Introducing Engineering to Teenagers through a Summer Camps Program

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Abstract

The paper focuses on the impact of a residential summer camps program targeting students who will enter the 7th and 8th grade from economically disadvantaged parishes in Louisiana. Each camp was one-week long with approximately 50 students in each camp. The primary focus of the summer camps was to motivate the students to consider selecting a career in science and engineering.

We started their engineering time with an introduction to problem solving techniques. They worked in groups to solve several problems. We introduced fatigue by having them fatigue until failure two different sizes of paper clips in order to emphasize that when an experiment is repeated you do not obtain the same answer every time. Subsequently, they were introduced to some simple statistical ways to analyze the data.

Students were introduced to mechanical behavior of materials by performing Charpy Impact tests on steel and aluminum at room temperature as well as at the temperature of liquid nitrogen. Demonstrations of polymeric behavior at liquid nitrogen temperatures were also conducted. Students were introduced to the concept of viscoelasticity by making and playing with a "silly putty" type polymeric material.

Engineering design was introduced in two different ways. First, they were exposed to the concepts of rapid prototyping by observing the construction of small paperweights that were individualized with their names. Second, students were introduced to the concept of stability during the construction of towers with straws and masking tape that would hold a soccer ball.

The students were very enthusiastic about the project. We would like to continue offering the exploration program as well as expand it to a two-year program where students in their second year do more in-depth research in an area of their choice.

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Introduction

Our involvement in this outreach program was a natural outgrowth of our previous involvement with introducing pre-service teachers to engineering concepts. We have created a course in engineering problem solving for future teachers[1]. A key part of this was to use laboratories to teach engineering skills to these future teachers[2]. We had an outreach into the K-12 community as a result of this class. In the past, our students have made presentations on topics covered in the class and related topics to fourth grade classes in our community. Our students had to create active learning experiences for the fourth graders so that they could understand the material. Additionally, we also held workshops for in-service teachers where our students made presentations to them and involved the teachers with actual active learning activities [3,4].

When we had the opportunity to become involved in this summer camps project, we were able to build upon our past experiences. This outreach program was part of a larger Explorer summer camp program that encompassed much more than just an introduction to engineering.

The mission of the Louisiana Tech Explorer Camps was to motivate students of GEARUP schools to begin planning and preparing for entrance into an undergraduate program upon graduation from high school. Emphasis was placed on motivating them to consider careers in math, science, or engineering. GEARUP school systems were ones that had been identified by the state as being economically poor and who produced few college students in the sciences and engineering.

The Louisiana Tech Explorer Camps were one-week residential programs for students entering seventh and eighth grade. Two participants were selected from each of the twenty-five GEARUP schools in Louisiana for each of the four camps to be offered during summer 2003. About 200 students had the opportunity to participate in the camps. Participants arrived by bus on Sunday afternoon, and returned home by bus the following Saturday. They were divided into two groups, to make it easier to handle in the laboratory settings. Leadership training and tutoring activities were provided to each group in the morning. In the afternoon, the groups were split again for participation in enrichment activities.

Upon their arrival camp participants were administered an abbreviated version of the Explore Test (*EPAS)*[5]. Project staff scored these tests, and the results were used to develop a focused tutoring program for the participants using the Pathway strategies identified by the EPAS system. Ten teacher cadets and teacher candidates worked in small groups with two or three project participants to develop the specific skills necessary to prepare participants for success on the Explore Test. Seventy-five minute tutoring sessions were conducted for each of the first four days of the camp. At the conclusion of the camp, participants were again administered the abbreviated version of the Explore Test.

Participants began their multimedia experience by viewing an example PowerPoint presentation. After learning the basics of PowerPoint presentations, participants received instruction in how to incorporate transitions, music, and other effects to enrich PowerPoint presentations. Each participant worked with camp counselors and project staff to develop an “All About Me” presentation that was shared with the whole camp at the end of the week.

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To help the GEAR-Up students to create a more positive attitude toward studying mathematics and science we used the Lincoln Parish Park as an outside classroom experience and addressed the relevance of studying mathematics and science. The students were actively engaged in collection of data outdoors and developed their cooperative learning skills as they collected, analyzed and presented their data. The mathematical topics covered included ratios and proportions, percents, measurement, calculation of perimeter, circumference, area and volume, and graphing.

Engineering Component of Summer Camps Program

The purpose of the engineering module for the GEAR-UP Summer Camp at Louisiana Tech University was to introduce middle school students to a career in engineering through hands-on/minds-on laboratory experiments. Central to the purpose of the module was to acquaint the students with typical engineering projects: problem solving and design. We prepared a number of activities for the students. Each week of the summer camp program, the students spent one afternoon exploring engineering issues. The campers were split into two different groups, so that we would have a more manageable group of about 20-25 students. There were also college students (education majors) and high school students (pre-education majors) with each group of about 5 students. They acted as chaperones, to keep the students in the right locations. This was because the overall camp experience was spread throughout several buildings on campus. These college student mentors also helped the students in performing and understanding their experiments.

We created more experiments than we had time to do on any given day. A typical afternoon's schedule is shown in the table below.

Topic	Activities
Problem Solving	Groups will solve problems
Fatigue and Statistics	Students will fatigue paper clips. Results will be plotted with bar charts
Mechanical Properties of materials	Students will do Charpy impact tests. Effects of very cold temperatures (liquid nitrogen) will be examined
Engineering design	Students will design and build a straw structure. Students will see how rapid prototyping can aid in the design process
Properties of plastics	Students will make and examine a "silly putty" type material

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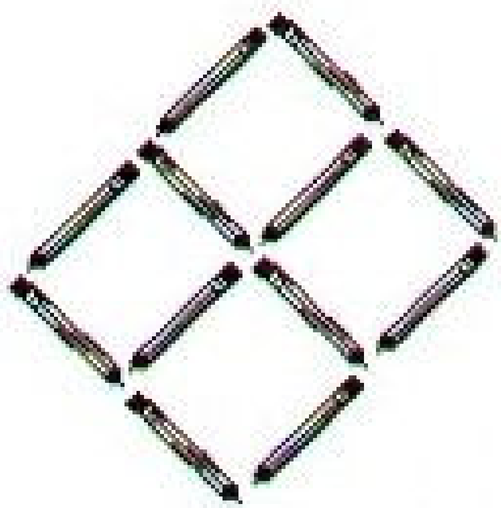
Problem Solving

To illustrate problem solving in the field of engineering the students used manipulatives to assist in solving problems. Engineering is different from science in that engineers use science, technology, and human experience to solve problems.

At the heart of engineering is the concept of problem solving. One way to solve a problem is to create something that is new. This is called engineering design. These designs could be changes to something that already exists. An example of this is a new car model. While some things in each new car model are different, many things within it are the same as previous designs. Sometimes the engineer designs something that has never been built before. An example of this is the space shuttle orbiter. A reusable liquid fueled rocket had never been built before.

In this section of the camp, we had the students solve some problems with the use of manipulatives. Some of the problems were from the excellent book by Fogler and LeBlanc[6]. The goal of this section was to teach some problem solving skills as well as get the students used to working in teams. A couple of these problems are described below.



Problem Number 1

Take twelve sticks and put them in the pattern shown below. Now rearrange four sticks so that you have six equal triangles.

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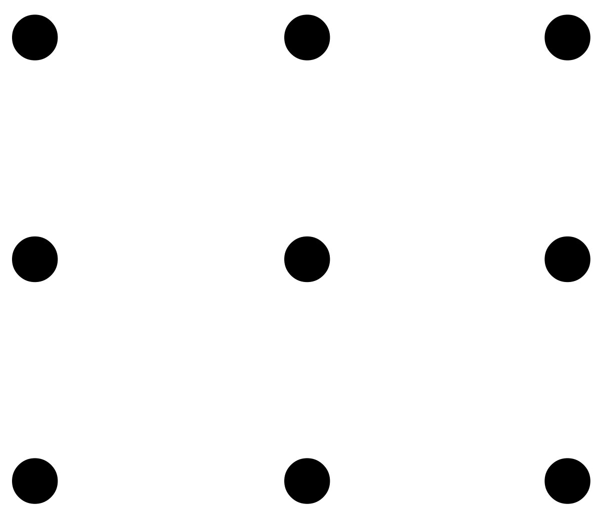
Problem Number 2

You have the nine dots shown below. Using your pencil (and not removing it from the paper) draw four straight lines that will go through all of the points.



<u>Fatigue</u>

Fatigue, a test typically conducted by engineers, was modeled through an experiment with different types of paper clips. The students bent paper clips until the clips failed. The results were graphed and discussed. Part of the discussion centered on how graphs allow engineers and scientists to quickly view trends in the data and on the fact that there is variability in all experiments.

The specific data for each time was different, but something similar to that shown below was obtained. For this experience, the students did graphs by hand. Later, they learned how to get the computer to do graphs in another portion of this summer camp.

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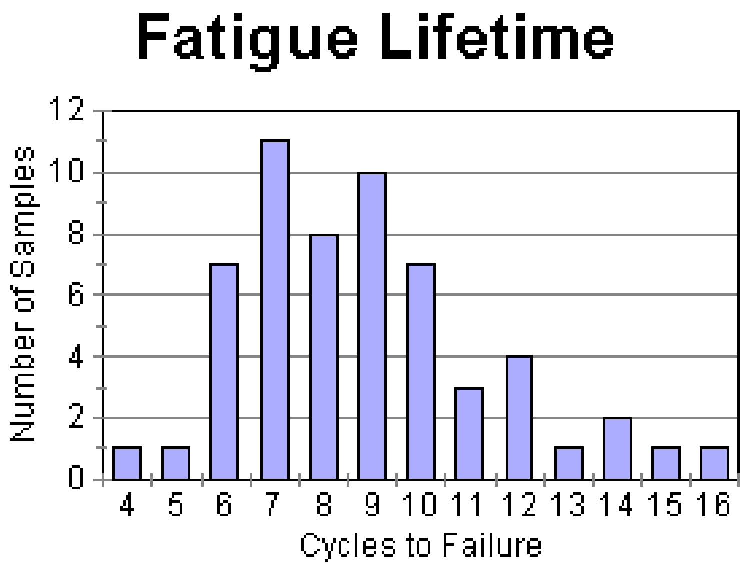

Figure 1 Example fatigue lifetime graph

For most students, graphing the fatigue data was the hardest task of all the engineering exploration activities. However, this also illustrated an important point about the variability of data. Some students seemed surprised that we did not get the same results on every test. This point was also made when we analyzed the Charpy impact test results described in another section.

Design

Design is an integral component of engineering. Students in cooperative groups were asked to design a structure with 3 packages of drinking straws and one roll of masking tape that would support a small soccer ball. The structure could be anchored to the table with the tape, but not to the ceiling or wall, a design limitation. The tallest structure that met the criteria won the "contract," a typical engineering task. Students were given about 30 minutes to work on this project. This was done simultaneously with the Charpy impact test laboratory. When both groups had done both labs, we then measured the heights of the structures. Some of the taller structures were not very stable and could not hold up the ball. Examples of some student designs are shown in the figures below.

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Figure 2 Images of Straw design contest

This section introduced students to the concept of stability. This is a different concept than strength. They could see this in practice when some of their designs collapsed without any parts of them actually breaking.

Rapid Prototyping

Scientists and engineers make models to better understand a concept and to develop new and improved products. The students were allowed to view the rapid prototyping machine, which produces 3-D models from computer-assisted drafting (CAD) drawings. To illustrate the capability of this machine, small round paperweights were made that had the university logo embossed into one side and their individual names raised on the other side. An example of this is shown in the figure below.

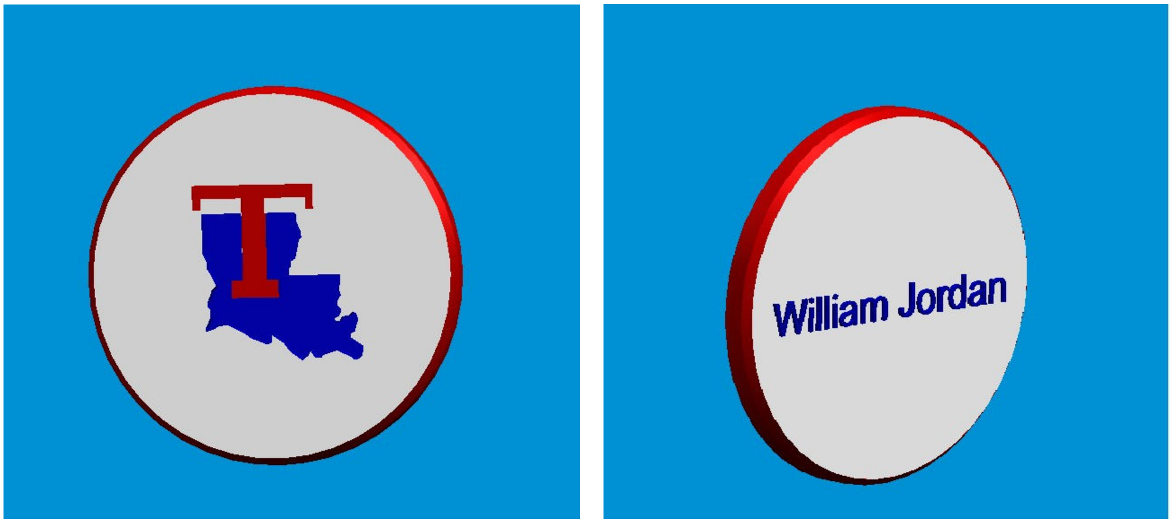

Figure 3 Rapid prototyping samples (approximately 75% of actual size)

Charpy Impact Testing

In addition to design, engineers conduct tests on materials and structures. The students viewed the Charpy impact test machine, which is shown below. This tester is a simple pendulum device that applies an impact load to a sample. The energy required to break the sample is then recorded.

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Figure 4 Charpy Impact Test Machine

In the tests conducted, aluminum and steel were tested at both room temperature and liquid nitrogen temperatures. The fact that steel changed its properties greatly with cold temperatures while aluminum did not was related to their different atomic structures.

While in this laboratory, the effect of cold temperatures on polymers was illustrated. A soft racquetball was immersed in liquid nitrogen for a few seconds. It was then very stiff and bounced much differently that it did at room temperature. It was then immersed in liquid nitrogen for about one minute. When it was then dropped on the floor it shattered into pieces. Students picked up the pieces and saw how they once again softened when they warmed up to room temperature.

Properties of Plastics

Students were introduced to plastic materials by making a "Silly Putty" type material by mixing starch and Elmer's glue. Students were then asked to decide whether they had created a solid or liquid, since it has properties of both. This lead to discussion of the non-crystalline nature of

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most polymers and how many of them do not have a precise melting point, but gradually change from what appears to be a solid to something that behaves more like a liquid. This was a very messy experience that most students really enjoyed.

Assessment

We did assessment of this project in several ways. Qualitative assessment results have been published in another location[7]. Students were tested for the math, science, English, and reading skills both at the beginning and the end of their camp experience. We used the Educational Planning and Assessment System[5] (EPAS), which has been developed by the organization that produces the ACT test. This assessment focuses on the higher order thinking skills students should develop in grades K-12 that are important for success during and after high school. One common time this assessment is used is in grades 8/9 to assess readiness for high school. We used this assessment to examine the students' capabilities at the beginning and end of our summer camps program. Results are shown in the table below. There was an overall improvement. The students showed the largest improvement in their math scores.

EPAS Analysis for All Participants			
Subject	Number	Pretest Mean	Posttest Mean
English	197	5.55	5.71
Math	197	5.65	7.47
Reading	197	4.64	4.73
Science	197	4.42	4.69
Total		20.14	22.52

Subscores based on gender and race were also analyzed. All of these groupings showed the same basic trends as the overall data shown above.

We also took a survey of their attitudes toward engineering and science. We adapted a survey that had been created at the University of Michigan[8]. Each question was on a five point Likert scale, with scores ranging from 1-5 (with 5 being the most positive score). Scores for each person are summed to get an overall score. Shown below are the averages of the sums. All groups showed in increase in their positive attitudes toward engineering and science.

Science Attitude Survey			
Group	Number	Pretest Mean	Posttest Mean
Female	135	95.72	99.13
Male	62	97.27	101.92
Black	137	95.34	98.78
White	60	98.18	102.80
Total	197	96.21	100.01

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Conclusions

Based on our assessment data, we believe that a summer camp experience such as the one we have developed will yield positive results in two major ways.

- Students' math and science abilities will improve.
- Students' attitude toward math and science will improve. This is critically important as we try to increase the number of students who will eventually become scientists and engineers.

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