NIU - Enhancing Engineering Pathways (NIU - EEP) - Combined Outreach and Mentoring Programs for Girl Scouts

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Abstract

This project puts forth an alliance between the College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU), the Collegiate section of the Society of Women Engineers (SWE), the Prairie Winds Girl Scouts Council and the Sybaquay Girl Scouts Council to develop a program to introduce engineering to the Cadettes and the Senior Girl Scout members. These two groups comprise of the middle and the high school age kids. The framework for the summer camp is focused on engineering design through hands-on activities, teamwork to enable the participants earn an Interest Project Patch [Girl Scouts, 1997] from the Girl Scouts Council and an Event Patch from the Society of Women Engineers and a mentoring program for all girl scout members.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) fields have become increasingly central to the U.S. economic competitiveness and growth. In order to maintain the engineering and scientific leadership in the midst of globalization, the U.S. must work to increase the innovative capacity of its entire people. Trends in K-12 and higher education science and math preparation, coupled with demographic and labor supply trends point to a serious challenge: Need to increase the supply and quality of "knowledge workers" whose specialized skills enable them to work productively in the STEM areas. These critical shortages in the nation's STEM workforce have generated substantial interest from government and industry leaders to increase the recruitment and retention of women in STEM education and employment[Leslie et.al 2006, NAS, 2006]. According to the Bureau of Labor Statistics, this shortage in the STEM workforce is expected to increase by approximately 44% over the next ten years. Engineering suffers the most of all STEM fields. Statistics of women in STEM education and careers nationwide is staggeringly low at 11%. The largest untapped pool for increasing the U.S. scientific workforce, as stated by the National Science Board of the National Science Foundation, includes women, blacks, and Hispanics[Rita, 2000] One major factor facing universities in their efforts to increase the number of women in undergraduate engineering programs is the small applicant pool. The small percentage of women in engineering and other technical fields many times results from inter-related social and educational issues. One significant factor is the lack of preparation and /or interest in the academic areas of math, science and technology. Insufficient opportunities to learn about the contributions the field of engineering makes to improvements in areas such as education, healthcare, and safety, fields that often resonate with women, as well as perceptions of young women, their parents, teachers, and school counselors are also contributing factors. Lack of female role models is another factor leading to a feeling of isolation in the classrooms. As a result, many highly capable girl students who develop negative attitudes towards science either do not receive adequate math and science education or drop out of math and science in high school or before college, thereby making it difficult to acquire the necessary academic background for STEM careers. So, definitely an aggressive, focused intervention effort at each educational stage must be made in order to increase the recruitment of women in the STEM areas. Effective strategies have to be developed and synergistic activities have to be laid out between the K-12 and the engineering colleges in order to increase the recruitment and retention of women and minorities. Enhanced engineering education in the K-12 classrooms could provide students at an earlier age with a more specific understanding of what a technical career would entail and would help in promoting engineering as a viable career option.

One approach in attracting more young women to study engineering is to sparkle their interest in engineering early on in their education especially in their middle and high school years. This introduction to engineering might motivate the students to take more math and science courses as a preparation for college. Studies indicate that a critical point in the pipeline of women into technological careers is the middle school years, when it is common for girls to lose interest in math and science. Middle school has become the crucial time to connect with students about their future career choices. A number of outreach programs like the after-school/out-of-school programs, Saturday enrichment programs, summer camps etc. which basically serve as a recruitment tool, have been developed to introduce and encourage the girls to careers in engineering[JoAnn&Susan 2002, Karen 1996]. Several opportunities are available to introduce young women to engineering through alliance with the local Girl Scouts of the USA councils, Society of Women Engineers (SWE) etc. Girl Scouts of the USA is an organization solely dedicated to the growth and development of girls and young women from kindergarten to the twelfth grade. They provide the girls with a wide variety of opportunities and activities in different focus areas. One such area where in girls can push their boundaries and look around with their inquisitive eyes is the STEM area. Girl Scout badges/patches can be earned in the STEM area by accomplishing all the activities in the specific area chosen. Society of Women Engineers (SWE) has been offering hands – on workshop for Girl Scouts in many councils for a long time now. These two organizations signed up a Memorandum Of Understanding (MOU) in the year 2001 to develop age-specific activities, facilitate ways for SWE members to serve as mentors and role models for the girls scouts and establish mutual web links to facilitate collaborations at all levels. Many universities have been running similar camps with their local girls scout councils and the SWE local collegiate sections [JoAnn&Susan 2002,Karen 1996,Fran&Paige 2007].

In this program titled, "NIU-EEP – Combined Outreach and Mentoring Program for Girl Scouts" one such alliance i.e., the student section of SWE at the College of Engineering and Engineering Technology (CEET) at NIU and the local councils of girl scout was initiated by a funding from the Motorola Foundation in the fall of 2008. In this program young women (ages 11-17) are being introduced to engineering and technology through a series of Saturday Engineering Workshops (SEW) and a summer camp. The Saturday Engineering Workshops and the camp have been designed for the Cadettes (ages 11-14) with the high school girls serving as the mentors for the program. One of the most innovative aspects of this combined outreach effort has been the chain mentoring that has connected the faculty and various women engineering professionals, the SWE undergraduate students, the Senior Girl Scouts and the Cadette Scout members. Studies of middle and high school females suggest that engagement with mentors can add significantly to improve the self-confidence with regards to math, science and technology[Nightingale&Wolverton 1990]. High school students mentoring the middle school students in the Saturday Workshops has helped to inspire the middle school girls to think about alternative long term futures as well as the path that lies immediately ahead of them – the high school. On the same mentoring note, connecting the high school students to positive role models at NIU with a special emphasis on undergraduate women students with different ethnic backgrounds in these outreach programs has helped and will also help these students make their career choices in the STEM related fields.

It is quite well known that during the middle school years, young women face many psychosocial developmental factors leading to decreased self-efficacy[Peggy 1994] and increased anxiety[George 1990]. Utilization of same sex role models is not only critical in the development of young women but also in the development of future engineers, specifically because these young women rely on social experiences for response and development. Women engineer/scientist role models or mentors educate, motivate, inspire and raise the self-confidence of young girls to obtain the outcomes they desire. In addition, a dialogue between middle school girls and high-school mentors, would help in reducing the fears, decreasing the failures, increasing the success, increasing the knowledge of various clubs for continued involvement in math and science, gaining information about the challenging classes and how to succeed in them, selection of science projects, etc. Hence, setting a mentoring chain would help the middle school students realistically face the challenges depicted by the high-school girls in the near term and, the other mentors namely, the SWE student members, the faculty and various female engineering professionals would help the middle and high school girls broaden their visions of possible long term futures. Networking various mentors with the middle and high school girls via e-mails, would enable young girls who are shy to express themselves at the camps or the Saturday workshops to be really verbal and freer to express emotional content. The high school mentors can also benefit from advice from their mentors about how to engage the middle school girls and can also work with their peers and can mutually offer guidance and support based on the experience in their own teams. Thus, the use of same sex role

models may combat the negative psychosocial developmental factors experienced during the adolescence allowing them to learn in a more comfortable and nurturing environment that prepares them for science, math and technology related careers. The key synergism exploited in this proposal is the involvement of SWE student members in the outreach activities as teachers, counselors, advocates, mentors etc. and the involvement of the high school girl scout members to mentor their middle school counterparts. These mentoring programs in addition to being a great recruiting tool would also serve as a great retention tool.

In this paper, the process of establishing the Saturday engineering workshops and progress that has been made so far towards achieving the goals is being reported. The summer camp is going to be conducted during the last week of June 2009 at the NIU, DeKalb campus. These engineering workshops and camps have been designed to be fun-filled with exciting ways to learn about the field of engineering and also learn of the various career opportunities that exist in the broad world of engineering and the physical sciences.

NIU-EEP Program Description

Funded by the Motorola Foundation, this program was initiated in the Fall of 2008 as a series of Saturday Engineering Workshops (alternate week for 2 hours in the morning) geared towards the middle schoolers with the high schoolers serving as mentors for the program. The program is nearing its completion of its maiden year culminating with a summer camp during the last week of June 2009. Two girl scout councils, the Girl Scout Council of Greater Chicago & Northwest Indiana and the Sybaquay Girl Scout Council serving the areas - Cook, Lake, DuPage, Kane, Kendall, Will, Grundy, Kankakee, DeKalb, McHenry and Lasalle counties in IL, Lake, Porter, Jasper and Newton counties in Indiana were partnered with for this program. A total of 48 middle schoolers were selected for this program. Sixteen high school mentors were selected based on their grades and recommendation letters to serve as Team Leader Mentors and Leader Mentors. Five undergraduate students from the College of Engineering and Engineering Technology served as the college mentors for the entire middle and the high school cohort of girls. As the major philosophical component of the saturday workshops and the camp has been the emphasis on teamwork, cooperation and creative problem solving when faced with engineering challenges with mentoring as a major component, the girls' scouts (cadettes) were grouped into engineering designing teams with a SWE student member & couple of Senior Girl Scout members as counselors/mentors.

Goals, Objectives & Implementation Strategies:

The major goals that were set for the program were:

1. To establish a sustainable pathway for the middle and high school girls through the Girl Scout Organizations to the Field of Engineering.
2. To increase the level of awareness among the female students about the opportunities available in the field of engineering
3. To establish a very successful mentoring program by providing the middle and high schoolers with positive role models and access to the professional community and also easing the transition from school to college.
4. To increase the retention of female engineering students to degree completion and beyond.

Specific Objectives that have been advanced:

- To reach out to an audience who may not have previously considered STEM careers as opposed to students who self-select into STEM outreach programs.
- To reach out to girls early enough to influence their choices of math, science and technical courses in their middle and high school years.
- To establish various mentoring methods: Group mentoring, Team mentoring, Student mentoring, Faculty mentoring, Peer mentoring, Academic and Professional mentoring.
- To inspire, motivate and prepare them to succeed in college-level engineering programs through the activities required to earn Interest Project Patches from the Girl Scouts.
- To provide the SWE student members with the chance to develop and implement engineering-related activi-

ties.

- To train the SWE student members as leaders and mentors to the high school girls, thereby enriching their college experience.

In order to achieve the above objectives and realize the outcomes the following strategies have been adopted for this program.

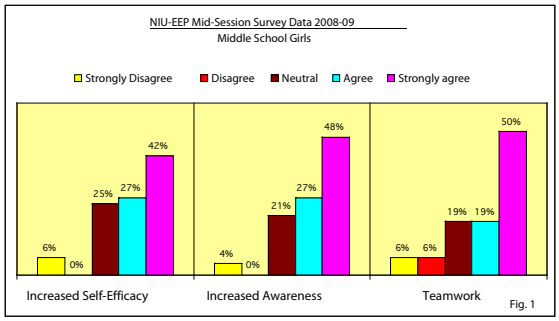
* *Hands-on Learning:* Activities involving critical thinking and problem solving skills like building simple circuits with light bulbs, series & parallel circuits, use of breadboards and multimeters to measure the voltages and currents, circuits with LEDs, analyzing Christmas lightings, exploring different types of flashlights (LEDs, hand crank ones etc.), fruit batteries, an introduction to Lean Manufacturing by building minijets, an introduction to animated computer programming etc. have been carried out for the past year during the Saturday Engineering Workshops (SEW).
* *Real-world problem solving:* One of the projects that have been designed for the program participants has been the problem associated with energy minimization at homes. Participants were assigned with tasks to determine the energy usage of lamps and other appliances at their homes and design a novel strategy to minimize the usage. The girls then learn to enter the problem solving process, by identifying and investigating the problem, assessing the current situation, identifying the critical issues and constraints that have been affecting this problem and the energy crisis globally, then explore the potential solutions to the problem. Through guided discussions with the mentors, the young girls have been learning to advance newer and appropriate concepts for solving the problem at hand.
* *Collaboration and teamwork:* As teamwork has been one of the major focus for the SEW, the entire cohort of 48 middle schoolers, 16 high schoolers and 5 undergraduate mentors were placed into 8 teams for the entire period of a year to carry out the various projects. This helped the girls experience engineering as a social, collaborative profession that benefit from oral and interpersonal communication skills.
* *Building self-efficacy and awareness:* The strong encouragement and support that was provided by the mentors has helped the middle school girls build their self-efficacy. Some of the performance accomplishments have been the biweekly presentation by the participants of each group for a few minutes before the start of each session & a strong desire to share their science fair projects with the NIU-EEP community. The interaction with various female engineering role models during the workshops, watching science and engineering discovery videos related to the hands-on projects has helped to increase the awareness of the field of engineering to a great extent. The awareness would be magnified to a much larger extent
* *E-Mentoring:* One of the main strategies to promote long-term effects of this outreach program has been the networking through e-mentoring. Middle school girls have been provided with the opportunity to be mentored by their immediate seniors -- the high scholars, the engineering female undergraduates who are members of the society of women engineers, women faculty from the college of engineering and engineering technology at NIU and various other professional women engineers by way of online discussion forums, frequent emails during the school year. In order to facilitate this mentoring method, the NIU-EEP website (www.niu.edu/eep) and the discussion board using the blackboard tool of NIU has been established.
* *Summer Camp:* The theme for the summer camp that would be held during the last week of June 2009 is “Sustainability: Green Technologies”. A camp atmosphere would help the students to relax, socialize, enjoy recreational activities, and interact with the other science and engineering college students & college faculty while doing their various hands-on activities. The campers would get a realistic perspective of what majoring in college science or engineering is by interaction with various college students. The ultimate goal of the camp would be to provide a challenging, motivating and a memorable experience for all campers where creativity, ingenuity, teamwork and hard work would be the high valued rewards.

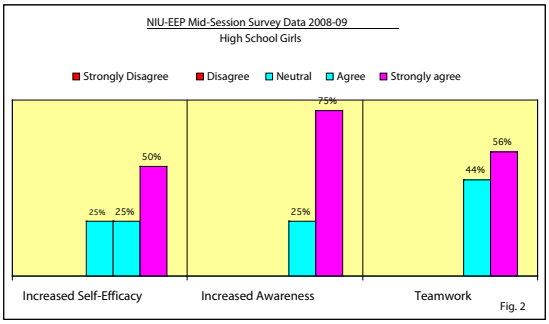
Results and Discussions

Most of the typical outreach activities include surveys which are typically formative and one-time, given at the end of the event when the participants are geared up with responses. While this type of survey is certainly important, from the point of view of larger goals and objectives, combining formative with summative along with traditional

outcomes tracking would definitely provide an overall picture for enhancing and redirecting an outreach effort. With this in mind, pre and post survey have been developed for this program. As the program, has not yet reached its end of the first year term, mid-session surveys were conducted in addition to the pre-surveys. The initial most significant program success were the increased degree of awareness and increased self-efficacy that were achieved through the series of workshops that provided opportunities for various hands-on activities, interaction with a broad spectrum of female engineering role models, lectures and video demonstrations etc. These results have been shown in the graphs below.

Fig 1 & 2 – Plots of Self-Efficacy, Awareness and Teamwork for Middle and High School girls.





It can be seen from the above graph (Fig#1) that 75% of the middle school girls strongly agreed or agreed to have an increased awareness in the field of engineering and 69% middle school girls strongly agreed or agreed to have an increased self-efficacy after four sessions of the Saturday engineering workshops. All the high school mentors (100%) strongly agreed or agreed to have an increased awareness in the field of engineering and 75% of the high school mentors strongly agreed or agreed to have an increased self-efficacy after four sessions of the Saturday engineering workshops (Fig.2). It can be seen from fig.1 that approximately about 25% of the middle schoolers either were neutral, disagreed or strongly disagreed to increased self-efficacy and awareness. This is because of the fact (as recorded from the pre-surveys), that a fraction of the middle schoolers came from families where the parent education levels were high and their awareness levels were significantly higher than their peers to begin with. However, it can be seen from the high schoolers that all of them either agreed or strongly agreed for increased awareness.

The graph plotting the teamwork shows that more than 70% of the middle schoolers and all the high schoolers either strongly agreed or agreed that teamwork helped them network with other students and helped in their engineering projects. However, approximately 30% of middle schoolers either were neutral, disagreed or strongly disagreed with this concept of teamwork. One of the most significant program challenges has been the teaming of the middle schoolers into various groups. There were lots of inhibitions amongst the middle school girls to work with girls from various other area schools and school districts. This challenge was overcome with the help of the high school mentors and the SWE undergraduate mentors who counseled them to work with new girls and make newer friends. Also, the focus on the various hands-on activities made the middle schoolers realize that it was fun to make new friends, get to know them and eventually work with them in their new teams. As this data was collected after four workshop sessions, the results of the surveys reflected have been very preliminary. A post-workshop survey would help in understanding this teamwork factor.

Some of the sampled answers/comments to the question: “List the three most significant things you have gained or learned from this workshop, so far.” from the questionnaire:

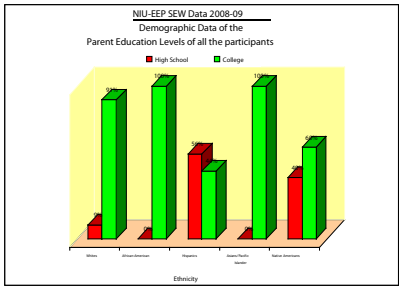
From Middle Schoolers:

1. *“I know more about circuits now, how to create series and parallel circuits and how to draw a schematic diagram – This has been an amazing program and is one of my favorite workshops”*
2. *“I like engineering now!”*
3. *“I am enjoying interacting with the mentors”*
4. *“ Have learnt about various courses required to be an engineer”*

5. *" Have learnt how to build relationships"*
6. *"Have learnt that some of the other girls are really nice"*
7. *"Have learnt to be social and to be open to new things"*

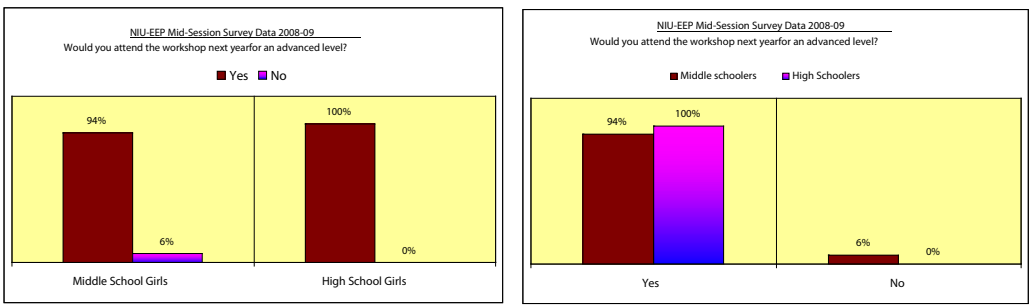
From High School Mentors:

1. *"I learned about how much engineers do, far more than I previously thought"*
2. *"I am learning a lot that I didn't understand about circuits and electricity"*
3. *"I am having a good learning experience with teaching the middle schoolers"*
4. *"I have learned how to be a good role model to middle school girls"*
5. *"I have learned how to explain complicated processes to people"*
6. *"I have gotten to bond and share my experiences with the middle schoolers"*
7. *"I have grown more confident and have an easier time leading a group'*
8. *"I have learnt how to teach middle school students"*



The initial success of the program for the first year has led to the funding for an additional year from the Motorola Foundation. The new partnerships that have been established for the second year have a high percentage of under-represented minorities whose awareness about the field of engineering is generally pretty low (Fig. 3 – adjacent figure shows the demographics of the parent educational levels for the present participants of this program). These female students would like to be provided with opportunities to participate in these STEM outreach programs. It can be seen from the adjacent figure that the percentage of high school graduates (with no college degree) amongst the parents in the present program is quite high for the Hispanic and the Native American ethnicities. Hence, enrolling a greater number of these underrepresented minorities into this program would help in increasing the awareness and self-efficacy of these female students, which would eventually help in realizing the objectives outlined in the present program. The plot shown below is a graph of the percentage of girls willing to attend the workshop next year at an advanced level. It can be seen from the figure that all the high school mentors and 94% of the middle school participants were interested in attending the workshop next year. This definitely points to the initial success of the program in achieving its goals.

Fig 4 – Plots showing the percentages of girls willing to attend the SEW for an advanced level next year.



Sample pictures from a few of the SEW Sessions:

Future Work

The renewal program for the second year the funding for which has come through, would comprise of two series of Saturday Engineering Workshops (12 Saturdays of 2 hours each for each series), one focused on the new incoming middle schoolers (beginner's level) and the other focused on the middle schoolers who have been part of this program (advanced level) for the past one year and advanced to the next level. These workshops would be spanning the Fall 2009 & Spring 2010 period and would be capped by a combined week long camp during the Summer of 2010. The Interest Project Patches that have been selected from the Girl Scout Organization book are the "Build a better Future" Patch for the beginner's level and the "Inventions and Inquiry" patch for the advanced level scout members. For the build a better future project, middle schoolers would learn the basics of electricity and magnetism through various hands-on activities, reverse engineer some of the consumer electronics like, a flashlight, and electric door bell, an electronic toothbrush, cellular phones etc. and design and carry out a project on energy consumption in their respective homes using a "Kill A Watt Meter". This project would help the middle schoolers in advancing newer and appropriate concepts which would eventually empower them in their understanding of the energy consumption. For the inventions and inquiry project, students would design, build and also learn to program robots. Students in this advanced level would learn concepts spanning the various engineering disciplines. Field trips to various places like the Argonne National Lab, Motorola Innovation Center, and Challenger Center in Woodstock etc. would be organized for the summer camp. The Saturday engineering Workshops for both the beginners and the advanced level would be conducted every other week starting September 2009 and ending in May 2010. An all engineering day would be conducted at the end of the workshop series during which all the teams would present their findings of their experiments in a power point presentation.

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