Exploring Engineering Day

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Abstract

Each year, approximately 65 teams of 9-14 year-old elementary and secondary school students from throughout Virginia qualify to participate in the First Lego League (FLL) state tournament held at Virginia Tech. Teams typically arrive in Blacksburg the day before the competition. Although in past years teams have had the opportunity to tour facilities at Virginia Tech during their stay, there has long been a desire among the coaches and mentors to have the students participate in an activity more directly related to engineering. This December the Virginia Tech student section of the Society of Women Engineers (VT-SWE) provided the opportunity for the students to participate in a hands-on engineering program, Exploring Engineering Day.

Attendance at the Exploring Engineering Day was expected to be more than 320, with 15 SWE members and an additional 10 non-SWE members as volunteers. Over the course of the afternoon event participants visited four engineering activity stations, highlighting Aerospace Engineering, Civil Engineering, Computer Engineering, and Ocean Engineering, emphasizing the major engineering concepts of problem solving and teamwork. Exploring Engineering Day aimed to promote engineering as a stimulating, exciting, and rewarding field of study as well as to dispel the idea that engineers must wear hard hats or work on trains. It was also our goal to have the children see that engineering is not just for men but to show the young women that they too can pursue a career in the fields in engineering, math, and science.

Previous experience has indicated that educational outreach events such as Exploring Engineering day benefit not only the participants but also the volunteers involved in the project. This paper provides details of the organization, planning and implementation of the event, as well as an analysis of the benefits to the participants, volunteers, and the university.

Introduction

First Lego League (FLL)[1] is an international program for 9-14 year olds designed to foster a positive view of science and technology through creative problem solving in a team-based competition. More than 45,000 students worldwide participated in the program in 2003. In 2004, in the state of Virginia alone, there were over 200 registered teams of up to ten children

each. The FLL program seems to be an effective way to get all children interested in science and technology. In Virginia, the FLL participants come from diverse backgrounds and regions of the state. For a number of participants, the FLL program is the only opportunity to be exposed to the world of robotics and the associated professions. A number of the participants are members of underrepresented populations in these professions, including women and minorities. One hope of the FLL program is to encourage a more diverse technical population.

Following regional competitions held across the state, 60+ teams are invited to participate in the Virginia State competition. Since teams must travel as much as six to seven hours to reach the tournament site, many teams arrive the day before the competition. Coaches and mentors traveling with the team are anxious to find activities to keep the students occupied prior to the tournament. Since the state competition has been held in Blacksburg, home of Virginia Tech (VT), for each of the four years the FLL program has existed in Virginia, it is natural to take advantage of the strong presence of the VT College of Engineering and offer the FLL participants an opportunity to learn more about engineering. For the past four years FLL participants have had the opportunity to visit the WARELab[2], a facility where the student engineering competition teams have space to work on their projects, and/or attend a talk on robotics in engineering delivered by Dr. Charles Reinholtz, a faculty member in the Mechanical Engineering Department. These activities are well-liked and have had strong participation each year, however, as a number of teams return to the state competition each year, new experiences were desired.

For the 2003 State Tournament, FLL participants were invited to participate in a 30-minute hands-on activity focusing on Mars, as the challenge for the FLL competition was "Mission to Mars." Although this program was proposed at the last moment, and was relatively informal, it turned out to be extremely popular, with more than 250 people attending. As a result, in 2004, the student section of the Society of Women Engineers (SWE) at Virginia Tech was asked to provide a formal hands-on engineering program, expanding on the one activity offered in 2003. SWE was approached for this undertaking mainly because for the past eight years it has run a well-established outreach program entitled "Girl Scout Exploring Engineering Day." FLL Exploring Engineering Day was modeled after this event.

The first FLL Exploring Engineering Day was held the day before the 2004 Virginia State FLL tournament. FLL participants were able to participate in hands-on engineering activities focusing on Aerospace Engineering, Civil Engineering, Computer Engineering, and Ocean Engineering. In addition, as in previous years, Dr. Reinholtz' presentation on robotics and engineering and tours of the WARELab were offered. Descriptions of the activities and details of the organization and planning of the event are provided in the sections that follow.

Activity Descriptions

The activities for the event were chosen from activities previously used for VT-SWE's long-standing "Girl Scouts Exploring Engineering Day." This provided us a set of established activities that had already been tested with a similar audience and were known to be effective. We selected the activities to reflect our budget, a need for simplicity in set-up (because of

concerns regarding a potential lack of volunteers), and our wish to show a wide selection of engineering disciplines to the participants. We decided to have the participants build foam gliders for Aerospace Engineering, construct gumdrop and marshmallow toothpick structures for Civil Engineering, "program" their peers in human programming for Computer Engineering, and create boats out of recyclable materials for Ocean Engineering.

The Aerospace Engineering session (foam gliders) focused on discussing what aerospace engineers do for a living, the general parts of an airplane, and concepts of flight. The activity itself was very simple to put together and required few materials. Participants took a normal foam plate, traced out a template from a piece of paper, cut out the parts, and then assembled a glider. Each person was provided a few pennies to add weight to the design. The children were then allowed to step into the (empty) hallway and test-fly their designs. They were encouraged to make alterations (such as cutting a flap into the wings, or placing pennies in different positions on the glider) to discover how the changes affect the flight of the plane. Thus, instead of hearing a lecture about Aerospace Engineering, the participants were able to take on the role of an "Aerospace Engineer" by experimenting with design changes and finding the optimal configuration for their glider.

We also offered a more traditional Civil Engineering activity in which the students had to build a structure from gumdrops, marshmallows, and toothpicks. The purpose was to give the students an understanding of jobs that civil engineers might have and the basic concepts behind forces in structures. After a brief introduction to the concepts of tension and compression, the students were asked to get into small groups and were provided a bag with approximately one hundred toothpicks, fifty marshmallows, and ten gumdrops. They were then told to design a structure with a number of different constraints using the materials they were given. The structures were to be as tall as possible, have a floor at the top to support added weight (nuts and bolts) and hold as much weight as possible. Through this activity the students learned that engineers must work within a number of restrictions on the type and amount of materials. The activity also encouraged teamwork and planning.

The Computer Engineering activity, which involved very few materials and an extremely simple set-up, was to explain what computer engineers do and emphasize the importance of logical sequential programming. After a demonstration in which the activity leader illustrated a number of possible ways to make a mistake in the "algorithm" for making a peanut butter and jelly sandwich, the students were put into groups and sent to one of the three stations in the room. Each station involved having one of the participants act as a "human computer" while his or her teammates tried to instruct him or her to do a certain task. At one station a small maze was constructed out of desks and the group tried to verbally guide a blindfolded peer through it safely. At another station the students attempted to instruct a teammate in how to draw a "VT" without the teammate knowing what was being described. The third activity was instructing a teammate in how to build a structure out of Legos. The groups rotated through the stations during the activity period. Each station clearly emphasized the importance of precision and a need to avoid assumptions when writing an algorithm, as well as general concepts of problem solving and teamwork.

The recyclable boats activity for Ocean Engineering also had a low operating cost and was fairly straightforward in implementation. Its major focus was showing what ocean engineers do and describing the concept of buoyancy. The session included a demonstration in which a ball of clay was dropped into water and promptly sank. When the clay was then molded into the shape of a boat so that it could displace more water, it floated. The students were formed into groups and were given a bag of materials, which included bottles, cardboard, cans, string, and plastic. As a group they were given the task of making a boat that would hold as many full soda cans as possible. The teams could earn extra materials for their boat by coming up with an engineering fact. In the center of each room where the activity was held, a full kiddie pool and several soda cans were available for the students to use to test their design. At the end of the session, each group went to the pool and showed the activity leader how many cans they could keep out of the water. This particular activity demonstrated a less familiar type of engineering and encouraged important aspects of teamwork and experimentation that are central to engineering.

Planning Information and Scheduling

Initial planning for the FLL Exploring Engineering event focused on an anticipated participation of 320 students and parents. This number could be accommodated using eight classrooms, two for each of the four activities, each capable of holding forty students. Because there would be over 600 students participating in the FLL Tournament, we decided to be prepared to expand the capacity to 480 participants very quickly. This entailed having supplies ready to expand to three rooms of each of the four activities instead of the planned two rooms. Participants were not asked to pre-register for the event as we were concerned that requiring pre-registration might discourage or prevent some teams from participating. Teams did not learn of their qualification for the State Tournament until two or three weeks prior the event, and as Thanksgiving fell during those two or three weeks, contact with all of the teams was very difficult and unreliable. While supplies were not an issue, volunteers were, and finding enough people willing to teach in the additional four classrooms proved to be very hard. The final plan was to recruit people the day of the event if necessary. As there were not expected to be as many participants in the first sessions, the potential instructors would have a chance to learn the program from one of the original eight before they had to teach it. Fortunately, this was not necessary.

FLL Exploring Engineering Day was planned to span a four hour block of time in the afternoon preceding the FLL tournament. To handle the anticipated 320 participants, the event was organized into eight tracks. Each track would to go through each of the four hands-on engineering activities discussed earlier, spending 50 minutes in each one, and having 10 minutes for travel to the next activity while volunteers prepared for the next group. The tracks were designated by color, Maroon or Orange, and number, 1, 2, 3 or 4. All of the maroon groups went through one set of four classrooms, traveling in a circle, with the orange tracks similarly using the other set of four classrooms. As students and adults arrived, they were divided into groups of roughly 40 participants. This was done on a first-come first-serve basis by having the participants sign up for one of the four Maroon tracks when they arrived. Once a track had 40 people signed up, it was to be considered full, and no one else would be added to it. The additional four Orange tracks were opened up and filled, one at a time, as needed after the Maroon tracks had been filled. A guide was assigned to each track, to lead the participants from

room to room and to act as an additional classroom volunteer for the individual activities. The guide also helped identify the tracks for participants that left during the event to participate in other activities, and wished to return.

Teams were allowed to start signing up for tracks 30 minutes prior to the start of the first activity. Each activity period started on the hour. After signing in, each participant was given an information sheet with facts about the four engineering professions that we would be addressing as well as a survey to be completed at the end of the event and a College of Engineering pencil. In addition to the four hands-on activities that have been discussed, there were two additional activities offered. As in the past years, Dr. Charles Reinholtz presented a talk on robotics and engineering, and the students were offered a tour of the Virginia Tech WARELab. While these two activities were not officially scheduled into the tracks, participants were allowed to leave during various activities to participate in these, and had the option to return for later activities.

Volunteers

Approximately 30+ volunteers were needed to assist both before and during the event. The main tasks requiring volunteers prior to the day of the program were supply collection and the development of handouts on the four types of engineering to give to participants. Supply collection was mostly performed by the coordinators of the event; however, several SWE members donated recyclable materials. A member of the SWE section's Educational Outreach Committee designed the engineering handouts.

At the actual event, four volunteer positions were available: activity leader, activity assistant, guide, and registration. To attract people to fill these roles, emails were sent over the SWE listserv, the Tau Beta Pi (an Engineering Honor Society) listserv, and other campus-wide engineering listservs. Announcements were also made at meetings of several organizations, including SWE. People were encouraged to pass the information on to friends and it was made very clear that we had positions even for those who were not engineers. We highlighted the benefits of fulfillment of required volunteering hours for other organizations, working with children, enjoyment, and free snacks. Interested VT students were instructed to email the event coordinator and indicate their preferred position(s). The activity leaders for each classroom were asked to arrive an hour before registration began with the rest of the volunteers arriving 15 minutes before registration opened.

Results and Evaluation

While the official attendance at the SWE sponsored FLL Exploring Engineering Day event was 299 participants (both students and adults), there were actually estimated to be 450 participants. A number of teams only participated in the talk and WARELab tours and thus never registered. In addition, some teams had additional students arrive later, and simply join their teammates without registering. Each registered participant was asked to anonymously complete an event survey and evaluation form and turn it in when they left the event. Completed surveys were received from 102 student participants, 69 adult participants, and 26 volunteers.

The student survey and evaluation requested information on age, gender, ethnicity, favorite subjects in school, prior exposure to First Lego League, Virginia Tech, and engineering, and how well the participant liked the various activities. The students were also asked if they thought they would like to be an engineer. Of the students responding to the survey, 60% were participating in the First Lego League Program for the first time. Sixty three percent of the student participants responding had visited the Virginia Tech campus previously. The student response to the four engineering activities was very favorable. As seen in Figures 1 and 2, the students enjoyed all six activities with the Civil Engineering activity being the favorite.

Female participants enjoyed the Computer Engineering activity, where communication skills were very important, more than the male students, while enjoying the Aerospace Engineering activity, where the experimentation process was used, less than the male students. For the two teamwork activities, Civil Engineering and Ocean Engineering, the male and female results were similar. The female students liked the Robotics talk slightly more than the male students, while the male students enjoyed the tour of the WARELab more than the females. Based on feedback from the survey the day's events increased the participants' level of interest in engineering as seen in Figure 3, with a larger increase in interest among female participants compared to the male participants. Overall the student participants gave the event a grade of 3.46/4.0.

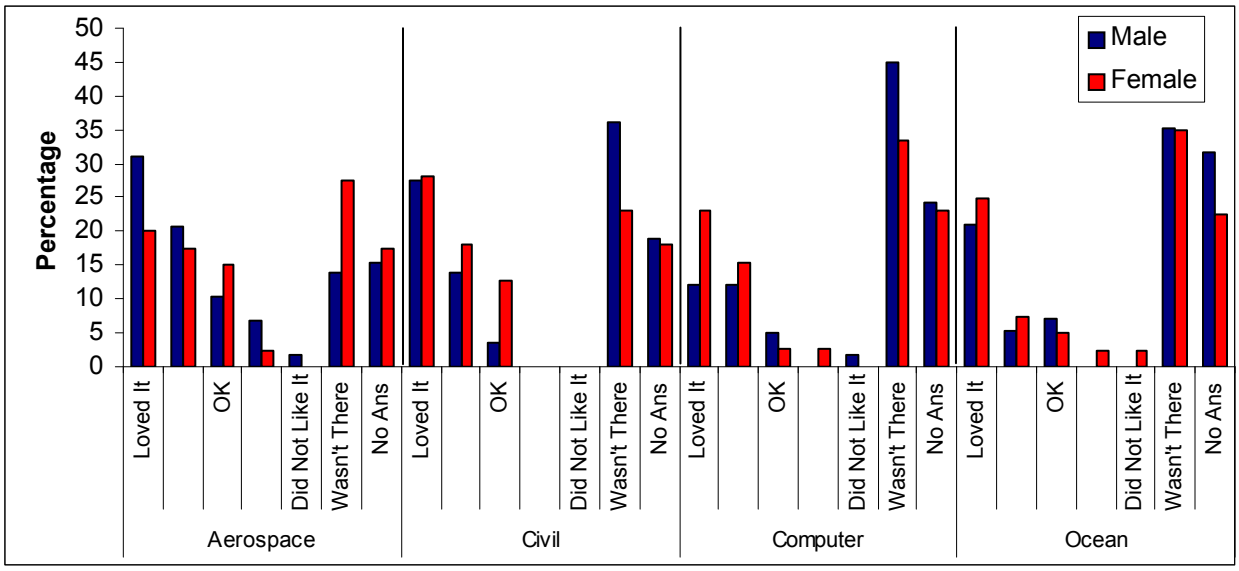

Figure 1: Student Ratings of Four Hands-On Engineering Activities. Participants were asked to rate each activity on a 5 point scale where 1 was "Loved it" and 5 was "Did Not Like it".

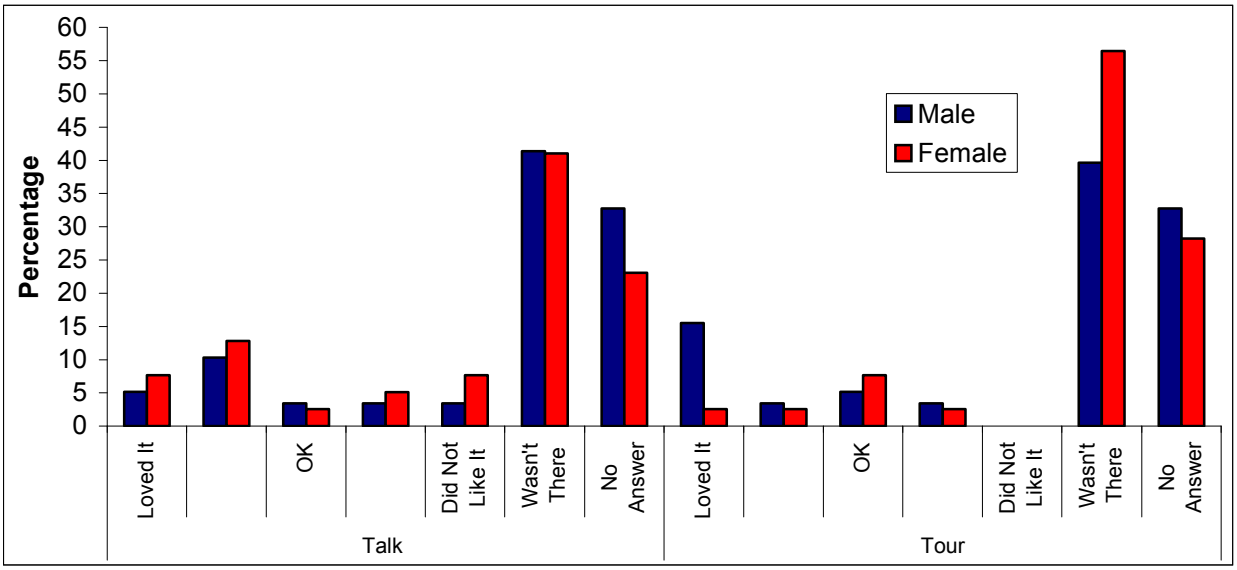

Figure 2: Student Ratings of Robotics Talk and WARELab Tour. Participants were asked to rate each activity on a 5 point scale where 1 was "Loved it" and 5 was "Did Not Like it".

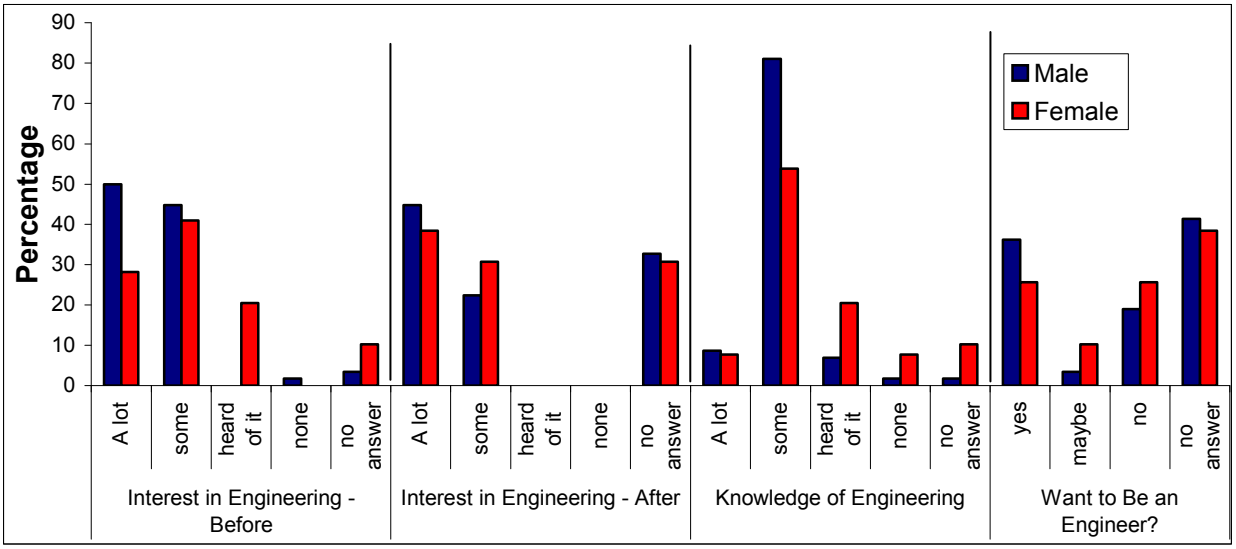

Figure 3: Student Response Survey questions on Interest and Knowledge of Engineering.

Question 1: Before today how interesting did you think engineering was?
Question 2: How interesting do you think engineering is now (after the event)?
Question 3: Before today, how much did you know about engineering?
Question 4: Do you think you want to be an engineer?

The adult survey and evaluation requested similar information to that requested of the students. Of the adults responding, only 40% had visited Virginia Tech previously. Eighty four percent of the adult respondents knew at least some about engineering before the day and 19% were trained as engineers. The adults enjoyed all the activities and as with the student participants liked the civil engineering activity the best. As seen in Figures 4 - 5, the male adult participants rated the Civil Engineering activity higher than the females, while the two groups rated the Computer Engineering activity similarly (overall having the same average rating). The Aerospace activity also received very similar ratings for both genders, and the female adult participants rated the Ocean Engineering activity much higher then the male participants. The Robotics Talk and the Tour were rated similarly by the male and female adult participants. Eighty one percent of the adult participants felt that the children understood the concepts presented well (17% did not respond to this question). The two most prevalent comments received from the adult participants were that the sessions were too long and that it was great to see women role models in engineering. Overall the adult participants scored the event 3.45/4.0.

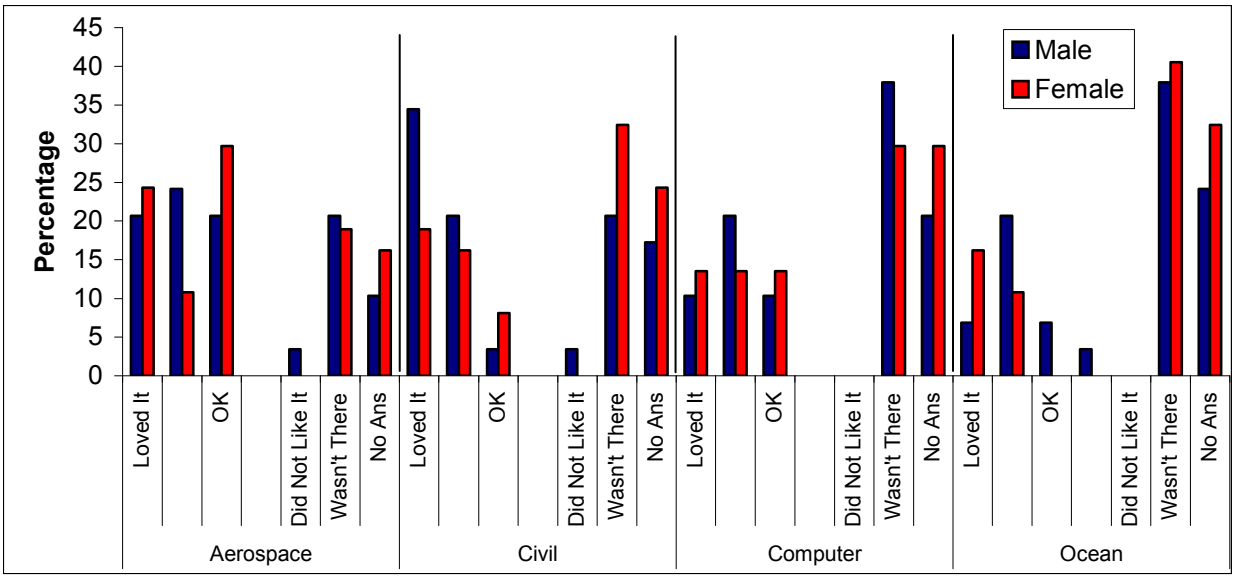

Figure 4: Adult Participant ratings of Activities. Participants were asked to rate each activity on a 5 point scale where 1 was "Loved it" and 5 was "Did Not Like it".

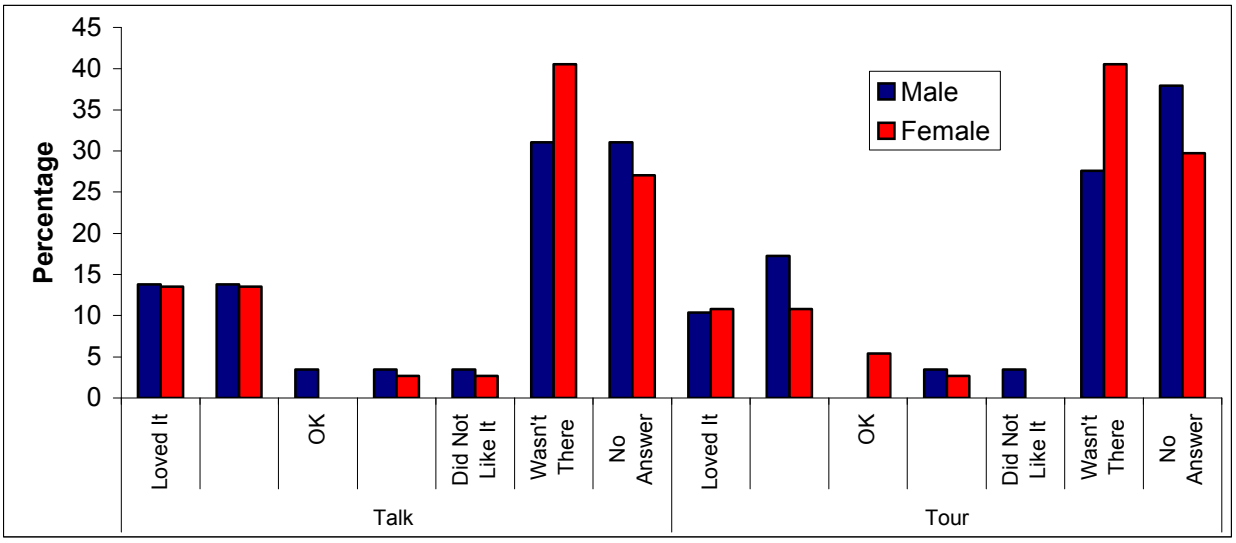

Figure 5: Adult Participant Ratings of Robotics Talk and WARELab Tour. Participants were asked to rate each activity on a 5 point scale where 1 was "Loved it" and 5 was "Did Not Like it".

The volunteer survey and evaluation focused on why the volunteer had participated. Twenty-six of the twenty-seven volunteers on the day of the event completed the survey. The volunteers were mainly engineers, ranging from freshmen to seniors. Forty six percent of the volunteers were female. All felt that the youth participants have a better understanding of engineering after events like this, and 77% felt that the youth participants are more likely to become engineers after an event like this. Thirty-eight percent had attended events like this as youth, and 50% had volunteered to help with events like this before.

Lessons Learned

While our first attempt with an event this large was successful, a number of improvements could be made in future years. Comments received indicate that the activity sessions were simply too long. Participants had traveled up to six hours that day, and to sit in engineering activities for another four or more hours was too much. In addition, the fifty-minute sessions exceed the attention span of most children.

Another change that would be made to the schedule would be to not allow participants to join sessions already in progress. Although this prevented large numbers of participants from having to wait up to an hour for the next activity to start, it was a detriment to the sessions, as the activity leaders and assistants had to continuously help the new people catch up to the rest of the class. With shorter classes, having the participants wait until the start of the next activity would not be a large inconvenience.

Another improvement to the event would be to schedule the robotics presentation and WARELab tours into the tracks. Many of the participants were upset to find out that they would have to choose one activity or the other and would have preferred to be able to attend everything.

As expected and mentioned in comments from both volunteers and participants, pre-registration for the event would help with organization. However, the desire to make this event available to as many participants as possible and issues with the timing of qualifying for the state tournament make this change unlikely for future pre-tournament events.

Summary

FLL Exploring Engineering Day attempted to present engineering as a wide-ranging, stimulating and rewarding field of study, and to counter the myths regarding what an engineer does for a living. During each session, the activity leaders defined the type of engineering and highlighted the types of jobs one might have in that particular discipline. Thus, as a result of attending at least one activity of event, the participants were exposed to a specific area of engineering that did not involve the stereotypical view of an engineer as a construction worker, train driver or mechanic. Because the activities reflected a wide assortment of engineering topics, those who attended multiple sessions were able to see the diversity of specializations within engineering. Further, by encouraging important engineering principles such as teamwork, creative problem solving, and experimentation, the children were able to associate engineering with something besides the more technical mathematics that gives the profession a "tedious" and "less stimulating" image. Both during the event, and the next day at the State Tournament, a number of the participants, student and adult alike, commented that they had enjoyed the event and that they were looking forward to next year.

One of the other core goals of the event was to demonstrate how engineering is a field open to all types of people wishing to pursue it, countering the mentality that such a career is only suitable for men. This was accomplished mainly by example. Six of the eight activity leaders – the role of authority in each activity – were female. By seeing women in leadership positions speaking and teaching engineering the children learn that the profession is not restricted to men. A number of the adults commented that this was a great opportunity to see female and minority role models in the field of engineering.

In addition to the benefits to the participants, there were also a number of benefits to the volunteers and to the university. Volunteers were able to get needed volunteering hours or recognition for other organizations and given the opportunity to share their excitement and knowledge with children. In addition, a number of them felt that the experience helped affirm their choice of major. It was also noted that programs like this benefit the university, not only by helping to recruit the next generation of students, but also by giving the university improved community relations.

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Biographic Data

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