AC 2012-3870: RULE THE AIR! SUMMER CAMP FOR HIGH SCHOOL STUDENTS

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Rule the Air! Summer Camp for High School Students

Abstract

During a weeklong summer camp, high school students were introduced to aviation and the airline industry. The camp curriculum used airline simulation software to provide students hands-on experience with some of the major challenges faced in the airline industry. The students formed teams that were tasked with creating and operating an airline, including purchasing aircraft; determining where and when the aircraft would fly while ensuring satisfactory maintenance checks; and determining staffing levels, advertising expenditures, and ticket prices. Throughout the week, lectures and activities presented by graduate students and professors aided the decision-making process of the new airline executives. The camp also included two field trips to Atlanta’s Hartsfield-Jackson International Airport and the Delta Air Lines’ Heritage Museum. The evaluation of this summer program utilized pre-post surveys to measure the impact of camp experience on student self-efficacy and STEM interest. The evaluation was also designed to determine students’ interest and understanding of the airline industry. Overall, the evaluation results showed the camp was a positive learning experience for students.

Introduction and Background

The Center for Education Integrating Science, Mathematics and Computing (CEISMC) at the Georgia Institute of Technology brings together educational groups, schools, corporations, and opinion leaders to ensure that K-12 students throughout Georgia receive an education in science, technology, engineering, and mathematics (STEM). The 2011 CEISMC Summer Program consisted of 13 unique classes (17 total) that ran between June 13 and July 29, 2011. The Airlines: Rule the Air! program took place from July 25-29, 2011. The program, taught by professors, graduate students, and industry leaders, consisted of hands-on activities, lectures, field trips, and projects. A team from CEISMC was responsible for advertising and recruiting high school students to attend the camp, handling logistics associated with the camp, and providing an assessment for the camp.

A professor and several graduate students from Georgia Tech’s School of Civil and Environmental Engineering developed curriculum and lead the summer camp. The camp focused on providing insight to the complexities of owning and operating an airline. Students learned why many of the customer service issues they encounter when traveling occur: why it can be difficult for an airline to make a profit without raising fares, how probability distributions affect flight delays and customer denied boardings, etc. Furthermore, the airline industry is of particular interest to students in Atlanta, as Delta Air Lines is a major employer in the area. The curriculum covered concepts from transportation engineering, industrial engineering, and the business areas.

The camp centered on using software provided by Simulate! Pty., an Australian company. This software was previously used in an undergraduate and graduate freight and airports course taught at Georgia Tech. The software for a camp (versus classroom) setting was piloted in summer 2010.
by high school students who were participating in summer activities sponsored by CEISMC, as discussed in a previous paper \(^1\).

The 2011 summer camp built on these activities by developing supplementary lessons to help students make better systems-level decisions related to how to run an airline. We enhanced directions for how to run the software programs and incorporated different software options. The changes are documented below in the curriculum section.

The paper follows with a brief description of the simulation software and an in depth look at the supplementary lessons and activities provided during the camp. This is followed by an evaluation of the effectiveness of the camp and conclusions.

**Curriculum**

**Airline Online Simulation Activity**

The camp centered on the use of a multi-user computer-based simulation program. The program, named Airline Online, was developed by an Australian company, Simulate! Pty. Ltd. In groups of two or three, students tested their entrepreneurial skills by setting up their own airline and running it over the course of a simulated two-year period. Students made decisions regarding which and how many aircraft to purchase, which origin-destination markets to serve, which aircraft to fly in each market (and when), when the aircraft had to be taken out of service for maintenance, how they should set airline fares, how much they should spend on staffing levels and advertising expenditures, and where they should locate corporate offices and maintenance bases. After setting up the airline, the simulation was run for six months. Each team or “airline” was then able to see how profitable they had been over the course of the six-month period and make strategic decisions before the simulation was run for another six months.

For this summer camp, a few modifications were made from the original Airline Online simulation lesson plans detailed in the previous paper \(^1\). Students were able to serve both domestic and international markets. Each team was provided with a large amount of start-up cash to ensure it could purchase longer-range aircraft to serve international markets.

The summer camp provided information for a large number of supplementary lessons. These lessons ranged from gaining a broader perspective of how aviation fits into transportation engineering to detailing how airlines make business and operational decisions. These lectures helped the students create ideas on how they might build and maintain a more competitive airline. During the course of the week, students participated in two field trips designed to give them a broad perspective on the history of the airline industry, as well as a first-hand look of how an airport operates. Below we provide a synopsis of the lessons, activities, and field trips taken throughout the week.

**Introduction to Transportation Engineering**

At the beginning of camp, students were introduced to transportation engineering. Interactive discussion was used to engage students on the many different modes of transportation and their
experiences with each mode. Discussion focused on the five main modes of transportation: pipelines, rail, waterways, airports, and roads. The pros and cons of each mode, and what each mode was predominantly used for was discussed. This led to a discussion on mode choice and how “utility functions” are used by transportation engineers to understand how passengers make trade-offs among time, money, comfort, and other factors. Students learned that passengers’ valuations differ (e.g., some passengers are more concerned about saving money, and other passengers are more concerned about saving time), and that they must balance many passenger interests when attracting passengers for their airline.

To complement this broad perspective of transportation engineering, students were given approximately 100 images of different modes of transportation throughout history. Students worked together to sort the pictures into modes, and then sorted them in chronological order, creating their own visual timeline of how transportation has changed throughout the centuries.

**Different Business Plans: Traditional Carriers vs. Low Cost Carriers**

The business tactics used by major and low-cost carriers were compared during an interactive lecture. Students initially shared their experiences flying on Delta, a traditional carrier, and AirTran, a low-cost carrier, both with hubs in Atlanta. Then students were presented with the business decisions made by the two airlines that resulted in their different experiences. For example, the network models of the two airlines were compared to explain why students had more connecting itineraries on Delta. The two airlines’ fleet selection was also discussed. For example, Delta, a traditional carrier that serves a broad range of domestic and international markets, has a more diverse fleet. This allows the airline to engage in more diverse services, but is more costly to maintain as maintenance facilities for multiple types of aircrafts are needed.

**Fare Setting Strategies**

A lesson on fare setting strategies was used to help students understand how to set fares for their airline. First, students learned about the various ticket taxes (e.g. segment fees, September 11 security fee, international tax) that are included in airfare. Next, they learned about different competition structures (e.g. monopoly, duopoly, and perfect competition) and how fares vary by competition structure. Real-life fare examples were displayed, and students discussed why a single airline providing non-stop service in a market can charge more for a ticket than an airline that competes with one or more other airlines. Next supply and demand curves were shown to convey their ideas in more formal theoretical terms. This lesson resulted in students striving for monopoly markets or strategically pricing their fares in markets where they were competing with other airlines.

**Field Trip to Delta’s Heritage Museum**

The first field trip was a visit to the Delta Heritage Museum, located by the Hartsfield-Jackson International Airport in Atlanta. This trip was arranged to expose the students to historical trends in airline operation and airplane design. The Delta Heritage Museum is housed in two Delta Air Lines hangars dating from the 1940s to the 1960s. It includes several notable collections, such as The Spirit of Delta, Delta’s first 767-200 aircraft. This particular aircraft is housed in Hangar 2,
and the interior has been modified into a cinema setting in the first class cabin, where students watched a short documentary on the Heritage Museum and the Spirit of Delta. Other collections in the Heritage Museum include “Ship 41,” the first DC-3 to carry Delta passengers; a 1931 Travel Air and a museum shop housed in a redesigned section of the hull of the first L-1011 ever built. In the museum shop, students had access to the cockpit, where they were able to explore the many controls pilots use. This fieldtrip was arranged by contacting the Heritage Museum.

**Probability and Statistics**

In another lesson, the students played Theme Park, an online probability game developed by a Georgia Tech industrial and systems engineering professor. Students determined the staffing levels for six different rides in an amusement park based on their popularity levels. After each run, the students could change the location of the staff members to better serve the growing lines. This activity helped students gain an understanding of basic probability concepts.

**Customer Behavior**

A lesson on customer behavior built upon probability concepts and helped students understand why airlines oversell tickets. Since airline seats are perishable, and because passengers sometimes miss a flight or elect to not show up, airlines use probabilistic models to determine the correct number of seats to over-sell. These overbooking models ensure that the aircraft departs full (i.e., that seats sold to customers who do not show for their flights are sold to other passengers who also want to travel on those flights). The problem is complicated because if the no-show predictions are too high, there will be more customers who show up for the flight than there are seats, which results in denied boardings. A lecture on airline no-show models explored the relationships among overbooking, denied boardings, and airline revenues. The lecture provided students with a broader perspective of how, by raising denied boarding compensation limits, the federal government may be able to reduce the number of denied boardings.

**Physics of an Airplane**

A “Physics of Flight” lecture introduced students to aeronautics. The lecture explained the science behind flight. A 10-minute PowerPoint presentation was followed by hands-on activities to practice the principles of aeronautics. The presentation began by introducing basic concepts from physics such as matter, energy, force, gravity, and Newton’s Laws. This introduction to basic physics was followed by the question, “How does something so heavy stay in the air?” This question was accompanied by statistics on weight of aircrafts and flight altitudes.

The presentation sought to answer this question by applying physics concepts. The principle axes of an aircraft (yaw, pitch, and roll) were defined, as well as the four types of forces that are exerted against an aircraft (gravity, lift, drag, and thrust). These forces were illustrated using a free body diagram. Lift was explained using the principles of fluid mechanics, differential pressure, and airfoils. Drag built on the discussion of airfoils by explaining how shape induces or reduces friction forces. Finally, the production of thrust through a jet engine or propeller was explained. Throughout the presentation, animations were used to convey key concepts (forces, fluid mechanics, lift, drag). These concepts were also used to explain why long queues of aircraft
on runways may occur: small airplanes need to wait longer if preceded by a large aircraft, and longer times between take-offs apply in inclement weather. The presentation concluded by reviewing the free body diagram and administering a quiz testing recall of the major concepts from the presentation. The quiz was self-graded and the answers were discussed as a group.

Following the presentation, the students broke into groups of two and were tasked with making paper airplanes that applied the physics of flight. They were given templates for four planes, and then asked to create their own design based on what they had learned from the examples and the presentation. Students constructed paper airplanes and held a competition to see whose could fly the farthest.

**Field Trip to Atlanta’s Hartsfield-Jackson Airport**

The second field trip was to the Atlanta Hartsfield-Jackson Airport, where students were given a behind-the-scenes tour of the airport and airfield. Students visited the ground control tower while staff explained the operations of the tower. Students were able to see the real-time flight controllers working and better appreciate the complexity of coordinating groundside aircraft movement. Students also visited one of the airport firehouses. Here the students learned about the emergency response services available for the airport facilities. The tour completed at Atlanta Hartsfield-Jackson’s unique “end-around” taxi-way. The end-around taxi-way, the first at any airport in the United States, allows planes to taxi to the gate without having to wait to cross other runways. Conceptually, this idea can be compared to replacing a traffic signal (in which cars have to stop to allow other cars to move through the intersection) with a divided roadway structure (in which cars in both directions can freely travel through an overpass or underpass). The group took several pictures at this location and also watched a plane taxi. The tour ended in the terminal for lunch. The tour was set up by Yasmina Platt, who works for the airport planning department.

**Advertising and Frequent Flyer Programs**

Students learned the importance of marketing in the airline industry and the roles of brand advertising and rewards programs. Marketing is defined by four concepts: product, promotion, price, and place. The largest shares of advertising, including television, direct mail, and newspaper ads, were presented and discussed. Students were also introduced to product and institutional advertising by participating in activities that helped them understand the two forms of advertising. Students learned the effectiveness of each type of advertising and how it related to and promoted marketing in the airline business.

The lecture concluded with an analysis of the similarities and differences between two airlines’ rewards programs. Students were then able to create their own advertising campaigns for their airlines, as well as a rewards program. This lesson in marketing and its associated activities allowed students to apply their new knowledge in advertising to the airline industry. This activity stressed the importance of investing in advertising when using the Airline Online simulation program.
Jeopardy

The knowledge students acquired throughout the week was tested on the final day with a two-round Jeopardy game. The topics included each of the activities, lessons, and field trips listed above, as well as airport codes, which students had become familiar with by working with Airline Online throughout the week.

Parents Participation Day

On the last day of the camp, the Airline Online simulation was reset so that the parents could join the groups. This gave the parents the opportunity to see what the students had been working on all week. The students were able to learn from their mistakes and have a fresh start on building their airline and competing.

Evaluation

The purpose of the program evaluation was to measure: 1) students’ interest and understanding of industrial engineering and the airline industry, 2) program impact on students’ experience and self-efficacy, and 3) students’ and parents’ satisfaction with the program. The evaluation instruments consisted of student pre-post surveys and parent surveys. The student pre-survey was given prior to the start of the summer program and was taken by each participating student. The post-survey was taken by each participating student following the summer program. Parent surveys were administered using an online survey called Survey Monkey. The summer program utilized a variety of pedagogical methods in order to create an enjoyable learning experience for participating students, including class discussion, class presentations, activities, and student field trips.

Student Demographics

A total of 13 high school students (grades 9-11) attended the summer program. Twenty-five percent were female. Only one student was granted financial aid for the program.

Goal 1: Student interest and understanding of industrial engineering and the airline industry

The camp was very effective in familiarizing participating students with the airline industry and in helping students understand the career opportunities available in industrial engineering (Table 1). The means before and after the camp increased from 2.70 to 3.75 and from 2.30 to 3.33, respectively, indicating that students were positively impacted by the program in these areas. The results also indicated that the camp had less impact on students’ future education or potential careers in industrial engineering. The data for these two questions suggests that students came into the program with an interest in the airline industry and in industrial engineering; therefore, it is possible that their interest would not have changed significantly following the program. Additionally, students reported in open-ended questions that they would be interested in going to college to pursue a degree in marketing or engineering (75%), which might be an indication of students’ interest in future careers related to the subject matter taught in the summer program.
Table 1: Reported student pre/post interest and understanding of the airline industry and industrial engineering (n=13)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Change *</th>
<th>Not at All</th>
<th>Slightly</th>
<th>Somewhat</th>
<th>Quite a Bit</th>
<th>Very Much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am familiar with the airline industry</td>
<td>1.05</td>
<td>15.4</td>
<td>0.0</td>
<td>23.1</td>
<td>15.4</td>
<td>0.0</td>
</tr>
<tr>
<td>I understand the career opportunities in industrial engineering</td>
<td>1.03</td>
<td>23.1</td>
<td>7.7</td>
<td>15.4</td>
<td>15.4</td>
<td>7.7</td>
</tr>
<tr>
<td>I want to study industrial engineering in college</td>
<td>-0.03</td>
<td>7.7</td>
<td>23.1</td>
<td>38.5</td>
<td>23.1</td>
<td>0.0</td>
</tr>
<tr>
<td>I am interested in a career in industrial engineering</td>
<td>-0.05</td>
<td>7.7</td>
<td>15.4</td>
<td>46.2</td>
<td>38.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Note: Student responses may not add up to 100 percent. Missing data is not included in this representation of student responses. Reported mean scores reflect the following values for each response category: 1: Not at all  2: Slightly  3: Somewhat  4: Quite a Bit  5: Very Much
* Mean change = Mean Post – Mean Pre

Goal 2: The impact of the program experience on student self-efficacy

The summer program was also very successful in increasing student confidence for the program objectives listed in Table 2. The results showed that students were less confident in achieving each program objective prior to the summer program (mean scores from 1.9 to 2.9) than following the summer program (mean scores 3.0 to 4.33). This yielded a positive mean change in student self-efficacy, shown in Table 2.

Table 2: Impact of Airlines: Rule the Air on student self-efficacy (n=13)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Changea</th>
<th>Not at All Confident</th>
<th>Not Confident</th>
<th>Somewhat Confident</th>
<th>Confident</th>
<th>Very Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>How confident do you feel describing the physics of what makes an airplane fly?</td>
<td>1.89</td>
<td>23.1</td>
<td>0.0</td>
<td>7.7</td>
<td>0.0</td>
<td>23.1</td>
</tr>
<tr>
<td>How confident do you feel formulating airline</td>
<td>1.28</td>
<td>15.4</td>
<td>15.4</td>
<td>38.5</td>
<td>0.0</td>
<td>7.7</td>
</tr>
</tbody>
</table>
How confident do you feel strategically selecting a reliable aircraft fleet? 

1.15 7.7 7.7 38.5 7.7 15.4 23.1 7.7 15.4 7.7 38.5

How confident do you feel setting competitive fares for airline tickets? 

1.10 15.4 7.7 30.8 15.4 23.1 15.4 0.0 30.8 7.7 23.1

How confident do you feel describing the history of the airline industry? 

1.10 30.8 15.4 30.8 7.7 7.7 38.5 7.7 23.1 0.0 7.7

How confident do you feel describing how aviation fits into the broader transportation network? 

0.97 23.1 15.4 7.7 7.7 15.4 0.0 30.8 38.5 0.0 30.8

How confident do you feel formulating marketing campaigns for an airline? 

0.68 7.7 7.7 0.0 7.7 61.5 30.8 7.7 15.4 0.0 30.8

Note: Student responses may not add up to 100 percent. Missing data is not included in this representation of student responses. Reported mean scores reflect the following values for each response category: 
1: Not at all confident 2: Not Confident 3: Somewhat Confident 4: Confident 5: Very Confident

* Mean change = Mean Post – Mean Pre

Goal 3: Student and parent overall feelings regarding the summer program experience

Student

The majority of students indicated that they chose to attend this summer program because they wanted to learn more about science or mathematics (53.8%). They also indicated that they wanted to spend a week at a Georgia Tech camp (53.8 %). When asked questions concerning the program instructors and their communication of program objectives, organization, class preparation, program content, and engagement in class discussion, students indicated that they were generally satisfied with the instructors. Most students indicated that they were clear about the learning objectives, the instructors were well prepared, the program was well-organized, and students were involved in class discussion (Table 3). Most students agreed that their instructors clearly communicated goals, clearly presented concepts, and involved the students in discussion (Table 4). Students did not think that their instructors were boring (Table 4). These results are further supported by the responses to an open-ended question geared to illuminate student opinion about the program instructors, where the majority of students stated that instructors taught students well and involved them in the learning process. For example, one student response was that the student “...like[d] them [instructors]. They were both informative and fun.”
Table 3: Student Program Reflection (n=13)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Never %</th>
<th>Seldom %</th>
<th>Occasionally %</th>
<th>Frequently %</th>
<th>Always %</th>
</tr>
</thead>
<tbody>
<tr>
<td>The program was well organized.</td>
<td>4.50</td>
<td>7.7</td>
<td>0.0</td>
<td>0.0</td>
<td>15.4</td>
<td>69.2</td>
</tr>
<tr>
<td>The instructors were well-prepared.</td>
<td>4.42</td>
<td>7.7</td>
<td>0.0</td>
<td>23.1</td>
<td>0.0</td>
<td>61.5</td>
</tr>
<tr>
<td>Program content was at an appropriate level of difficulty.</td>
<td>4.25</td>
<td>0.0</td>
<td>7.7</td>
<td>0.0</td>
<td>46.2</td>
<td>38.5</td>
</tr>
<tr>
<td>The learning objectives were clear.</td>
<td>4.08</td>
<td>0.0</td>
<td>15.4</td>
<td>0.0</td>
<td>38.5</td>
<td>38.5</td>
</tr>
<tr>
<td>I engaged in class discussion throughout the program.</td>
<td>3.67</td>
<td>7.7</td>
<td>0.0</td>
<td>23.1</td>
<td>46.2</td>
<td>15.4</td>
</tr>
</tbody>
</table>

Note: Student responses may not add up to 100 percent. Missing data is not included in this representation of student responses. Reported mean scores reflect the following values for each response category:
1: Never 2: Seldom 3: Occasionally 4: Frequently 5: Always

Table 4: Student Reflection on Program Instructors (n=13)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Strongly Disagree %</th>
<th>Disagree %</th>
<th>Neutral %</th>
<th>Agree %</th>
<th>Strongly Agree %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, I enjoyed the instructors for this summer program.</td>
<td>4.42</td>
<td>0.0</td>
<td>0.0</td>
<td>15.4</td>
<td>23.1</td>
<td>53.8</td>
</tr>
<tr>
<td>The instructors clearly presented program concepts.</td>
<td>4.33</td>
<td>0.0</td>
<td>0.0</td>
<td>15.4</td>
<td>30.8</td>
<td>46.2</td>
</tr>
<tr>
<td>The instructors involved the students in discussion.</td>
<td>4.08</td>
<td>7.7</td>
<td>0.0</td>
<td>7.7</td>
<td>38.5</td>
<td>38.5</td>
</tr>
<tr>
<td>The instructors clearly communicated program goals.</td>
<td>4.08</td>
<td>0.0</td>
<td>7.7</td>
<td>15.4</td>
<td>30.8</td>
<td>38.5</td>
</tr>
<tr>
<td>Overall, the instructors for this summer program were boring.</td>
<td>1.58</td>
<td>46.2</td>
<td>38.5</td>
<td>7.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Note: Student responses may not add up to 100 percent. Missing data is not included in this representation of student responses. Reported mean scores reflect the following values for each response category:
1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

Parent

A total of six parents responded to our online parent survey, yielding a response rate of 46%. All of the parents stated that their children were “inspired by this camp experience.” Following are a couple of example quotes by parents:

“[The program was] a vision to a future career”
“He loved being the CEO of his own airline and touring both the airport and museum”

The majority of parents (83.3 percent) stated that the summer program seemed to increase their child’s interest in science. One parent reported that:

“[I noticed this change in interest during] the conversations in the car on the way home from camp everyday”

The majority of parents (66.7%) stated that the program exceeded their expectations and they also felt that the camp exceeded their child’s expectations (60.0%). Overall, the responses to the parent survey indicate that participating students’ parents were also satisfied with the overall program experience.

Conclusions

The success of this camp can be attributed to two factors. First, this camp was centered on the use of software that had been used and refined various times before this camp. Being familiar with the software and piloting it on students in the prior summer allowed for seamless use of during this camp. Second, the efforts put in by a diverse group of individuals who helped educate the students on a broad range of topics associated with the airline industry greatly contributed to the camp’s success. By engaging a large range of topics and incorporating various activities and two field trips, students’ engagement level was kept high throughout the week. In the future, incorporating guest lectures from individuals who work in the industry would give students more exposure to the types of jobs they could pursue within the industry. It might also be helpful to market the camp in a different light, as an opportunity to explore many facets of the industry, as the camp didn’t solely focus on engineering as initially planned. Overall, this was a successful camp that will likely be refined and reused in future summer programs hosted at Georgia Tech.

Acknowledgements

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