Using K'NEX to Stimulate Interest in Engineering at a Summer Camp for Middle School Students

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ABSTRACT

For the past two years, the Mercer University School of Engineering and the Office of Undergraduate Admission have jointly sponsored a summer engineering camp for teens. The camp is named ESCAPE (***E***ngineering ***S***ummer ***C***amp ***A***dvocating ***P***rofessions in ***E***ngineering). The ESCAPE program features hands-on activities and is designed for middle school students who excel in science or math. This paper focuses on the use of K'NEX construction sets in the camp's team building and engineering design labs.

INTRODUCTION

A growing number of engineering schools are offering summer engineering camps for middle and high school students. For many schools, the main purpose is to stimulate interest in engineering as a career, as well as to encourage students to take advanced math and science courses in high school. In addition, camps promote school/community awareness and good will.

In the past few years a variety of engineering schools have reported on their successful summer engineering camp programs.

> Florida Atlantic University started a small summer enrichment program for high school students in 1983. The coeducational week long residential program now serves over 100 middle and high school students. [1]

> Holland [2] reports that, in the summer of 1994, Texas A &M first offered GEMS (Girls in Engineering, Math and Science). GEMS is a program for eleven year old girls designed to increase the chance that the participants will eventually follow careers in science engineering and math.

> As part of the TIDEE (Transferable Integrated Design in Engineering Education) program, Tacoma Community College and the University of Washington teamed together in 1995 to offer a two week long summer camp for 20-25 freshman and sophomore high school students. The first week of this program is a day camp; the second week is residential. [3]

> Mills [4] writes about a civil engineering technology class offered as part of Western Kentucky University's two-week long program called "Summer Camp for Academically Talented Junior High School Students".

> Mattmuller [5] describes a three-day summer mini-camp designed to introduce high school

aged women students to the field of electrical engineering technology.

In the summer of 1996, ASU's Women in Applied Science and Engineering (WISE) Program conducted a two-day commuter program consisting of hands-on engineering activities, career information, and team building exercises. [6]

Last year, Worcester Polytechnic Institute held a two week residential engineering summer camp for 30 rising sixth grade girls. [7]

Although each school's approach is different, there are a number of similarities. The schools try to stimulate interest in science, engineering and math. The programs include a residential component, and the typical duration of camp is relatively short (three days to two weeks). All of the camps feature hands-on activities. Many of the more recently developed camps are designed for girls only; however, several camps include boys and girls in common classes. In general, long term consequences of camp attendance have not been reported. However, most of the schools offer anecdotal evidence that their programs are successful in the short run.

MERCER'S ESCAPE PROGRAM

Mercer University's ESCAPE (***E***ngineering ***S***ummer ***C***amp ***A***dvocating ***P***rofessions in ***E***ngineering) program is sponsored by the Mercer University School of Engineering and the Office of Undergraduate Admission. The goals of the camp are to:

- help students become more aware of the field of engineering
- encourage students to enroll in high school math and science courses
- show that engineering design can be fun
- help students develop team skills
- increase students' confidence and self-esteem
- expose students (especially women) to positive role models
- motivate students to consider a career in engineering

Like many of the summer science camps mentioned earlier, ESCAPE is open to girls and boys. Selection is based on the applicant's personal statement, a math or science teacher recommendation, and an evaluation of the applicant's transcript. Each session is designed for approximately fifteen students. Typically, more than half of the applicants are boys. When accepting applicants, we make sure that there are no fewer than four girls per session. Ideally we would like to have an even mix, and we hope to attract more girls in the future.

This year the camp was staffed by three engineering professors (two men, one woman), three engineering students (two women, one man), a high school science teacher, and a high school student (both women).

During the one week long ESCAPE program, campers get a taste of college life; they live in a campus dorm and eat cafeteria food. In 1997 there were two sessions: July 13-18 and July 20-25. The camp featured a variety of activities including team building exercises, science

demonstrations, computer labs, electronics labs, engineering design labs, and athletic activities.

This paper focuses on the use of K'NEX in the team building and engineering design labs. For additional information about the camp, see our web site at http://egrweb.mercer.edu/escape972.

K'NEX ACTIVITIES

One of the most successful features of this year's camp has been the use of the K'NEX construction sets. K'NEX sets consist of color-coded interlocking plastic parts that can be used to build a variety of objects without using tools or fasteners. An advantage of K'NEX is that they are very durable; we expect to use the sets again in next year's camp. A disadvantage is that the sets are relatively expensive. We used K'NEX four times during the week long camp. A supply of four GIANT K'NEX sets and two INTERMEDIATE K'NEX sets was sufficient for the exercises we designed.

Day 1: For the first K'NEX exercise we decided to have the students replicate one of the models shown in the K'NEX manual. We divided the group into teams of six or seven students. We gave each team a GIANT set of K'NEX and told them to build the windmill. In an effort to encourage teamwork, we chose a design that was sufficiently complex that each team member could contribute to the building of the device. By referring to the picture of the device, each team was able to successfully build the windmill within three hours. However, some teams did get discouraged when they couldn't figure out how to construct the device. Occasionally a member of another team volunteered to help a team which was stuck. After building the windmill, most campers were eager to try their own designs.

Building a Windmill

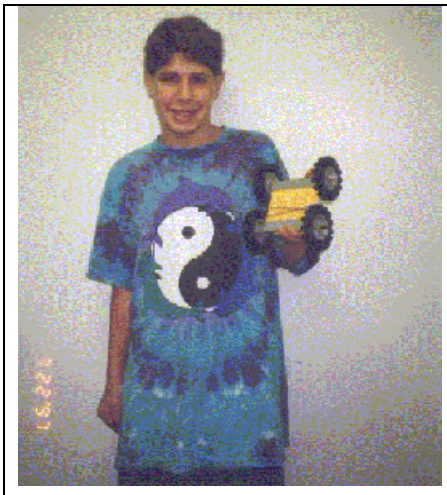
A Job Well Done

Figure 1. K'NEX Activities on Day 1

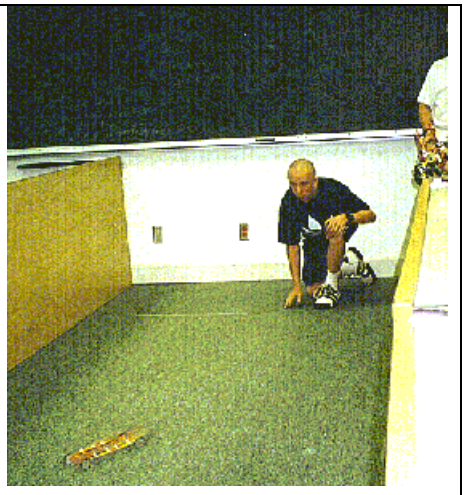
Day 2: The students were given a talk on the nature of gears. Each student was given a small supply of K'NEX and was told to design a device which combined two or more gears. Several students chose to work together and built a more complex gear system. A

number of campers were excited because they were able to build something on their own; however, some campers were bored by this exercise. After building a simple gear system, several campers started to build their own K'NEX cars.

Day 3: Responding to the interest in cars, we developed a lesson in which teams of two students each would design and race their own cars. Each team was given four wheels and a small supply of assorted K'NEX pieces. In order to make the exercise more interesting, as well as to relate the lesson to engineering, the students were given a brief lecture about engineering design. The students were required to develop design criteria before they were allowed to build their cars. After all the cars were built, the campers moved the furniture in the room and set up a racetrack in the room. The teams competed on the basis of the design criteria they developed. Although the campers had fun building the cars, they seemed to enjoy the contest even more.



A winning design



A sleek car

Figure 2. K'NEX Activities on Day 3

Day 4: Many campers wanted more time to work with the K'NEX. We let Day 4 be an unstructured session. Some campers designed and built large vehicles; others replicated designs that were shown in the K'NEX booklet. Several students asked to keep their models to show their parents. Near the end of the session, teams sorted and counted the K'NEX pieces (a tedious but essential task).

For session two, we used the same K'NEX exercises except the students used the K'NEX Giant Set to build the crane instead of the windmill. The crane was a little more difficult, but the students persevered. Building the pulley system was somewhat frustrating for some groups. One student, who had built the crane before, became the "pulley expert". He moved from team to team to show others how to construct a working pulley system. Nevertheless, two teams could not finish the crane within the time allowed for the first session. We let them work on their cranes at the beginning of the second session. All of the cranes were functional by the end of the second session.

DISCUSSION

We believe that using K'NEX exercises in our summer engineering camp is an effective way to stimulate interest in engineering. To support that belief, we offer the following anecdotal evidence.

Were the K'NEX exercises effective? Student reaction to the K'NEX activities was quite positive.

> "I had a great time at camp. It was a lot more fun than what I had expected. I especially enjoyed the K'NEX blocks. I know much more about engineering now that I came to camp." (8th grade girl)

> "The camp was fun we did lots of different things with K'NEX , and we made digital clocks. I think this camp was cool and I recommend it to anyone." (8th grade boy)

In addition, data from the student survey administered on the last day of camp indicate that K'NEX lessons were a good idea. In response to the question, "What did you like most about camp? ", approximately one-third of the campers mentioned the K'NEX activities.

Was the camp effective in encouraging students to consider a career in engineering? Data from the end-of-camp student survey indicate that the campers have a wide range of interests. In response to the question, "What are your career plans? ", approximately 40% of the campers mentioned engineering; 12% said they wanted to become doctors. The careers of biologist, veterinarian, architect, lawyer, zoologist and computer programmer each received one vote. Not surprisingly, a large number of students (40%) responded "don't know" when asked about their career plans.

How did the girls respond to the entire camp experience?

Student comments indicate that the girls enjoyed the camp as much as the boys did.

> "At this camp I had a lot of fun. I learned a lot I needed to know for my future as an engineer." (8th grade girl)

> "Camp was fun and interesting. I enjoyed the experiments and the people in the camp are real fun. I look forward to coming next year." (9th grade girl)

> "I came to camp last year and decided to come back this year. I learned a lot about engineering and had a lot of fun. I wish I could come back next year, but it is only for rising 8th, 9th, and 10th graders. I will be too old to come back next year." (10th grade girl)

> "I think this camp will be of some use to all participants sometime in the near future. The skills that we were exposed to will definitely be of some use to me." (10th grade girl)

We plan to stay in contact with the campers through the use of annual follow-up surveys. Long-

term effects of camp attendance will be analyzed three to four years from now when the ESCAPE '96 campers graduate from high school.

CONCLUSION

In summary, we have learned that the use of K'NEX is a valuable addition to the summer camp curriculum. The construction sets have proved to be both durable and versatile. The K'NEX activities we developed for the Mercer University ESCAPE program are appealing to middle school students and can be used to encourage interest in engineering. We plan to use many of these activities again during this summer's camp.

We also feel that the Mercer University ESCAPE camp K'NEX activities are also appropriate for middle or high school science classes. For the benefit of teachers who would like to use these activities in the classroom, lesson plans for each K'NEX exercise are included at the end of this paper.

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APPENDIX

ESCAPE97 Lesson Plan: Windmill

Objective:
1) The students will learn how the pieces of K'NEX fit together to build a structure.
2) The students will use a picture and written instructions on how to build the K'NEX Windmill.
3) The students will learn critical thinking skills in discovering how to put the K'NEX Windmill together.
4) The students will learn to work together in a cooperative manner in order to build the K'NEX Windmill.

Time: 3 hours

Materials: K'NEX Giant Set

Procedure:
1) The students will draw to see which part of the Windmill they will construct.
2) The students are given a picture of the K'NEX Windmill and the written instructions for the K'NEX Windmill.
3) Two students will work on the base.
4) One student each will build one side of the tower (2 students total), one student each will build one panel of the wings (2 students total).
5) Upon completion of each section, the 6 students will work together to put the Windmill together.
6) The students will then determine how to put the motor together to cause the Windmill to move.

Assessment:
1) Did the students work well together?
2) Did the windmill get put together correctly?
3) Does the windmill work?

ESCAPE97 Lesson Plan: Gears

Objectives:
1) The student will use critical thinking skills in order to build a K'NEX model of a gear.
2) The student will be able to describe how a gear works.

Time: 45 minutes

Materials: K'NEX Intermediate or Giant Set

Procedure:
1) Discuss simple and compound machines with the students.
2) Discuss gears. In what direction do they move?
3) Students will build their own working model of a gear. They may construct any design they wish as long as the model works. It may be as simple or complex as they wish. If the students desire to work in a group, they must construct a complex and big gear.

Assessment:
1) Does it work?
2) Is it sturdy?

ESCAPE97 Lesson Plan: **Cars**

Objective:
1) The students will learn how the pieces of K'NEX fit together to build a moving object.
2) The students will learn critical thinking skills in discovering how to put the K'NEX Car together.
3) The students will learn to work together in a cooperative manner in order to build the K'NEX Car.
4) The students will use their knowledge of structural support to build a car that is well supported.
5) The students will use creativity in their design of the car.

Time: 1 hour: building time 2 hours: competition time

Materials: K'NEX Intermediate or Giant Set

Procedure:
1) The students may individually build a car or work in groups of no more than two. All students must participate.
2) The car will be subject to a battery of tests: design, speed, distance, impact support.
3) The students will determine the rules for each test.
4) The students will implement each test.

Assessment:
1) Did the students work well together?
2) Did they build cars that fit well to the areas for competition?