In rare cases small individual breaks like making them stand in the corner or not allowing them to participate has worked. 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. The latter situation has not risen in any of the camps.

Program Cost

The cost to run the camps can be broken down into non-recurring program cost, capital investment, recurring, and miscellaneous costs[2]. 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 case volunteers are not available. 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 be executed when further funds are secured or other means are determined. 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 by introducing them to the field in their teen years. Aerospace engineering summer camps are held at the Southern Polytechnic State University. Youth camp activities that work and do not work are described in this paper. In the past two years, AE camps have been run very successfully and have generated great amount of interest. Student feedback is collected after each camp. Camps are further improved with the feedback. In this paper, a few effective teaching techniques are outlined. The lessons learned and potential areas of improvements are highlighted.

References

1. Aerospace Engineering Summer Camp at Southern Polytechnic State University – Camp Website: < http://www.spsu.edu/aerospace>
2. Chu, M., 'Education Case Analysis For Pre-Engineering Robotics After School Program: Assessing The Intangibles,' 2011 ASEE South East Section Conference
3. McCue, L., Waller, T., Crede, E., Gaines, J., 'Give them what they want: A look at student directed curriculum revision in a summer bridge camp,' 2011 ASEE South East Section Conference
4. Anderson, L. S., Gilbridge, K. A., 'Pre-University Outreach: Encouraging Students to Consider Engineering Careers,' Global Journal of Engineering Education, Volume 7, Number 1, 2003