Engineering Alive: A Summer Engineering Camp for Middle School Students and Teachers
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Abstract

Middle school is a crucial time for kids deciding on possible career paths. Especially in the state of North Carolina, kids are expected to have their career decisions ready by the time they enter high school, so sixth, seventh, and eighth grade are critical times for contact with the fields of engineering from a recruiting perspective. This paper describes a summer camp held in conjunction with Centennial Middle School in Wake County, North Carolina. The first week of the camp consisted of a teacher week, where teachers came to NC State University College of Engineering to work side by side with engineering faculty to plan and test camp activities. Additional enhancement experiences were incorporated to help provide ideas and enrichment for the teachers in other areas covered by their science, math and social studies goals. One long-term objective was that the teachers use some of the material they learned to change the way they teach various subjects during the school year. An evaluation was done six weeks after the camp.

During the second week of the camp, fifty middle school students came to the campus of Centennial Middle School. The camp was co-led by the middle school teachers, engineering faculty and some engineering students. Areas covered by the camp activities included generic problem solving, aerospace engineering (designing and building an airplane to fly), civil engineering (testing various building materials for earthquake resistance), and chemical engineering (studying the components and manufacturing processes of various consumer products—like diapers and cookies). Various competitions were integrated throughout the camp activities and an award ceremony was held at the end of each day.

Creative recruiting was used to ensure a diverse student population, but gender and ethnicity were not taken into account during the application process. The student population was one-third female and about one half underrepresented minorities. Student and parent evaluations were 100% positive.

Introduction

Middle school has become the crucial time to connect with students about their future career choices. In many school districts, students are required to choose a “career path” when entering high school. While it is not impossible to change course midstream, it can be difficult. Therefore, middle school is where colleges must now concentrate their recruitment and outreach efforts in grades six through eight.
Middle schoolers are inherently curious about things, and that innate curiosity and willingness to learn makes this age a particularly effective one to plant seeds of experience. In Wake County, North Carolina, the experience of typical middle school students in math and science varies widely. Yet, we know from surveys across the country that middle school students need more science and problem solving instruction\(^1\). Outreach efforts by the North Carolina State University (NCSU) College of Engineering have included “career” and “science” day presentations giving a high level view of opportunities in engineering fields, but rarely do the students have the opportunity to solve problems using math and science in a “hands-on, minds-on” manner.

The idea proposed to Alcoa involved grant funding to hire middle school teachers to work with College of Engineering faculty and develop ways to integrate engineering problem solving methods into the North Carolina Standard Course of Study curriculum strands in math and science. Teachers would be paid an amount enticing enough to encourage them to forgo two of their short six-week summer. The first week, the teachers and COE faculty met at NCSU to learn about engineering, technology, exemplary materials and the curriculum strands to be covered in each grade. Lessons and activities were the expected outcome. Then, the following week, 50 middle school students were brought in to test out the planned activities. At the end of the student week, parents were invited to the engineering design competition that capped the week’s activities. Teachers were paid a significant stipend for participating in the camp, but university faculty time was donated as an in-kind contribution. All university students that participated were also paid a stipend.

Each of the faculty participants has a long history of working in the field of K-12 outreach. In addition, they have lengthy experience in design and implementation of programs for encouragement of underrepresented groups in science, technology, engineering and math careers. Middle school was felt to be a particularly vulnerable time for these groups in their relationship to STEM subjects\(^2\).

Prior to implementation of the camp, the College of Engineering had established a close working relationship with Wake County Public Schools in general and Centennial Campus Middle School in particular. University students and faculty had spent many hours working with teachers and administrators with various projects, including a National Science Foundation sponsored GK-12 grant\(^3\). This relationship made implementation of the camp very easy and has made it easy to repeat the camp the next summer.

Session Overview

The teacher/faculty week began one week after school had ended for the year. This gave the teachers time to wrap up their responsibilities for the school, but not so much time that it was difficult to get back into routine! Six teachers were hired, all from Centennial Campus Middle School, a Wake County Public School System/North Carolina State University Magnet School. The school, now in its second year, is a model middle school; i.e. it uses the connections with the university to augment its instructional offerings while maintaining a small (600) student population. The students are on teams of 50, with two teachers per team, and the school day runs on a block schedule. Centennial’s block schedule keeps the students with their team teachers for

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four periods a day, with the other two periods spent in any of a limited number of physical education, visual art, technology or performing arts “exploratory” classes. During the “block” period, the two-teacher team is responsible for covering the core subjects of mathematics, language arts, social studies and science. Time spent on subject is left to the discretion of the teachers, and curriculum integration is a key focus of this campus. Classrooms are heterogeneously mixed, and academic differentiation takes place through varied assignments in all subjects save mathematics, where the students are segregated into higher, middle and lower ability groups for that period. The characteristics of this school, primarily its partnership with NCSU and curriculum integration expectations, that made it a natural candidate for the inaugural Alcoa camp. In addition, the school already had a relationship with the College of Engineering through a National Science Foundation GK-12 grant.

The teaching staff was composed of two sixth grade, one seventh grade, and two eighth grade math/science teachers. The school’s curriculum integration specialist was also on staff. Dr. Laura Bottomley, Director of Outreach and the Women in Engineering Program, and Ms. Liz Parry, a consultant for the college of engineering on K-12 science and assistant director of outreach, represented NCSU. Forty-eight students in grades 6-8 enrolled in the camp, and attendance remained constant throughout the week. The camp ran from 9 am – 3 pm Monday through Friday. The teacher week was held on the campus of North Carolina State University, and Centennial Campus Middle School hosted the student week.

Week One: Teacher Week

The first week’s objectives were many but they were primarily to:

- plan and test the activities for the student week,
- increase the comfort level of the teachers when teaching science,
- illustrate through example how engineering is a natural integrator and an effective problem solving approach,
- enhance the teachers’ ability to integrate math and science into other core subject areas and
- widen the sphere of knowledge of cutting edge research and technology by exposing the teachers to university research.

All activities were planned to teach and reinforce the application of engineering concepts and principles of problem solving to middle school curriculum strands in math and science. The first day was spent introducing the teachers to the concept of logical problem solving. Using team activities, the teachers were shown how engineers are taught to approach problems. Indeed, “problem” was redefined in these sessions, as any situation that requires a logical approach to solve, and one that had parameters to take into consideration for any solution. Small group sessions involved discussions about each professional’s early memories of math and/or science, and each was asked to identify early influences, positive and negative, in those subjects. It was interesting to note that almost all the participants cited a teacher’s attitude in middle and high school as “very important” in determining an aptitude and/or interest in science or math. In addition, parental attitudes and expectations were of high importance. The remainder of the day
was spent in mapping out the math/science curriculum strands by grade level, and tying social studies areas of concentration to these.

Throughout the week, the teachers, who had been given access to the university computer network, were given time to research ideas and topics. Surprisingly, their school had suffered under “start up” woes and technology is only now prevalent in the building. Time, of course, is always an issue as well. The teachers appreciated being given time to research lessons and lesson ideas, and to do so on a fast network. In addition, “field” trips to the wind tunnel, the nuclear reactor and the electron microscopy lab gave them glimpses into cutting edge technology and research.

Days two through four were spent in specific fields of engineering. The NCSU faculty had decided to concentrate on aerospace, civil and chemical engineering. One entire day was dedicated to each, and the schedule was similar. In each field, the teachers worked with a professor and students from that discipline to obtain background information, develop a project for the students to complete, and devise ways throughout the day to educate the students about that specialty area. The teachers were given ample opportunity to question the discipline’s experts to gain confidence in their content knowledge. Each project was built and weak areas noted and changed to accommodate the middle school student.

The last day of the teacher week was spent developing several engineering design contests for the students to participate in to close the student week. The intent was to have three projects for each student to build, individually or in a team. The projects had design, material and cost parameters, and the testing procedure was given at the beginning. During the teacher week, the teachers developed the projects and built them to insure the young teens could do so.

The teachers seemed to really enjoy trading professional knowledge with the science, math, technology and engineering professionals they worked with, and were eager to apply their knowledge in the classroom. The teacher evaluations of week one were nearly 100% positive, with the only area of improvement being the exercise of reviewing the North Carolina Standard Course of Study.

Week Two: Student Week

The second week we put our plans into action. We had 50 participants representing a wide variety of ethnic and socioeconomic backgrounds. Eighteen (36%) were female. (Targeted recruiting of female students was done in each of the sixth and seventh grade classrooms in the school, but no preference was given in the application process.) Approximately 20% of the students received scholarships to attend the camp. This portion of the camp was held at the Centennial Campus Middle School campus.

The first day concentrated on teams and helping the students understand whom engineers are and what they do through team building exercises and a presentation on different engineering disciplines. In addition, we kicked off a project for the week, asking students to design a product of the future and prepare an exhibit to be displayed on design day. We closed with an Internet
scavenger hunt, utilizing this time to help the students understand better search protocols and Internet usage.

Tuesday was Chemical Engineering day. Through an interactive presentation, students were introduced to the world of the chemical engineer. Consumer science mixed with chemical engineering to give our students real-life examples of how engineers work in the everyday world. The students were introduced to chemical engineering through an interactive discussion of consumer products and the chemical engineer’s role in developing and producing them. Hands on activities included a team cookie baking exercise, a disposable diaper absorption lab, and an experiment testing the efficacy of various stomach acid relievers.

On Wednesday, the students concentrated on Aerospace Engineering. Two graduate students spent the day at the camp, giving the students background information about how things fly. Then, the rest of the day was spent building a complicated motor driven plane out of balsa wood, which was tested at day’s end. This was a frustrating experience for many of the students, as their designs did not hold up as well as they had hoped! We used this opportunity to reinforce the concept of failure analysis, and it’s importance to engineers.

Civil Engineering was the order of the day on Thursday. The students began by breaking up into teams, and preparing a “foundation” of Jell-O or plaster for a building project. Next, we took the group to the Constructive Facilities Testing Facility on NC State University’s campus, where they learned about foundation construction and the engineering behind building. The afternoon was spent on building towers on different foundations, using materials such as straws, coffee stirrers, toothpicks, gumdrops, marshmallows and bread balls. An “earthquake” test was held at the end of the day to test each team’s best building practices.

On Friday, the focus was on applying the engineering principles learned during the week. The morning was spent in teams rotating through three design centers: design and build a marshmallow shooting catapult, design and build a “space platform” to hold an unabridged dictionary, and design and build a boat or a car to compete a race the fastest. In addition, the student’s projects were displayed in the hallway around the gathering area. After lunch, nearly 90% of the parents showed up to watch the design competitions and close the week.

The structure of each day was very similar, and we began and ended each day the same way. The first thing each morning was the schedule overview, and a discussion of the scientist or engineer of the day. The students were given College of Engineering lanyards and on the first day, designed nametags to hang from them. Each day, the last fifteen minutes were spent as a large group, going over items put in the issue bin during the day and handing out the awards earned that day. We gave awards for teamwork, attitude, leadership and effort. Any staff member who noticed exemplary action throughout the day could nominate students for an award. The awards consisted of small pins that the students attached to their lanyard straps. At the end of the week, all participants received the Wolfpack award pin. These award ceremonies turned out to be a highlight of the week for many students.

Evaluations
Teacher comments were very positive overall. They really appreciated the opportunities they had during the teacher week, such as previewing exemplary materials, the field trips to the university’s research facilities, testing and analyzing the activities, computer time and access, helping to plan this new approach to their curriculum and (surprisingly enough!) having time for lunch! We asked them the following questions for the student week evaluation:

- What went differently from your expectations? (Nothing, went more smoothly, more fun than I thought it would be)
- What would you say went particularly well? (Contests were great, activities, student enthusiasm)
- What didn’t work well? (Planes difficult, field trip could have had more action)
- Would you choose to participate in something like this again? (Definitely—unanimously)

Student comments were equally effusive. The students liked learning about engineering, and commented that the activities working with “cool” teachers and learning about engineering were what they liked best. The trip to the construction facility was liked least, but in all fairness, their testing schedule had altered and the students did not get to see actual testing after all, so this came as no surprise! Students said they would change little about future camps, except to make them longer! Overall, 85% of the students rated the camp experience as “Excellent” and the remaining 15% rated it as “Good”.

Parents welcomed both the opportunity for their children to learn more about engineering and the offering of a day camp for middle school aged children. All parents reported their children talking about camp in a positive way each evening at home. When asked to rate, on a scale of 1-5 with 5 being the highest, their interpretation of how much their kids enjoyed the camp, the average rating was 4.93. Many added relevant comments, such as:

- “She wished it was longer than one week”
- “Each day she tells me about the different activities…it was really cool”
- “They made airplanes and he demonstrated his inaugural flight for the family”
- “He has told us how cool it was and how much he liked his teachers. He loved the experiments”
- “They have really learned a lot. Each day they told me of their activities. They both seemed to have liked building the airplanes. They were also proud of the pins they earned. They wish the camp was longer than one week.”
- “Fun; a lot of it was interesting; building stuff was cool”
- “Very much enjoyed it; had a lot of fun; something different every day”
- “Lots of fun—interesting hands-on projects—enjoyed learning about how engineers test their designs”

According to the parents, the biggest complaint was that the camp was too short. Finally, we asked them to add any comments THEY had about the experience. These, to us, were the most telling about the parent’s reception to the camp:

- “Great idea for introducing students to engineering career options. Thank you!”
- “Hope this camp is offered next year!”
Summary

The initial Alcoa/NCSU Middle School Engineering camp was a great success. It provided an opportunity for students at a critical time in their academic careers to be exposed to, and experiment with, a profession that many people do not understand. One of our goals was to educate our teachers, students and their parents about the prevalence of engineering in daily life, and to remove some of the mystery about the profession. Judging from the feedback we received, we achieved that goal. Our team of teachers is very interested in continuing this camp and expanding it. Primarily, they spoke of teaching other teachers, from Wake and other NC counties (especially rural areas), how to hold an engineering camp and tie engineering principles and problem solving to their curriculum. New participants could use the model we developed this year, while our local version of the camp could explore some of the other engineering disciplines. The opportunity to increase the public’s knowledge of engineering is great through a camp such as this.

References

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