ONE THOUSAND AND STILL FLYING

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Abstract

The freshman engineering and computer science program at Wright State University is designed to teach engineering principles through hands-on experience, establish a sense of community, develop an understanding of how to be successful in studying engineering, and to foster collaboration among students through cooperative teaming events. This paper presents one of the teaming events which involved building and flying a radio controlled airplane. Included is the rational for the event, description of the airplane choice, construction method, logistics, event administration, community involvement, resources required, and student learning. Through this experience the course administrators learned to fly, how to teach students to fly in a short time, how to quickly repair planes that crash, and how to incorporate this event into student recruitment. The college used this program and teaming events in their recruitment brochures. At orientations, an emphasis on the fly-in was presented to prospective students, and former students willingly told their friends in high school about it. As a result freshmen students arrived anticipating the event and participated with enthusiasm.

1. Introduction

The Freshman Engineering and Computer Science (FECS) Program at our university is designed to introduce engineering and computer science principles through hands-on experience, establish a sense of community, develop an understanding of how to be successful in studying engineering, and to foster collaboration among students through cooperative teaming. All incoming first year engineering students are required to take the FECS course. This course has one lecture section, a computer lab, and an instrumentation lab. The computer labs are designed for students to work independently and the instrumentation labs are designed for students to work in teams. Table 1 shows a typical outline of the course.

The computer lab exercises involve e-mail and web searching, designing an airplane wing, HTML scripting, MatLab, Excel, and statistics, and how things work as the writing intensive assignment. The instrument labs cover 2-D and 3-D drawing using TurboCAD and SolidWorks, use of lab instruments, circuit measurements on resistive circuits, and building and testing a multi vibrator, decade counter, and flip-flop using integrated circuits. In addition, basic soldering and basic wireless communication is taught using a temperature satellite. The three teaming events, three exams and two labs constitute 10% each, home work 15% and class participation 5% of the course grade. This paper focuses on one the teaming events, the airplane project.

Table 1: Typical Outline of the FECS Course.

Week	Focus
1	Bridge Building Competition
2	Engineering Art, Email and Web – Plane Building Starts
3	3D Art and Fundamentals of Flight – Plane Building Done
4	3D Art and Web Design-I – Plane Flying Starts
5	Exam I and Web Design-II
6	Instrumentation and Web Design-III – Final Project Assigned
7	Circuits and Engineering Math
8	Timers, Flip Flops and other ICS, Exam-II
9	Temperature Satellite and How Things Work
10	Launching Temperature Satellite, Recording, Analyzing Data, and Presentation of Final Project – Plane Flying Ends

Five years ago we were looking for a more complex teaming event then the simple design and construction tasks we had been doing. We wanted it tied to a lecture and laboratory and also provide the students an unusual and fun teaming experience outside the regular classroom schedule. At that time a new technology was just being introduced to the radio controlled (RC) airplane community that involved the use of very small electric motors to power airplanes. These airplanes could be designed to fly in confined spaces such as an enclosed arena. Their attractive features were slow flying speed, quiet operation, battery power, and relative safety. Gas power RC airplanes fly fast, are noisy, require lots of space, produce combustion byproducts, are messy, and require significant care not to be injured. The electric powered ones we considered flew at approximately 7 mph. There were some that flew at walking speed but they were more difficult to build and not very crash worthy.

Several engineering schools have incorporated a project on model airplane building in an undergraduate curriculum. The University of Toledo has a project for the undergraduate seniors that involve flying a model plane on a computer and later building and flying the plane to compare the results to actual flight[3]. Recently a professor at the University of Dayton introduced the concept of model plane building to some of his freshman engineering students[1]. Societies like SAE International have conducted competitions where one team of students from an engineering college designs and builds an airplane lifting heavy loads to compete against other college teams[7]. In all of these cases the time line for building and flying a plane ranged from 10 hours to months, required gas power, and involved small groups of students.

2. Methodology

Each year there were about 250 freshmen students in our program. The course is required of all freshmen and limited to 90 students once a quarter. This event is intensive in terms of time spent by the course instructional group. For this event, each class was divided into teams of four with a few of three. The plane building spans across two weeks (week 2, 3) where students chose their own team members and picked a two hour build time. The teams purchased their airplane and were discouraged from attempting to build it on their own as experience had shown they would have to disassemble and rebuild it properly. During build time, help was provided by graduate teaching assistants using well established procedures. Upon completion of the plane the team picked a flight time.

The planes settled on were the PICO-J3-S and the PICO-STICK-S manufactured by Grand Wing Servo-Tech Co., LTD (GWS)[3]. They came in kit form with an electric motor and prop and sold for less than $40.00 US. The wings and tail were made from molded Styrofoam and the fuselage was a balsawood stick. Also required were the landing gear, and mounts for a receiver, two servos, the battery, and an electronic speed control (ECS). The receiver, servo, battery, and ESC were available from GWS as a flight pack with crystal oscillator for $95.00 US. The first quarter for this event the teams were required to purchase the flight pack. Realizing that the packs could be recycled, the college decided to purchase enough packs for each team and loaned them at build time. The college also provided the radio transmitters, JR QUATTRO's at $74.00 US with crystal oscillator[4]. In addition, battery chargers and spare parts were provided. The batteries were nickel-cadmium, assembled in a pack of six, wired in series producing 7.2 volts with a capacity of 270mAh.

These airplanes were designed to be flown indoors and needed enough space so beginners had time to react when inputting control signals before the airplane crashed into a wall. To meet this need, the Ervin J. Nutter Center was used[6]. This state-of-the-art facility at Wright State University features an enclosed main arena with a clear space of 30,000 square feet and an open ceiling of 76 feet. This is the part of project that required considerable effort from the course professor. The course comprised about 25 teams on average, with each team taking around 2 hours to learn and fly. Flight times were scheduled to fit within the center's event programming, and for this reason, the flying spanned from week-3 through week-10. On the day of flying, time periods from 3 to 6 hours were scheduled. Prior to team arrivals, a reception area was set up for airplane safety inspection, battery charging, repair, and flight ground school.

Ground school and flight instruction was provided by RC instructors with experience building and flying RC airplanes and instructing beginners. Each session required from three to four instructors. A flight time of 1.5 hours was allocated for each team. During flight, a student was coupled with an instructor using two transmitters. The student's transmitter was set up as a "buddy box" connected via a control cord to the instructor's transmitter. On the instructor's transmitter was a single throw, momentary contact switch. When the instructor held this switch closed, the student's transmitter was activated and the student could control the airplane. If the student got into trouble the switch was released and the instructor took control. Each student was taught how to control the plane through rudder and elevator input, and speed adjustment.

After each student received instruction and flew, the team picked one member to be their competition pilot. In competition the pilot was expected to fly without instructor help. A grade was given in competition for having the airplane ready to fly (40 points), successfully taking off (25 points), landing (35 points), and flying an elliptical course within the arena (10 points each lap around the arena).

One regularly scheduled lecture and laboratory was coupled to this event to provide students an understanding of how a plane operates. During the lecture students were introduced to the physical plane, how it flies and center-of–gravity (COG) considerations. The forces of lift, weight, thrust, and drag were discussed. The control surfaces were covered along with how the airplane maneuvers in flight. The COG was used to introduce static force and moment calculations on a beam. The NASA airfoil simulator, FOILSIM II, was used to provide real time feedback[5]. Students investigated what happened when they varied wing parameters such as thickness, camber, and surface area along with physical parameters of airspeed, altitude, and angle of attack. They were also required to design a wing using FOILSIM II to meet the requirements of an airplane, similar to a Piper Cub, weighing 1,220lbs, 22 feet long, maximum speed of 85mph, wing span up to 35 feet, stall angle of 40 degrees and operate at a maximum altitude of 11,500 ft.

3. Results

During construction, students learned to use instant glues, fit parts and mount electronics, check the center of gravity, and test for proper operation. Test flying did not occur at this time. The most difficult task was properly aligning the control surfaces and applying the hinges. Too much space between the fixed and the movable surfaces resulted in sloppy control in the air. The second most difficult task was assuring proper alignment when the elevator and rudder were attached to the fuselage. The kit provided a neat way to mount the servos using rubber washers and screws with plastic holders. However, during actual flight training it was found that when a plane crashed the servos would break loose and often the mounts broke. Reinstalling the servos was a time consuming process. After one crash a field modification was made whereby the mounts were discarded and the servos attached at the same location to the fuselage using double sided tape and a cable tie. Doing this, the servos no longer came off in a crash. So, this change was incorporated in the construction phase.

The first airplane used was the Pico-J3-S. During flight it was discovered that it did not have enough wing dihedral(upward angle of the airplane's wing with respect to the horizontal). As a result turning during flight was sloppy and required a lot of space. The problem was solved by bending the wings up about 2 inches at the tip and holding them in place via a thread stretched between them. This plane, with the wing modification, was used successfully for the first two years. During the winter quarter of the third year the Pico-Stick-S was used. In construction it was very similar to the Pico-J3-S but, in flight it proved to be superior. It had a different wing design that did not require any modification and was easier to fly. It has been used since.

Scheduling the Nutter Center arena has been an interesting experience. It is used for basketball, hockey, concerts, graduations, banquets, ice skating shows, monster truck contests, and arena crosses. As a result flying might occur on a hockey rink, within a basketball court, or on bare concrete. At times there were long cables hanging from the ceiling and sometimes a curtain support girder would be in the way. Another obstacle was the massive score board and speaker system that hung from the center of the ceiling. For a hockey set up there were nets at each end of the arena designed to catch flying pucks. It did provide a large open flight area. Flying from ice required warm foot gear and coats. Flying within the basketball set up was not difficult as the backboards could be lowered until they extended about seven feet from the floor. The floor area was smaller than the hockey set up as bleachers would extend out from the sides; however, the airspace was the same. Operating from concrete was the best as there were no obstacles to contend with, the bleachers were pushed back, the whole floor area was available and the airspace was larger. It was found best to ask the center to schedule flight time in all of the available time offered as events would cause rescheduling. Once, the basketball court had to be resurfaced and that took a week and two of the scheduled flight times. Usually it took 8 to 10 days each quarter spread over six weeks to complete the teams. One quarter the center was able to let us have a full week on concrete. We went from 3:00 PM to 10:00 PM each day and finished in the week. It was a pleasant but tiring experience.

Each flight period required 30 minutes for set up and 1.5 hours per team. Two teams could be managed in three hours as the second team would be undergoing inspection and ground school while the first team was flying. During a 6 hour period five teams could be accommodated. The most common period was 4.5 hours. It took five large folding tables for a flight set up. Before the teams begin arriving one table was set up for charging batteries and battery packs would be prepared. At least five battery packs were required per team. When a team arrived their airplane was checked for construction errors, corrected if necessary, and then prepared for flight. The instructors would test fly the airplane, trim it, and set up the instructor-buddy box transmitters. During this period the team was given a short ground school on how to use the transmitter.

During flight instruction the airplane was taken to a comfortable height, the speed was set, and as it was flying away, control was given over to the student. There was continuous verbal instruction coming from the flight instructor and at times by one of the other instructors. The main difficulty students exhibited was banging the control sticks from side to side as they do when playing a video game. This caused the plane to head for a crash and required quick recovery by the instructor. As the students gained confidence, and got a feel for the 3-D setting, the verbal instruction reduced significantly. In about 10 minutes most students were flying with little help. There was no difference noted between the male and female students in their willingness and ability to learn to fly. Some were aggressive, some hesitant, but the most often expressed emotion was excitement.

When all team members had flown they picked their pilot for the competition. The pilot was given additional instruction on take off and landing, and how to fly the correct circuit. When ready, the pilot was allowed to proceed. This consisted of taking off, flying as many circuits as possible before the batteries started to fail, and making a safe landing. A carefully prepared battery was provided each team for the contest. This battery held enough charge for at least ten minutes flight time depending upon how the plane was flown. If the pilot controlled the air speed to maintain altitude more flight time would occur.

Initially the pilot was handed the transmitter and left alone. Some of the pilots did well but many had problems resulting in early crashes. So, it was decided to use the instructor-buddy box set up and fined the pilot 10 points whenever the instructor made a save. During some quarters sixty percent of the teams needed saving at least twice some six times and in other quarters less than ten percent needed help once. For winter quarter 2004 the number of circuits after saves varied from 3 to 49 with an average of 33. For spring quarter 2004 the number varied from 3 to 41 with an average of 22. There were more saves the spring quarter. The reason for this difference is

Table1: Results obtained from Student Surveys

Questions Asked	Percentage

	Yes	No
Do you have prior Experience to Flying RC Planes	5.88	94.12
Do you have prior Experience to Flying Model Simulators	47.05	52.95
If given model simulator, would you practice flying	81.17	18.83
Did the flying lab help you understand aspects of flying	90.69	9.31
Were the professor's expectations clear for the project	90.47	9.53
Did the Professor/GTA provided enough feedback for the project	84.88	15.12
Did this project contributed to learning experience	88.23	11.77
Did you have fun in this project	93.12	6.88
Did this project Increase your interest in engineering & computer science	84.7	15.3
After this project, do you have a better understanding of aerodynamics & flight	89.41	10.59
Was it always easy to understand the standard of work expected	82.35	17.65
While learning to fly, did you crash the plane?	34.52	65.48
Did this project help towards developing your ability to work as a team member	83.33	16.67
Do you feel confident about tackling unfamiliar problems	84.52	15.48

unknown. The positive side of using the buddy box was a more confident pilot, better performance in the air and happier teams. At the end of the project, surveys were given to students and the data collected is presented in Table 1.

There were many times when the instructor did not have time to recover the airplane from a student mistake and it would crash. Sometimes this would be into a wall, into the floor but usually into the arena seating. A table was set up for crash recovery manned by a very experienced RC builder. Before the servo mounting was changed it took about 20 minutes for repairs. Later, repairs ran from 5 to 10 minutes. The airplane was easily recoverable from most crashes. Sometimes the crash produced a junk pile. It that case, a spare airplane was provided. The electronic packages proved to be very durable. After three years of use some battery packs began to exhibit a loss of power. In five years of flying two servos broke and one battery pack failed. All of the receivers were still functioning as were the ESC's. Once in a while a wire would break from an ESC which was easily repaired.

During training the flight instructors were very busy. It took concentration, quick reflexes, and lots of fortitude to keep a student airborne. Because of the physical and mental effort required, flight instructors were changed between teams. Their most common reaction to the students was amazement at how fast they learned. In the general community it takes many hours before a student catches on and can fly alone. The instructors reported that their own skills in teaching slow flying have improved. Survey results showed that a number of students, 47% practiced using a computer flight simulator. Our program tried providing an RC flight simulator in the dorms but the logistics of signing out and retrieving transmitters proved too difficult to keep it going.

As a teaming event, students had to pool their funds, work together building the airplane, and cheer each other on as the flying took place. They were held accountable for attendance during building and flying. There were times when a student missed a meeting. The student's grade was then limited to only what they participated in. Sometimes the member with the airplane was late for flying and several times a team had to leave and roust out the missing member. The survey showed that 94% had never flown before. As a learning (90%) and teaming (83%) experience it was successful and 90% said they had fun doing it.

4. Conclusions

This event provided students with an educational and fun teaming experience. This is in line with the predication of Wankat and Oreovicz that activities that are similar to computer games and simulations would be useful in introducing students to engineering[8]. The event provided a bridge between the world which students are familiar and the world of engineering. It also added a third dimension to the familiar two dimensions of gaming as well as the requirement to respond in real time.

The teams were required to purchase their airplane while the college provided the flight packs. After the initial investment in flight packs, materials cost for the college was low. The flight packs were very recyclable. The availability of the Nutter Center arena for indoor flying made this event feasible. Its large, open, enclosed space worked well even when flight hazards were present. The event is manpower intensive and requires significant after hours commitment. It would not be possible to accomplish this without the help of community RC instructors. Coupling them with the students using a buddy box was a good learning experience for both student and instructor. A surprising outcome was how fast the students picked up on how to fly the RC airplane. Verbal feedback from students has been very positive and their enthusiasm for the event is high.

References

[1] Camm. M, "Backpack airplane being developed by UD engineers." Dayton Daily News, March 25, 2004, sec. Neighbors, p. 11.

[2] Grand Wing Servo Tech Co., Ltd, Internet: http://www.gws.com.tw/, December 2004.

[3] Hansen. R. P, Long. L. N, and Dellert. T. A, "Experiences using Flying Models in Competitions and Coursework." Proceedings ASEE Zone I Conference, 2002.

[4] JR Radios, Internet: http://www.jrradios.com , December 2004.

[5] NASA Airfoil Simulator, Internet: http://www.grc.nasa.gov/WWW/K-12/airplane/foil2.html, December 2004.

[6] Nutter Center, Internet: http://www.nuttercenter.com, December2004.

[7] SAE International http://students.sae.org/competitions/aerodesign/east/, December 2004

[8] Wankat. P and Oreovicz, "Gaming the Curriculum", ASEE Prism, September 2005, p. 48

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