AC 2011-1753: EVOLVING A SUMMER ENGINEERING CAMP THROUGH ASSESSMENT

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Evolving a Summer Engineering Camp through Assessment

Background

EPIC (Engineering Possibilities in College) is a one-week summer program for high school students (entering 9th-12th grades) to learn about engineering and experience hands-on labs in a university atmosphere. It's an opportunity for students to explore the different types of engineering available at many universities. The aim of EPIC is to expand the College of Engineering mission to K-12 students: "To educate students for careers of service, leadership and distinction in engineering or other fields by using a participatory, learn by doing, 'hands-on' approach" (Figure 1).

Figure 1. High school students in the EPIC summer engineering program do hands-on lab activities to explore different engineering disciplines.

The program goal is to inspire a diverse set of students to become engineers, while a secondary goal is for those students to apply to the College of Engineering at California Polytechnic (Cal Poly) State University, San Luis Obispo. Students applying to Cal Poly are required to select a specific engineering major (out of 14 programs), and thus the most well known majors (i.e., mechanical, civil, aero) tend to have the most applicants.

EPIC students attend 8 hands-on labs throughout the week. Labs are offered in Aerospace, Architectural, Biomedical, Civil, Computer, Electrical, Environmental, Industrial, Manufacturing, Materials, Mechanical, and Software Engineering. All labs are taught by Cal Poly professors and assisted by current Cal Poly students. In addition, EPIC participants tour several engineering labs, as well as local engineering companies.

The social aspects and bonding among the program participants are also significant. The participants are placed in teams for the week and have a Cal Poly student as their counselor. EPIC isn't all work and no play. Students meet other students through fun activities on campus like bowling, rock climbing, scavenger hunts, or video game systems. They listen to speakers from various engineering companies, learn networking skills, and play games. An important

factor towards becoming an engineer is to be able to visualize oneself in that role, and through the EPIC program, we hope to instill confidence and excitement about engineering to the young students.

Initial Assessment

In 2007, a summer engineering program was developed as a pilot program to promote engineering to underrepresented students[1]. That year 20 students participated, and the camp has grown each year in terms of students participating, as well as university faculty and departments. An outreach coordinator was hired in 2008 to help promote and run the program. University students also helped with the marketing and organization of the program. In 2010, 136 high school students attended EPIC (Figure 2).

Figure 2. The 2010 EPIC camp participants (including staff and counselors) spell out "EPIC."

During the second year of the camp with a greatly expanded program, assessment[2] revealed that while the program was successful in serving students of underrepresented groups, many were already interested in and planning to study engineering in college. Changes in self-perceived abilities, knowledge, and attitudes towards engineering were investigated with statements on a Likert scale to measure the impact of the camp. Analysis revealed that while there was an increase in all the areas, the Likert scores were already starting out high, consistent with the response rate of students planning to study engineering. From conversations and responses to the open-ended survey questions, we learned that many of the camp participants were trying to distinguish the different types of engineering and very much enjoyed the hands-on approach to the labs. Results of the assessment have been previously published[2], and have influenced the summer program.

Over the years, we have also improved our assessment methods for gathering data and quickly being able to use the data. Pre-camp surveys were tied to registration, and we were able to learn about the camp participants' backgrounds, attitudes, and expectations early to inform the faculty developing their lab activities. Based on the collective assessments, we realized that the lab activities needed to give a good overview and be representative of the field versus a specialized

subtopic. A presentation was given during the spring quarter to the faculty involved with the summer camp to share such findings and to help guide their lab activities.

The surveys also help to make data-driven decisions about changes to the camp. Assessments have proven extremely useful in helping to refine the goals and outcomes of the camp, as well as measuring how well we are achieving them. While the surveys served many purposes, our main question was to determine the impact of the EPIC program. Survey results from the past two years are the focus of this paper.

Demographics

Ever since the beginning, the camp has tried to target under-represented groups in engineering: female, non-Caucasian, and first generation college students. We mainly advertise in the local area (i.e., within a 40 mile radius), but some participants discovered the program online or were referred to by locals.

EPIC participants in 2009 and 2010 were similar in terms of gender, ethnicity, and year in school. Table 1 gives the percentages of gender and ethnicity of the students. A significant number chose not to specify their ethnicity, and thus percentages in the other ethnic groups could change dramatically. The "total number" of participants in the Table also reflects the number of camp participants that completed both the pre and post-surveys, and might be smaller than the total number of students that actually attended the camp.

Table 1. Demographics of the EPIC participants for 2009 and 2010.

Camp participants	2009	2010
Total number (n)	124	136
Female	43%	42%
Male	57%	58%
White/Caucasian	46%	37%
Hispanic/Latino	30%	32%
Asian	5%	9%
Black/African American	5%	2%
Native American	1%	1%
Other	5%	3%
Not specified	9%	16%

The percentages of the targeted under-represented groups in EPIC greatly exceed those of current students in the College of Engineering at Cal Poly. Through a positive experience with the EPIC program, we hope that many of the students will apply and attend Cal Poly. To date, we only have a few anecdotal stories of former EPIC participants that are now studying engineering at Cal Poly, and hope to be able to conduct thorough longitudinal studies in the future.

From the 2009 survey, we investigated whether certain camp participant characteristics (e.g., demographics, parent education, and exposure to engineering before the camp) were associated with how they perceived engineering and if they wanted to major in engineering in college. All the Chi-squared tests were insignificant, and thus there were no associations between variables of interest and the comparison across demographic variables. While nothing significant came out of that particular study, the results may indicate that our camp participants may be very similar in terms of inclination towards engineering.
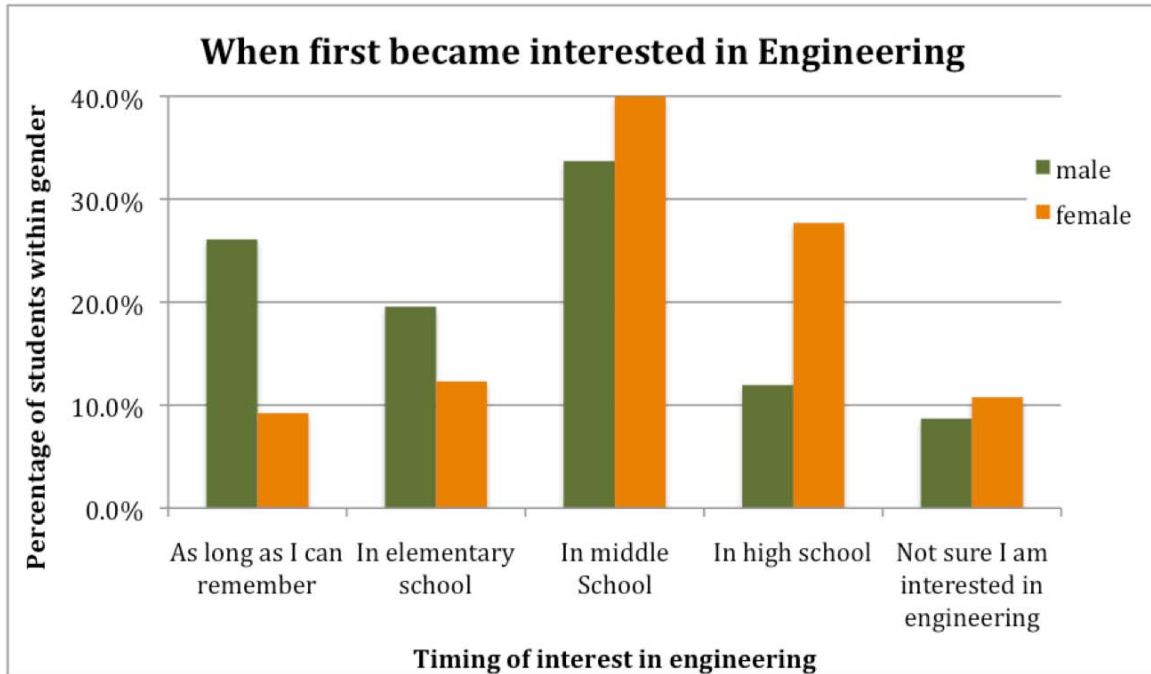
Interest in Engineering

One goal of the camp was to introduce students to engineering, but most students came to the camp with a high level of interest in engineering. From the 2010 survey, ninety-one percent of the students either planned on studying engineer (51%) or were considering engineering as a major (40%). However, we found an interesting difference when looking at the distribution of males and females. The most common response for males is "I plan to study engineering in college," while the most common response for females is "I am considering engineering but am also considering other majors for college."

Another question answered on the pre-camp survey was when the individual first became interested in engineering (Figure 3). There are striking differences between the genders in response to this question. The responses were given ordinals for purposes of computing averages (with smaller numbers representing earlier times in life), and the results imply some level of degree. The average response for males was 2.57 (standard deviation of 1.24), while the average response for females was 3.18 (Standard deviation of 1.09). This difference is statistically significant ($p=0.001$).

Clearly females identify interest in engineering later than males. As depicted in Figure 3, females show more of a normal distribution with the maximum at middle school, while the males show a fair percentage at earlier points in life for their interest in engineering. Factors as to why females become interested in engineering later than males were not investigated in this study, but would be an interesting study. Also from this question, only 15 of the 157 (less than 10%) were not sure about engineering as a field of study, the same results as the interest level question.

Consistent with earlier findings, many of the camp participants at least already have some interest in engineering, and thus we may be missing students that haven't even considered or know enough about engineering. The results also indicate the importance to outreach to younger students (e.g., middle school) for our program. By high school, many students have already decided on a certain path and may be too late to have a large impact on inspiring students to study engineering.

Figure 3. Distribution of EPIC participants of when they first remember being interested in engineering. The males report that their interest in engineering appears earlier in life than for most females.

We also looked into who was encouraging the student's interest in engineering with a multiple answer question that had: "my parents, a relative, school counselor, teacher, and no one really." Overwhelming, parents had the largest response (90%), and the next significant response was teacher (57%). Since multiple responses were possible, we looked at how many different groups were encouraging the students (i.e., how many answers were selected by each student). On average, two different groups were giving encouragement, and there were no differences between genders.

To measure the impact of EPIC on the commitment level to study engineering, we gave the same question on the pre and post-camp survey and examined if there was an increase or decrease for each student. Of course, if camp participants already marked "I plan to study engineering in college," then there is no possibility of increasing their level on the survey. If they were still committed to studying engineering after EPIC, then there would be no change in the response, and thus those students were not counted in Figure 4. The survey choices are in Table 2.

Table 2. Survey choices for the level of commitment to study engineering

Please choose the statement that best fits you.
I plan to study engineering in college.
I'm considering engineering but am also considering other majors for college.
I'm not sure what I want to study.
I don't plan to major in engineering.
I don't plan to go to college.

Overall, there is an upward trend of the camp participants to have more commitment to studying engineering. Roughly 29% of the students who hadn't planned to study engineering in the pre-survey chose that response in the post-camp survey. Thus, the camp may have helped solidify their decision.

However, not all the changes were in a positive direction in terms of the level of commitment to study engineering in college. As shown in Figure 4, a few students (7 total) went in the opposite direction, and perhaps no longer are interested in studying engineering. However, if the camp program helped the individual determine what they were truly interested in as a career, then we consider the outcome positive. For instance one year, a camp participant realized that architecture was a better fit for her rather than engineering, but was still grateful for the engineering camp experience.

While many of the camp participants already had a strong interest in engineering, we wanted to see if there was any effect of EPIC on their level of commitment. We took out those who reported the highest level of commitment to avoid the "ceiling effect," or skewing that could occur. In Figure 4, we show changes in the level of commitment and separated the upper level students (11-12th graders) with the lower level (9-10th graders). As suspected, there was more variation among the younger students. Overall, there was an increase in the level of commitment to study engineering after the EPIC experience. 49% of the younger students, and 66% of the older students reported the highest level of commitment.
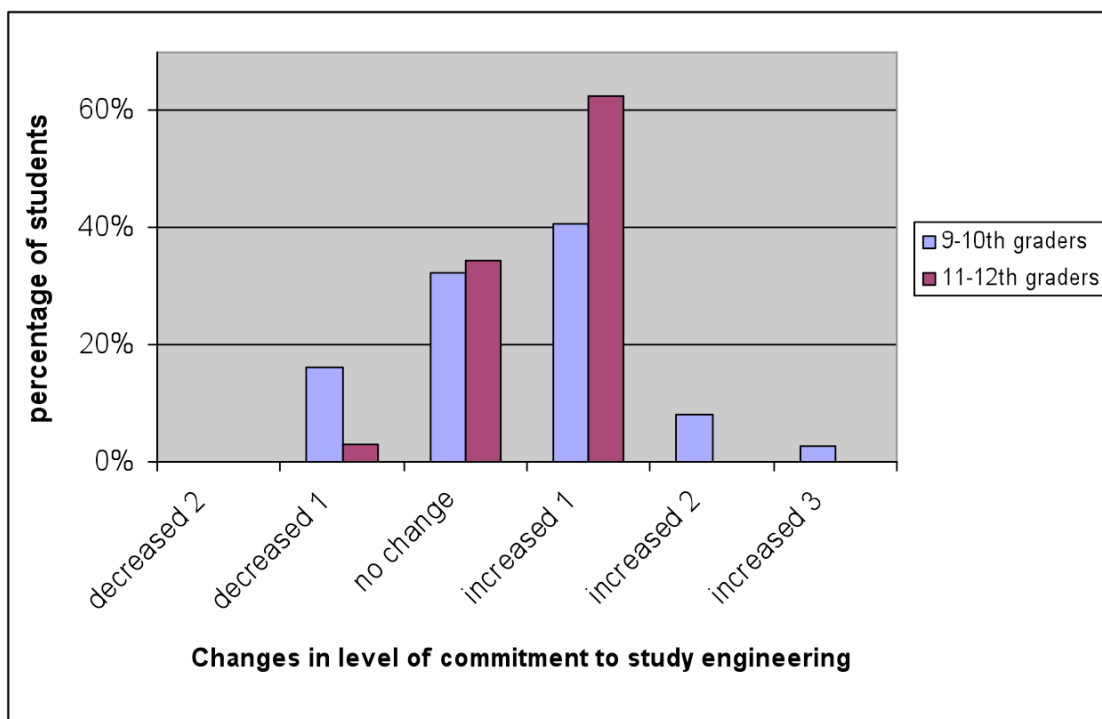

Figure 4. Distribution of younger and older students (excluding those already strongly interested in engineering) who changed their level of commitment to student engineering after EPIC.

Perceived Traits of Engineers

In order to gain understanding of how the young students perceive engineering and the traits needed to be successful, we asked the open-ended questions on the 2009 survey, *"What are some of the important personal traits needed to become an engineer?"*

Word clouds were generated to visually see the most common responses to questions posed before and after the camp. A "word cloud" gives a visualization of the frequency of certain words from a block of text; and in this case, from all the survey responses. For example words gathered for the "important personal traits needed to become an engineer" on the word cloud showed the word "creativity" overwhelmingly large in the post-camp survey (Fig. 5b) compared to the pre-camp survey (Figure 5a). (We deleted some words, such as *engineering, things, something*, and *define*.)

(a)   (b)
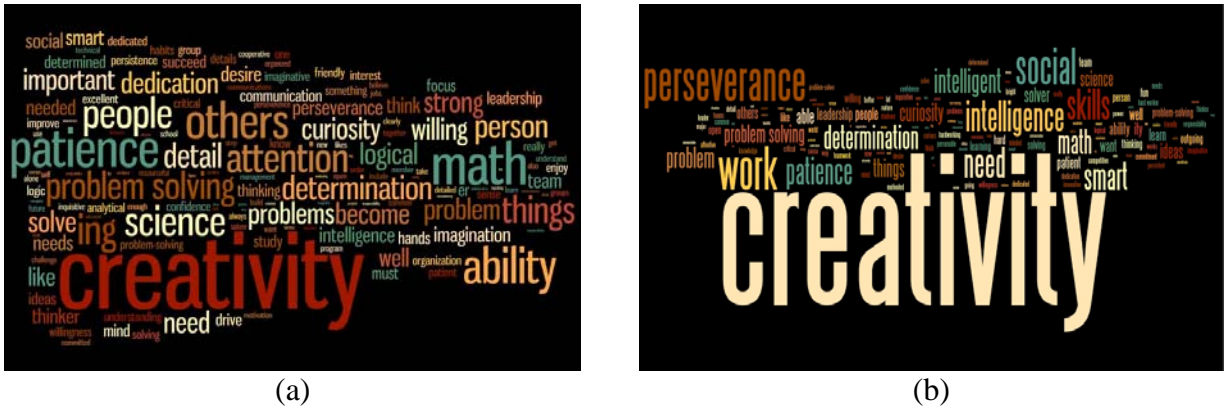
Figure 5. Word clouds that pictorially show the frequency of certain words by size to the open-ended question of *"What are important personal traits needed to become an engineer?"* on the a) pre-camp survey and b) post-camp survey.

From grouping similar free responses in the 2009 survey, we were then able to then create a survey question with specific phrases for the following year, and asked participants to rank them in order of importance (Figure 6). We wanted to see what young students thought were the most important traits, even though all the choices are important and possessing a variety of traits is ideal.

From this sort of question format, we could then also measure changes in responses after the camp in order to gather quantitative statistics. The question asked the participants to: *Rank the following traits in the order of importance that you think are important to be a successful engineer:* (1= most important, 10= least important; only one number used once). The ten traits selected appear along the x-axis in Figure 6.

As shown in Figure 6, there was little change in the average ranking number per trait before and after the camp. However, the relative average ranking for "creativity" rose in average ranking from the 3rd most important to the 2nd most important trait (switching with "good in math and science") after the week-long camp. "Creativity" showed the relatively high increase in ranking

(0.42) and "good in math and science" had a large decrease (0.64). The other interesting switch in relative average ranking is "works well with non-engineers" (0.47 increase in rank) and "good with computers" (0.23 decrease in rank). While the changes are small, the particular items demonstrate that perhaps the camp is successfully demonstrating the importance of the "soft" or "professional" skills that have been overlooked in the past.

However, the standard deviation in the most of the responses was about 2-2.5, and thus, these switches in relative ranking are not significant but might indicate some trend. The top three important traits (i.e., "good problem solver," "creative," and "good in math and science") are significantly different from the last two ranked traits ("writes neatly" and "draws well"). What traits students believe are to be important and their confidence or self-efficacy of them may play a role in whether they choose to pursue engineering.
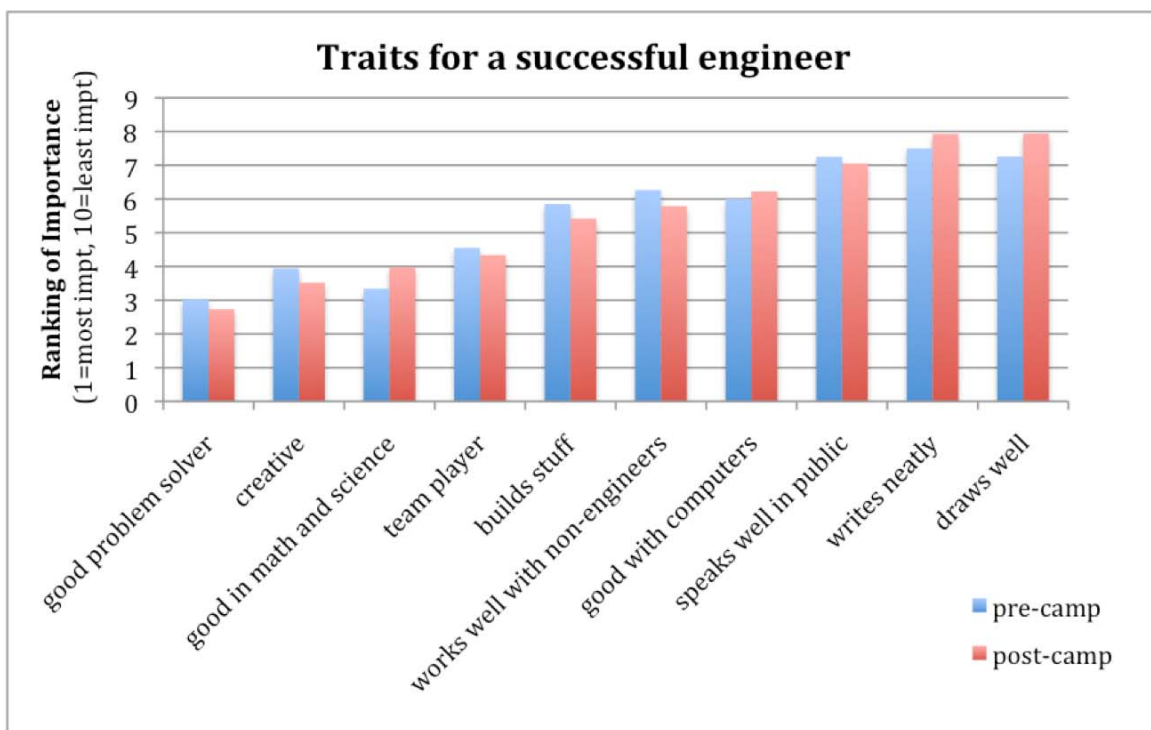
Figures 6. Average ranking of traits in terms of importance to being a successful engineer.

The high school or middle school student probably has a limited understanding of the profession of engineering. Throughout the camp, the students were told that creativity and innovation are important factors in engineering design. This seemed to contribute to the students understanding of engineering as a multifaceted profession. The summary of the questions and how the answers changed after the camp are in Figure 7. These were statements that students were asked to answer with a Likert scale of from high agreement (1) to no agreement (5). The averages are plotted. We only included those students who answered both the pre and the post survey. There was no statistically significant difference in these answers when comparing pre and post-camp surveys. There were no significant differences in these responses based on gender.
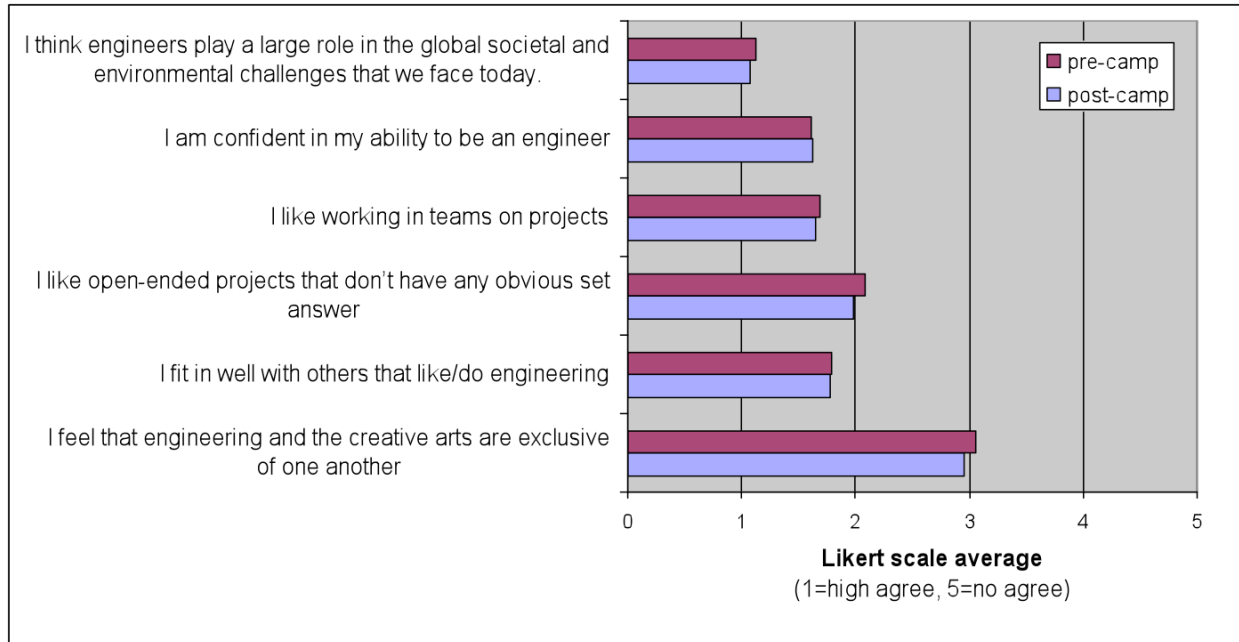
Figure 7. Averages of the level of agreement to statements about engineering. Very little changes were found after the camp and no gender differences were found.

Perceived Activities of Engineers

In another open-ended question on the 2009 survey, we asked *"How would you define engineering?"* Again, word clouds (Figure 8) were generated from the pre and post-camp surveys to look for significant changes.

(a)   (b)
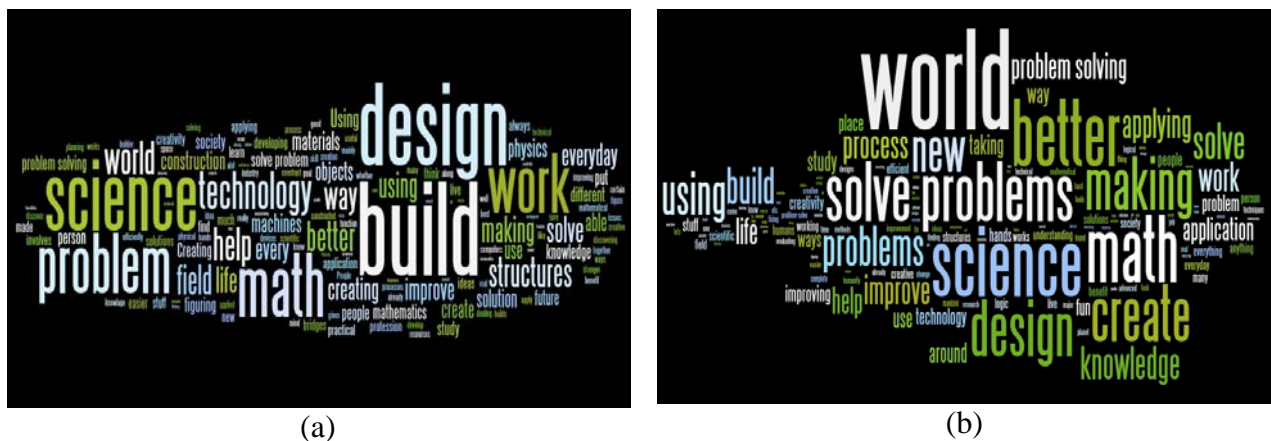
Figure 8. Word clouds of the responses to the open-ended question, "How would you define engineering?" from the a) pre-camp and b) post-camp surveys.

Before attending EPIC, participants defined engineering as builders and problem solvers, though no clearly representative words emerge from analysis. After attending EPIC, several of the same

words continue to be mentioned frequently. A more global outlook is apparent with the large size of the word, "world." Interesting additions in post-EPIC responses include mentions of "making the world a better place" or "shaping the world." Roughly 12% more students defined engineering as "helping humanity" after the camp. Responses were grouped together under that distinction included phrases such as "improving the quality of life" or "making the world a better place." These particular phrases were used in the large presentations during the camp (and perhaps particular labs), and indicate that the students retain particular messages about engineering. Thus any outreach or informal learning program should carefully consider what is presented to an audience.

Based on the responses of the 2009 survey, we created a question on the 2010 survey to investigate the strength of certain phrases that might describe what engineers do. The question asked the following: *Rank the following phrases that you think best describes what engineers do on a scale of 1-6:* (1= best describes, 6= least describes; only one number used once):
- analyzes data
- applies math and science
- comes up with creative solutions
- designs, builds, and tests
- gives presentations
- helps society

As Figure 9 shows, there was no overwhelming consistent "best" descriptor (although perhaps there is a "least" descriptor) of what engineers do. The phrases of engineers solving problem and designing/building/testing ranked high. What is interesting is that the phrase "applies math and science" had the greatest difference between the pre and post surveys, and it in the direction of not being a good description (while starting out as the best descriptor in the pre-survey). The trend indicates that the perception of engineers applying math and science becomes less prominent after the EPIC program. The results from the ranking of being "good in science and math" as one of the perceived traits of a successful engineer decreasing with the post-surveys is consistent. The perception that engineers must be good at math and science may limit the pool of students that might enter the field (especially the under-represented)[3].

The descriptor, "helping society," rose slightly in ranking, but not by a significant amount. The highest increase towards a better descriptor of engineering was "comes up with creative solutions." Videos about how engineers are creative and help the world were presented during the large group sessions during the week. Comparisons of the pre and post-camp surveys indicate that the "message" about engineering helping people[4] is being heard.
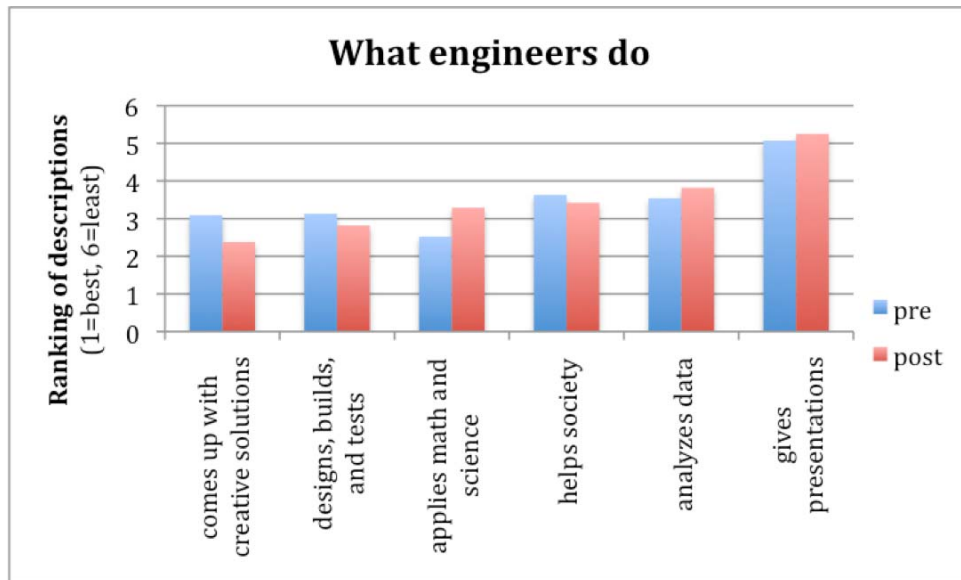
Figure 9. Comparison between the pre and post-camp surveys on the perceived ranking of descriptions of what engineers do.
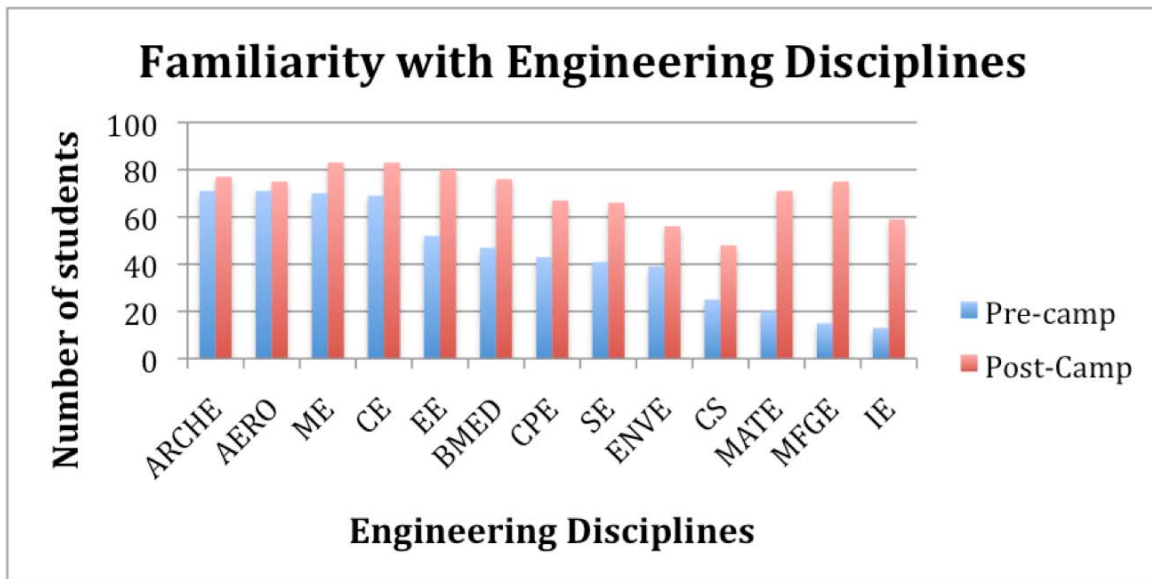
Awareness of Engineering Disciplines

As a way to measure the participant's familiarity with the different engineering disciplines, we asked them to "Check which engineering disciplines you are familiar enough with such that you could describe them to another person" and had a check box for each of the following:

Aerospace Engineering (AERO), Architectural Engineering (ARCHE), Biomedical Engineering (BMED), Civil Engineering (CE), Computer Engineering (CPE), Computer Science (CS), Electrical Engineering (EE), Environmental Engineering (ENVE), Industrial Engineering (IE), Manufacturing Engineering (MFGE), Materials Engineering (MATE), Mechanical Engineering (ME), Software Engineering (SE).
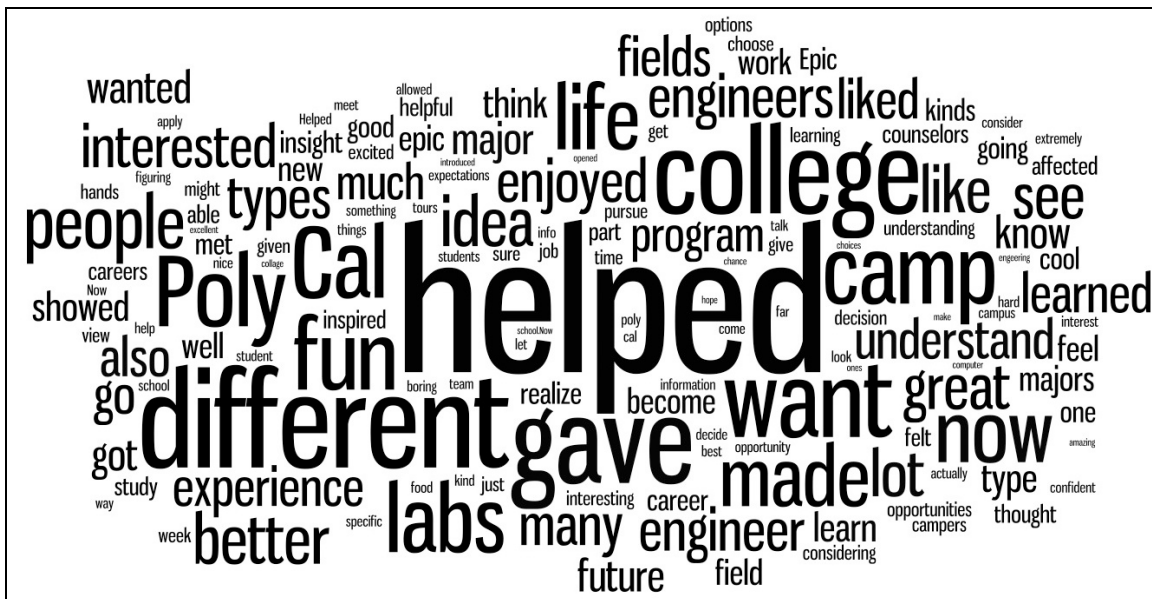
Since there were 8 different lab sessions during the week, not all camp participants did labs in all of the available disciplines. But they may have heard about the different engineering disciplines through the program and talking to the other camp participants and counselors. They had also selected a particular track they were interested in when registering, and thus may have looked into some of the different engineering disciplines.

As Figure 10 shows, the number of students being able to describe the different engineering disciplines rose for all disciplines after the EPIC program. The disciplines that showed the largest gains were Materials Engineering, Manufacturing Engineering, and Industrial Engineering. (Similar results were found in the 2009 surveys.) These disciplines were also the ones that started out the lowest in terms of familiarity before the camp. The lesser-known engineering departments definitely benefit from participating in EPIC for the exposure as a recruitment tool. Not surprising, the more well-known engineering disciplines, such as Aerospace, Mechanical and Civil Engineering, showed smaller gains because they started out high in familiarity in the first place.

Figure 10. The familiarity of all engineering disciplines increased after the camp, with MATE, MFGE, and IE showing the largest gains.

Most significant impact of the EPIC program

One way to determine what the biggest impact of the EPIC program on the students is to actually just ask them as an open-ended question. From their responses, we generated the word cloud shown in Figure 11. By far, the most common response was that the summer camp helped them better understand what engineering is and what the different engineering disciplines are.

Figure 11. Word cloud of the responses to the post-camp survey for the open-ended question for feedback, where the word "helped" refers to helping understand engineering and the disciplines.

Revisiting the goals

Analysis of the surveys show consistent results and allows us to understand who our camp participants are and what EPIC can achieve. We find that although the camp does reach members of under-represented groups, many are already interested in engineering and we may be missing opportunities for others. For greater impact, we might consider a camp for middle school students, which was also the timeframe when most of the females became interested in engineering. Greater outreach about our program to young students not necessarily committed to studying engineering would also have greater impact on the pipeline of future engineers. Unfortunately due to budget cuts, we no longer have an Outreach Coordinator to do the groundwork for effective recruitment.

The EPIC program does appear to be highly successful in presenting what engineering is and exciting the participants to continue the path towards becoming an engineer. If the largest impact of the program is for young students to distinguish among the different engineering disciplines, other methods (e.g., weekend workshops) could be considered. Future assessments should include how effective the program is in recruiting students to Cal Poly and what other possible long term impacts there may be.

References

[1] Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future http://books.nap.edu/catalog/11463.html

[2] K.C. Chen, D. Belter, T. Fredeen, S. Magnusson, and Heather Smith, "Inspiring a diverse population of high school students to choose engineering as a career path," ASEE Annual Conference Proceedings, June 2009.

[3] www.engineeryourlife.org/

[4] Changing the Conversation: Messages for Improving Public Understanding of Engineering, National Academy of Engineering