Lessons Learned Developing an Engaging Engineering Summer Camp

Ms. Karen J Krapcho, University of Utah

Karen Krapcho,M.S. is the Outreach and grant coordinator for NSF-0652982.

Dr. Cynthia Furse, University of Utah

Lessons Learned Developing an Engaging Engineering Summer Camp

Introduction

In order to meet the growing workforce needs in science and technology it is projected that the U.S. must increase the number of undergraduate STEM (Science, Technology, Engineering and Math) degrees by about 34% annually over current rates[1]. At both the national and statewide level, a significant number of initiatives have been launched to stimulate interest in STEM disciplines and improve the coordination of efforts between K-12 and higher education. Most recently, the state of Utah introduced the Governor's Prosperity 2020 challenge to increase the number of post-secondary degrees in the state and realign Utah's educational outcomes towards a STEM centered-workforce[2]. With support from a National Science Foundation grant (0652982) aimed at increasing the number of engineering graduates in the state of Utah, staff and faculty from the College of Engineering at the University of Utah have been developing an engineering summer camp program to help recruit students into higher education. This paper describes a few of the summer camp options we have implemented and discusses the challenges, opportunities and lessons learned from our experiences.

The idea of using summer camps to promote STEM disciplines is not new; it is typically part of a multi-prong approach to attract future science and engineering students. Other effective recruitment tools include outreach into K-12 schools, on-campus open house sessions, hands-on workshops, robotic competitions and demonstration/information sessions. A review of the literature yielded several themes related to the planning, implementation, and assessment of summer STEM camps. Targeting women and minority populations to develop an awareness of engineering is a common practice and has been shown to successfully influence decisions to pursue engineering[3,4,5]. Longer-running camp events and/or those with more involved activities has also been shown to positively influence a student's perception and desire to pursue engineering[6] .

The College of Engineering at the University runs two summer all-day programs. First, is the HI-GEAR (Girls Engineering Abilities Realized) program for female high school students[3]. It is a 5-day camp subsidized by private donations, camper fees, faculty grants and the College. There is an application process that requires prospective campers to write a personal statement, and provide letters of recommendation and references. This camp tends to attract academically-strong girls, referred by teachers and/or school counselors, who know that they are interested in science or engineering. The second camp, and the topic for this paper, is the Exploring Engineering Camp. The original goal for the camp was to introduce larger numbers of high school students, to the seven disciplines of engineering (bioengineering, civil engineering, chemical engineering, computer science, electrical and computer engineering, materials science engineering and mechanical engineering) offered as majors at the University. The camp was structured similar to a school day; campers participated in a series of 50 minute sessions presented by each of the engineering departments with time taken for a lunch break and an afternoon speaker and/or tour. In these sessions high school students were provided with information about each discipline of engineering and then participated in a hands-on activity showcasing that discipline and/or a tour of a research lab. Students spent the final day tackling a problem and their solutions were presented to the entire group in the form of a “summit”. The camp was subsidized by the grant with very little cost to the attendees; however it required participation from every department, typically a faculty and group of 5-6 students for 2 days in the summer, as well as substantial preparation time from these groups as well as a faculty member directing the camp. By the third year, the choice was made to hire a coordinator. We took the information we gained from the positive aspects of the original format and distilled them down into a much more manageable camp format for long-term sustainability.

Lessons Learned

1. The Importance of Setting the Goals for the Camp Program

Many people have been involved in the planning of our summer camps; our best practices have emerged based on implementation of multiple strategies and follow-up assessments. Reflection on our experiences suggests that the key strategic issue in camp planning is agreeing on the goal of the camp and communicating this to all of the parties involved. This decision impacts whom you target, and how you program, advertise, and recruit faculty to involve. There are a variety of goals that can be addressed by an engineering summer camp; increased awareness of engineering (outreach), recruitment of high school students to college programs, providing an experiential learning opportunity(true STEM), improving the academic preparedness of high school students (bridge) and helping students to identify which area of engineering they are most interested in. It has been our (and others’)[7] experience that the same camp cannot address all of these goals, because each will attract and appeal to different students and their parents. While there are areas of overlap in the objectives listed above, we found that it is best to agree on the primary goal and whom your target audience will be before designing the camp. This way the advertisements, activities and the level of academic rigor can be planned accordingly.

2. Format for the Camp Experience

In 2008, our first camp enrolled 70 high school students into a program themed as a BioInnovation Summit. The camp was coordinated by a single faculty member and each department prepared an activity relating to biological applications. Since this is one of the research strengths at our University, this was a relatively easy topic for most of our engineering departments to design activities around. The activity on the final day was taking several wheel-chair bound adults (some of them UofU engineering alumni) to lunch at the student union, learning about their experiences with adaptive technology, and envisioning a new adaptive technology that could help that particular adult with a task they wish they could do but cannot today. The second summer camp theme was Alternative Energy. This camp was built upon groups of high school students already supported by the grant to work with University engineering students on an energy project throughout the school year. These student groups made up a portion, but not all of the attendees. The activity time was shortened, and students were given substantial time each afternoon working with University engineering students to envision their ideas for the energy future. The final day included tours and presentations of high school student ideas.

We learned a couple of things from these two camps. One was that it takes a lot of effort and substantial coordination to put these camps together. Another was that the hands-on activities were the most appealing, and as much time as possible should be spent doing/building. The tours and speakers were also often seen as highly appealing, so we continue to use them in balance with the hands on activities. The college student ambassadors hired on as camp counselors had a very positive impact on the high school students, provided they have faculty/director supervision in the development of the activities. We also found that many of the high school students were coming in with some idea what engineering discipline(s) they were interested in and preferred to spend more time exploring fewer diciplines.

During the third year summer camp a coordinator was hired for the grant and tasked with organizing and running a sustainable summer camp program. The current camp is geared towards a smaller number of participants (20-40 instead of 60-70). The individual sessions are longer to accommodate more-involved experiments and extended interactions with college students. This experiential approach to engineering instruction is well supported in the literature. Richard Felder, one of the seminal researchers in the field of engineering education, contends that taking a more active approach in teaching engineering concepts is more effective than lecturing alone[8,9]. The idea of improving student learning and engagement through "active" activities in the classroom is supported by many other researchers and learning theorists[10,11,12].

There is a moderate fee to attend the camp as we, and others[13], have found that this ensures a higher level of commitment to attending the camp. The camp is planned and run by undergraduate student ambassadors headed up by the camp director/grant coordinator. We find that our engineering undergraduates bring a unique and valued perspective to camp planning. They reflect on those attributes of engineering that most excite them and do their best to bring them into the activities. Cook-Sather[14] and others support this model of students being active in the teaching process. We also find that the process of teaching others reinforces our undergraduates' learning and satisfaction with engineering[15].

Campers choose two of three different activities offered each day, all of which have a unified theme. In the last year we changed the requirements so that camp attendees now must be rising 10th through 13th graders as experiences with rising 9th graders were mixed; while the younger students were enthusiastic about the building activities some lacked the maturity to interact socially with the older students. Our current summer camp is not meant to be a rigorous academic experience or bridge program; it takes place shortly after school has gotten out for the summer and most of the students are looking for something that feels more like camp. Thus far only 2 of the 225 campers that have attended reported that the lack of substantial academic rigor was disappointing. The reformatted camp continues to be a good recruiting tool as seen by the high percentage of students that enroll at the University after they graduate high school. (Keep in mind that a significant number of the students that attended the camp in 2011, 2012 and 2013 were rising freshman and sophomores in high school so there is a delay before they will apply to college)

Table 1. Summer Camp attendees that have gone on to enroll at the University

Camp Year	#Number of Camp Attendees	# Enrolled at U (% that graduated high school)	#STEM Major (#engineering)
2008	67	24(36%)	13 (9)
2009	41	28 (68%)	13 (10)
2010	5	3 (60%)	2 (1)
2011	42	8 (61%)	7 (6)
2012	45	5(71%)	2(1)
2013	25	---	---

3. Advertising and Timeline

Advertising is a critical component of a successful summer camp. Early in the planning process it is important to outline your advertising campaign. Once the dates for the camp have been set, usually near the beginning of the academic year, websites with contact information should be updated. We have found that getting information to parents is the most important indicator for higher camp enrollment. In the years that we listed our summer program in the Youth Education Summer Program Guide, distributed through Continuing Education at the University, the number of applicants doubled. This summer camp guide is sent out to thousands of families whose children have participated in any program offered on the University campus. Youth Education retained part of the registration fee (20%), but we felt that this was a reasonable trade-off for their advertising and registration services. To be included in the brochure camp information and the theme needs to be supplied to them by mid to late January.

Somewhere around mid-April, Summer Camp program information is sent electronically to students and parents that have signed up to be on our mailing list (COE webpage and outreach events). Our undergraduate engineering ambassadors[14] carry the message out to classrooms they visit, and posters are sent to high school counselors in the local vicinity. Recently we have seen a significant increase in out-of-state students coming to our summer camp, which would suggest that search engines on the Internet provide a valuable referral service. For the June camps, online registration typically opens in the beginning of April. A general timeline for camp preparation is provided in Figure 1.

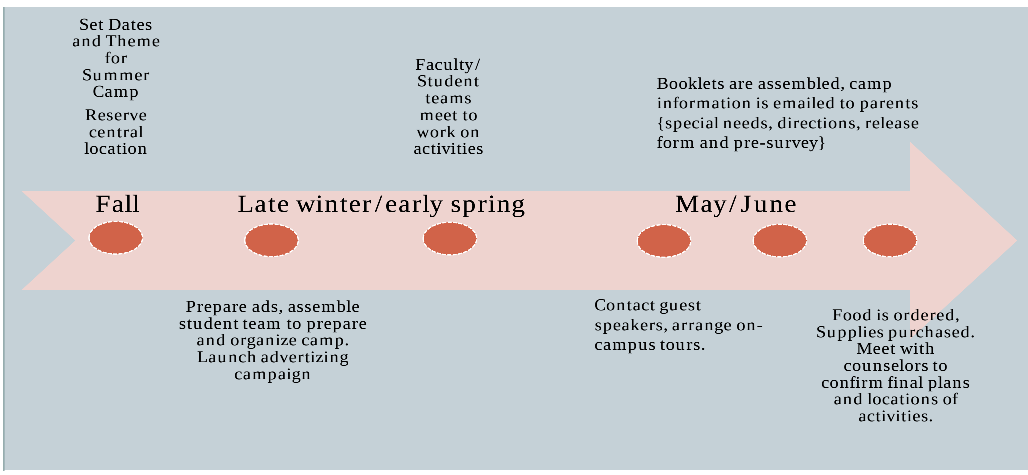

Figure 1: Timeline for Summer Camp Preparation

4. Themes and Activities

To create a more cohesive camp experience and reduce preparation time, three themes have been developed to guide the departmental activities and the group challenge activity on the final day. Themes for the last three years have been: 2011: Engineering a Greener Planet, 2012: BioInnovation and 2013: Lights, Camera, Engineering. The lead department and their undergraduate engineering ambassadors' works closely with the camp director to develop the final day theme-based challenge activity which is designed to highlight the lead department's field of engineering.

Each morning of the summer camp begins with "tabling" activities from the three departments that will be running activities that day. The table demonstrations are developed by the college students to showcase their departments and recruit the campers to their sessions. Campers then choose their activities for the day. The morning and afternoon sessions run about 90 minutes each. During this time our undergraduate students introduce their field of engineering and provide an experiential activity. These activities have included building a zombie-battling prosthetic arm (bioengineering team – Lights, Camera Engineering), making dye-sensitized solar cells (materials science team -Engineering a Greener Planet) and building Ornithopters (mechanical team -BioInnovation). This format also means that each department only needs to provide students and faculty for one day rather than two.

On the final day of camp the students are given an interdisciplinary design challenge. As an example, in 2011 the civil and environmental engineering group was the lead for the Engineering a Greener Planet camp program. One of the students served as the camp co-director and, with help from their faculty representative, they developed a schematic for cleaning and distributing a polluted water source (figure 2). Our chemical engineering team was responsible for designing a filtration system to purify out pollutants from a body of water (i.e. swimming pool); the mechanical and civil teams helped students to design and build multiple systems for transporting the water, while the electrical and computer engineering team helped students build the mechanical pumping system. The bioengineering team populated the pool with microbes (yeast) that were counted pre and post filtration; the material science engineering team created solar cells to help power the pumps, and the computer science team explored modeling of water distribution systems. Campers were divided up into three teams; within each team there were three groups dedicated to designing and assembling the different components of the system; water transport, filtration and distribution. The final projects were assembled outside on the final day of camp. An eclectic group of materials was supplied to build each system. Awards were given for best design, cleanest water post-filtration and highest throughput.

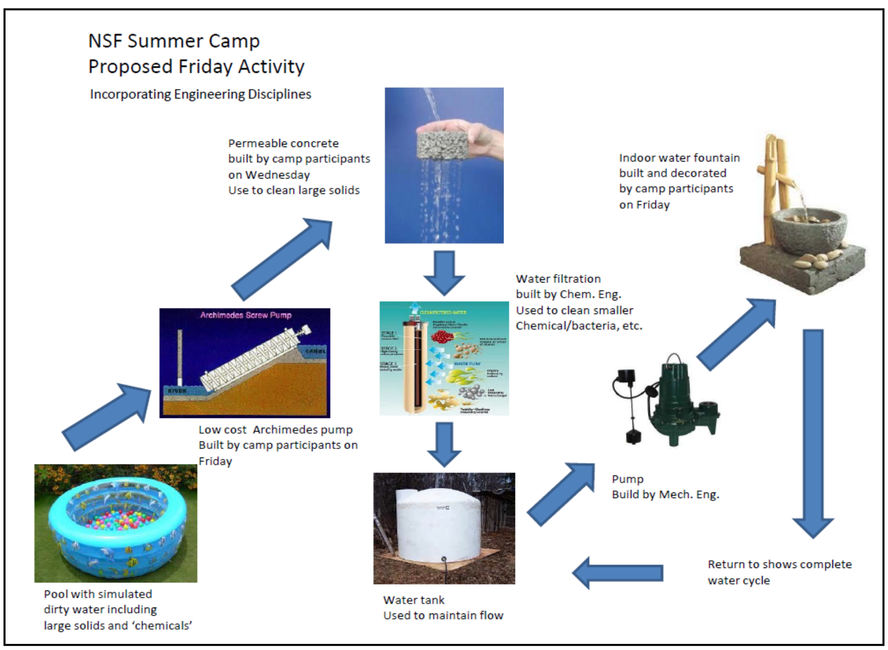

Figure 2: Schematic for Challenge Activity: Cleaning and Distributing a Polluted Water Source

5. Getting Faculty and Alumni Involved

During the first 5 years of our NSF grant, each department had a lead faculty member (co-PI) that received some funding off of the grant. This guaranteed their involvement helping undergraduates' students in creating activities for the summer camp. For the last two years, the majority of the responsibility for planning events and activities has fallen on the camp director and the undergraduate ambassadors; alumni and faculty have helped out with presentations.

Getting our faculty involved in the development of the activities is a significant time commitment, and, with limited financial incentives to offer, it relies on their personal interests in community engagement and outreach. Now that much of the groundwork has been laid with proven themes and activities we are not as dependent , but always appreciate, faculty participation. Looking forward it may be useful to dove-tail efforts and activity preparation with the HI-GEAR camp that tap into the faculty that have written in support via an outreach component in CAREER or other broader impact NSF grants.

6. Assessment and Impact

A significant amount of effort has gone into evaluating the content and impact of our summer camp. As our main goal was to positively influence high school students' awareness of engineering; our primary survey was geared towards looking for changes in their perceptions. Attendees were sent a pre-survey and asked to return it to us prior to the first day of camp. The survey measured their "opinion" of engineering as a profession and asked them to let us know what they hoped to get out of attending the camp. This was followed up by an exit survey at the end of camp to see how their opinions had changed. Assessment data from our 2012 summer camp is presented below. The lead team was chemical engineering and the theme was BioInnovation. The challenge activity was to build an artificial circulatory system that could neutralize three glucose challenges simulated by neutralizing a dye-challenge using an acid-base reaction.

Table 2: Results of Pre and Post Surveys: Summer Camp 2012

Answers are rated on a Likert scale with 1 as strongly disagree and 5 as strongly agree.

Survey Questions (from College of Engineering) : 45 respondents	Pre-Camp	Post-Camp	Change
1. Engineering is a "helping" profession (i.e. like nurses, teachers, and doctors).	4.0	4.6	+0.6
2. Engineering is a "creative" profession (i.e. like artists, architects).	4.2	4.6	+0.4
3. Engineering is a "social" profession (i.e. get to meet lots of people, work a lot with others).	3.5	4.3	+0.8
4. Engineering is a profession that appeals to girls.	3.3	3.8	+0.5
5. Engineers make a good salary.	4.0	4.6	+0.6

6. Engineers work on lots of social issues (i.e. healthcare, saving environment, etc.).	3.7	4.6	+0.9
7. Engineering and technology make our lives better.	4.6	4.8	+0.2
8. I am considering majoring in engineering.	3.9	4.4	+0.5
9. I know what engineers do.	3.7	4.5	+0.8
10. I enjoy taking math and science courses	4.2		

Campers also responded to short surveys at the end of each day of camp to collect feedback on the activities they participated in. In an attempt to directly assess the influences of participating in specific activities, students were asked to rank order the area of engineering that most interested them at the end of each day. Table 3 shows that participation in experiential activities increased interest in the type of engineering they were exposed to and that by day 3 all campers felt they knew enough about each area of engineering to rank them.

Table 3: Tracking Primary Engineering Interest over Time and Camp Activity:
The percentages for the day the department activity occurred are bolded

What type of engineering are you most interested in at this time (please rank order with 1 being your top choice)? First choice rank:	Pre	Day1	Day2	Day3	Net change
• Biomedical	15%	9%	**16%**	18%	+3%
• Chemical (lead team)	11%	11%	11%	**21%**	+10%
• Civil/ Environmental	9%	**9%**	5%	5%	-4%
• Computer Science	7%	0%	**7%**	8%	+1%
• Electrical/Computer	13%	**13%**	14%	16%	+3%
• Materials Science	7%	2%	**7%**	5%	-2%
• Mechanical	15%	**33%**	16%	28%	+13%
• Don’t know enough to rank them, not sure	24%	22%	23%	---	

Taken collectively, our survey data suggests that the summer program increases in the camper’s positive perceptions about engineering. Their day-to-day experiences appear to correlate with their level of interest when they leave the camp. For the 2012 camp, nearly 60% of the participants said that the camp exceeded their expectations, while the remaining 40% said that their expectations were met. It is of interest to note that over the last three years, the lead team that runs the final day challenge activity has seen one the largest increases in interest, suggesting that departments that are looking to recruit would benefit the most by being the lead team.

The camp counselors also expressed their satisfaction with the camp experience. This is a unifying event in which undergraduates from all the departments meet and work together in the implementation of a cohesive camp. It helps to reinforce the aspects that they enjoy about studying engineering, and why this is a good field for them. More details about how our college students are impacted by their involvement in our summer camp are provided in another paper presented at this conference[15].

7. Costs and Sustainability

The net cost for running a three-day engineering camp for 40-50 students over the last three years, has been approximately $8,000. A majority of the expense is attributed to personnel costs for the 20 to 25 undergraduate students that are paid to help prepare and run the camp. The cost of supplies varies depending on the activity, and the registration fee of $60-75 per camper offsets all of the food costs for all participants and counselors. The camp costs discussed here do not include approximately 160 hours of professional staff time to prepare, organize and run the camp.

Looking forward, we can see a few ways that the camp costs can be reduced. As we currently have three themes and activities designed for each, preparation time should be reduced in the future. We will also try to share activities and supplies with the HI-GEAR girl's camp. A co-operate sponsor has been secured so that Exploring Engineering Camp will be sustained by the College of Engineering.

Conclusions

Summer camps are an excellent way to introduce high school students to the field of engineering. Our data shows that we have successfully increased awareness of engineering as a career for all of the students that have attended our summer program. Changes made to the program over the last 3 years has helped the camp gain popularity within the community, and has increased the number of attendees to a point where we have decided to limit the number that can attend. Of the 133 college-aged participants that attended our camp between 2008 and 2012; 20% are now engineering majors at the University. As it is impossible to track students that may be pursuing an engineering degree at other institutions we can only hope that additional campers have gone on to pursue their engineering interests elsewhere.

Bibliography

[1] House, W. (2012) Engage to Excel.

[2] http://prosperity2020.com/the-vision/

[3] Lighty, J., C. Barnhart, C. Whitaker, and J. Coleman, 2004. University of Utah College of Engineering Hi-GEAR: Girls' Engineering Abilities Realized. *Proceedings of the 2004 WEPAN Conference*, Albuquerque, NM.

[4] Sinkele, CM 2011, 'The Effectiveness of Engineering Workshops in Attracting Females into Engineering Fields: A Review of the Literature', *Clearing House*, 84, 1, pp. 37-42, Professional Development Collection, EBSCO*host*, viewed 11 March 2014.

[5] Zurn-Birkhimer, S., & B. Holloway (2008), A summer camp program to introduce girls to opportunities in engineering. *Women in Engineering ProActive Network*.

[6] M.Yilmaz , J .Ren, S. Custer, and J. Coleman, "Hands-on summercamp to attract K–12 students to engineering fields," IEEE Trans. Educ., vol. 53, no. 1, pp. 144–141, Feb. 2010.

[7] Hylton , P. and W. Otoupal, "Stratification of Attitudes and Skill level as correlated with knowledge and Self confidence", Proceedings *of the 2007 ASEE Annual Conference*, Milwaukee, Wisconsin.

[8] R.M. Felder and R. Brent, "How to Improve Teaching Quality." *Quality Management Journal, 6*(2), 9-21 (1999)

[9] Gasser, M., L.Yung-Hsiang, and C.-K. Koh, "Outreach Project introducing computer engineering to high school students", *ASEE/IEEE Frontiers in Education Conference 2010*, Washington, D.C.

[10] Bloom, B. S. (1956) *Taxonomy of educational objectives: the classification of educational goals. Handbook 1: Cognitive domain.[DEWEY]*.

[11] Bonwell, C.C., and J. A. Eison, "Active Learning: Creating Excitement in the Classroom," ASHE ERIC Higher Education Report No. 1, George Washington University, Washington, DC. , 1991.

[12] Fink, L. D. (2003). Creating significant learning experiences: An integrated approach to designing college courses. San Francisco, CA: Jossey-Bass.

[13] Lorenz, B. "Bringing Engineering Forward to High Schools", *ASEE/IEEE Frontiers in Education Conference 2004*, Savannah, Georgia.

[14] COOK-SATHER, A. (2006). Sound, presence, and power: "Student voice" in educational research and reform. *Curriculum Inquiry, 36*(4), 359-390.

[15] Krapcho, K., J. S Bates, C. Orantes, and N. Farhang "How to Recruit and Retain Students using an Engineering Ambassador Program". *Proceedings of the 2014 ASEE Annual Conference*, Indianapolis. Indiana.