Girls Reaching and Demonstrating Excellence (GRADE) Camps: An Innovative Recruiting Strategy at the University of Houston to Increase Female Representation in Engineering

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Abstract

The University of Houston Cullen College of Engineering hosts GRADE (Girls Reaching and Demonstrating Excellence) Camps through grants from the National Science Foundation and the Texas Engineering and Technical Consortium. This innovative weeklong summer day camp is designed to introduce ninth through twelfth grade high school females to the marvels of engineering.

Program content is comprised of electrical, computer, and mechanical engineering topics, such as electricity and magnetism, motors and generators, and control systems, all of which are necessary for the girls to design, build, and program a Lego™ robot to autonomously maneuver through a maze. Multidisciplinary engineering faculty and Society of Women Engineers (SWE) undergraduate and graduate mentors guide the girls through the curriculum and help them develop problem solving and teamwork skills. Through these exercises, the girls develop a working knowledge of fundamental engineering concepts involved in building the robot and discover the fun of creating a working design. The girls interact with local female engineers, faculty, and undergraduate and graduate students throughout the week. Topics of discussion not only include general engineering questions, but also issues specific to females pursuing careers in engineering. At the end of camp, the girls present what they learned and demonstrate their robots to their parents, teachers, and peer participants.

To date, over 125 girls representing a broad spectrum of ethnic and socio-economic backgrounds have completed the program. To provide continued support, guidance, and contact with other GRADE campers, faculty and guests throughout the girls' academic careers, all GRADE Camp participants are encouraged to use a dedicated and secure GRADE Camp Communities of Practice website. Efforts are ongoing to track GRADE camp participants through their college years.

Program Rationale

The continuation of the technology explosion into the 21st century necessitates the availability of a diverse and highly capable, technical workforce. The formation of a diverse workforce depends on active recruitment of women and minorities (both historically

underrepresented groups in the field of engineering). Recent statistics show that while women represent more than half[1] of all U.S. undergraduates, only about 20% of bachelor degrees awarded in engineering in 2003 were to women[2]. Many young women have the skills and qualifications to study in one of the science, technology, engineering, or mathematics (STEM) fields, but choose careers in business, social science, and the humanities without ever considering more 'technical' careers. We believe this is due in large part to lack of appropriate role models for traditionally underrepresented students, lack of early exposure to STEM related fields and career information, insufficient knowledge about how to study effectively, and lack of resources to support students throughout their academic careers. For these reasons, the University of Houston (UH) created Girls Reaching and Demonstrating Excellence (GRADE) Camps. Our program focuses on recruitment of females into the STEM areas, particularly engineering. Furthermore, the diversity of our community and campus allows us to reach a number of historically underrepresented ethnic groups.

The program goals of GRADE camps are 1) to help female students make an informed choice about pursuing an engineering or other STEM career field and 2) to help increase the number of female and minority students in engineering careers. The program has grown from two one-week camps in June of 2003 to four camps held in June of 2004. GRADE camps are targeted towards entering ninth through twelfth grade girls (25 to 30 per camp) with appropriate math and science background for their grade level.

Program Content and Pedagogy

GRADE Camp provides direct and formative exposure for ninth through twelfth grade female students to engineering principles through a challenging and interesting weeklong summer day camp where participants have opportunities to experience engineering first-hand. GRADE Camp utilizes active, co-operative learning and hands-on experiences rather than traditional lecture or demonstration-based formats. Participants learn theory during the mornings and then apply the theory during the afternoons in sequential, hands-on laboratories completed in teams of two or three girls. Each activity and discussion session is carefully designed to lead into a portion of a final design project, thereby linking theory to practice. Opportunities are provided for participants to learn and practice skills essential for success in engineering: problem solving, teamwork, and communication skills. By working on design projects, students are required to apply their science and math knowledge to solve real world problems. Teamwork skills are developed as the participants discover that they must coordinate with other team members to carry out the tasks efficiently. The hands-on nature of the program content allows participants to experience first-hand the processes of scientific inquiry as well as engineering design. The design project also illustrates the necessity for a good foundation in math and science, which may be the first step toward making engineering a viable career choice.

To date, GRADE Camp has focused on the fields of electrical, computer and mechanical engineering. The girls learn engineering principles such as voltage and current, motors and generators, feedback control, and problem solving during the mornings, and apply their knowledge in the afternoons to program, design, and build a Lego™ robot. By the end of the weeklong camp, each team has built a robot that can that can autonomously navigate a maze. Our program is expanding to other fields of engineering, and a GRADE Camp with an

Environmental Engineering emphasis will be tested with focus groups in summer 2005 and piloted in summer 2006.

One pedagogical goal of the camp is to create a single-sex learning environment free of gender stereotypes and enriched with female role models[3-7]. This is accomplished in part by the involvement of current female undergraduate students as Society of Women Engineers mentors, who are assigned to each team of participants. Mentoring drives desired outcomes not only for GRADE camp participants, but provides current female students at University of Houston the opportunity to gain valuable mentoring experience. Mentors complete training prior to the Camps, which includes completing the same laboratory sequences as the Camp participants. Mentors are encouraged to ask participants guided questions to help the girls discover the necessary answers on their own. The motivation for providing girls with a learning atmosphere free of gender stereotypes is illustrated by the comments of two female high school students who participated in a focus group during the planning stages of GRADE Camp: these two girls shared a story about their first day of class at their high school. Both were enrolled in a computer course, but when they approached the room for the class and looked through the door, they saw a room full of male students. They turned around, walked to their counselor's office, and promptly requested a course change.

In addition to interacting with their camp mentors, the girls are able to enjoy lunch with a variety of female role models, which include female engineering students, engineering faculty and local practicing engineers. The conversations are candid and engaging; it is not uncommon to hear questions about how the role models decided to enter a STEM field. Breaks with entertaining non-project related activities are scheduled throughout each day of camp. These activities help ward off fatigue and prevent burn-out, and include fun sessions like "circuit jewelry making" and a Jenga™ challenge.

Each camp culminates with the GRADE participants' presentation of their design project to their camp peers, parents, and high school teachers of their choosing, followed by a formal luncheon with an honorary guest speaker. Past speakers have included a female NASA astronaut and a female engineer in upper administration at UH.

The entire camp's schedule for summer 2004 is shown in Figure 1.

G.R.A.D.E. CAMP 2004 Schedule					
	Mon	*Tue*	*Wed*	*Thu*	*Fri*
9:00	Meet/Greet/ Form Teams	Voltage & Current	Presentation Skills	Feedback Control	Presentation Preparation
9:30					
10:00	Problem Solving	Voltage & Current Lab	"Super" Science	Chair Course	Team Presentations & Robot Demos
10:30	Mental Twist	Circuit Jewelry Art	Motors & Generators	Work on Presentation	
11:00	Problem Solving cont.	Flowcharts			
11:30			Motors & Generators Lab	Lunch	
12:00	Lunch with Engineering Students	Lunch with Engineering Faculty	Lunch with Engineers	Visit to Visualization Lab/Communities of Practice	Guest Speaker and Luncheon
1:30	Robot Lab: Build & Learn Programming Environment	Robot Lab: Program Sensor Measurements, Collision Avoidance	Robot Lab: Build MazeBot, Program to Move & Turn	Robot Lab: Program MazeBot to Navigate in Maze w/ Sensor Feedback	
2:45	Machine Mime	Jenga Match	Trivia Challenge	Ice Cream Party	
3:15	Robot Lab: Build & Learn Programming Environment	Robot Lab: Program Sensor Measurements, Collision Avoidance	Robot Lab: Build MazeBot, Program to Move & Turn	Robot Lab: Program MazeBot to Navigate in Maze w/ Sensor Feedback	
4:30 - 7:30				Working Pizza Dinner: Finish Robots, Presentations	

Figure 1. GRADE Camp Schedule from 2004.

Demographics

A total of 129 girls have participated in the GRADE Camps to date (44 in 2003 and 85 in 2005), and another 100 are anticipated in the 2005 Camps. The ethnic diversity of the participants over the two summers reflects that of the diverse city of Houston; seven different ethnic groups have been represented, and 60% of participants come from a minority group. Figure 2 describes the ethnicities of participants to date.

Percentage of Participants	Ethnic Identity
40%	Caucasian
23%	African American
19%	Mexican American
12%	Asian/Pacific Islander
3%	Central/South American
2%	International
1%	Native American

Figure 2. Ethnic breakdown of GRADE Camp participants to date.

Continuity After Camp

Following GRADE Camp, participants are provided with a secure Communities of Practice (CoP) website hosted through the Cullen College of Engineering's Blackboard™ server. The site, available to the Camp participants, mentors, faculty, and Houston-area engineers involved in the GRADE program, is designed to maintain formative relationships between campers and role models and allow the girls to have a resource for technical questions, support, and camaraderie. Despite providing a training session to Camp participants on site navigation, a major impediment so far has been the use of the site after Camp. Analysis of site hits after Camp has revealed that participants are not using the site regularly after leaving GRADE Camp. Methods to further encourage its frequent use are being explored. One such proposed method is to develop a periodic newsletter to be posted on the site. Announcements of new issues can be emailed to subscribers, which will serve as a reminder to check the site and use it regularly.

In order to further recruit former GRADE Camp participants to STEM fields in general and the University of Houston in particular, girls who successfully complete the camp will be awarded a one-time $1,000 scholarship if they subsequently enroll in engineering, natural sciences or mathematics at the University of Houston their freshman year.

Assessment of Outcomes

The assessment techniques chosen for this program include interviews, surveys, observations, and a tracking system. Assessment goals are based on Kirkpatrick's program evaluation model[8], and can be classified as one of four levels: Reactions, Learning, Transfer, and Results. Figure 3 illustrates these levels of assessment.

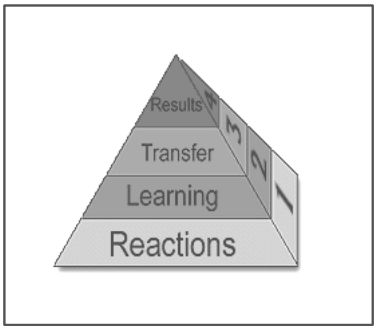

Figure 3. Kirkpatrick's Program Evaluation Model.
Taken from Encyclopedia of Educational Technology website.[9]

The "Reactions" level of assessment evaluates participant response to program content. GRADE Camp participants were asked to rate their agreement with various statements related to program content and administration on the fourth day of camp using a Likert scale (responses of "strongly agree", "agree somewhat", "not sure", "disagree somewhat", "strongly disagree"). This level of assessment included statements 2, 10, and 15-19 on the post-camp assessment shown in Figure 5.

The "Learning" level of our assessment was designed to measure STEM interest and awareness both pre- and post-camp. Girls were asked to evaluate their agreement with a series

of statements (numbers 1, 3-9, and 10-14 on the pre- and post-camp assessments) using a Likert scale on the first and fourth days of camp. Results are shown in Figures 4 and 5.

Item	Statements	Mean Rating [a]	No. With Rating ≥ 4 [b] (N=85)
1	I think that both males and females can study engineering.	4.96	85
2	GRADE camp will be interesting, meaningful, and worthwhile.	4.18	65
3	I believe that I can be successful in engineering.	4.25	67
4	I have been successful in my high school math courses.	4.41	66
5	I have enjoyed my high school math courses.	4.15	56
6	I have been successful in my high school science courses.	4.23	60
7	I have enjoyed my high school science courses.	3.96	52
8	I have an interest in studying engineering.	4.09	60
9	I will pursue a college degree.	4.86	82
10	I will have fun at GRADE Camp.	4.31	71
11	I will be more confident to pursue an engineering degree as a result of having attended GRADE Camp.	3.79	49
12	I will be more confident to pursue a science degree as a result of having attended GRADE Camp.	3.47	34
13	I will be more confident to pursue a technology degree as a result of having attended GRADE Camp.	3.64	47
14	I will be more confident to pursue a math degree as a result of having attended GRADE Camp.	3.55	42

Figure 4. Pre-GRADE Camp assessment corresponding to the "Learning" level of Kirkpatrick's model. Assessment was administered prior to the start of camp program on the first day. Participants were asked to use a Likert Scale to evaluate their agreement with the statements. [a] Rating of 5-0 were assigned to the responses "strongly agree", "agree somewhat", "not sure", "disagree somewhat", "strongly disagree", respectively. [b]Number of students with rating ≥ 4 ("agree"); N = 85, the total number of students who completed the survey.

Item	Statements	Post Mean Rating [a]	No. With Rating ≥ 4 [b] (N=85)
1	I think that both males and females can study engineering.	4.90	82
2	GRADE camp has been interesting, meaningful, and worthwhile.	4.55**	78
3	I believe that I can be successful in engineering.	4.46*	70
4	I have been successful in my high school math courses.	4.54	62
5	I have enjoyed my high school math courses.	4.46*	62
6	I have been successful in my high school science courses.	4.40	60
7	I have enjoyed my high school science courses.	4.29**	58
8	I have an interest in studying engineering.	4.29	70
9	I will pursue a college degree.	5.00*	85
10	I have had fun at GRADE Camp.	4.49	77
11	I will be more confident to pursue an engineering degree as a result of having attended GRADE Camp.	4.30**	70
12	I will be more confident to pursue a science degree as a result of having attended GRADE Camp.	3.90**	57
13	I will be more confident to pursue a technology degree as a result of having attended GRADE Camp.	3.99**	58
14	I will be more confident to pursue a math degree as a result of having attended GRADE Camp.	3.95**	59
15	I received all the help I needed from the staff.	4.76	81
16	I had ample opportunities to ask engineering questions.	4.82	80
17	I have made friends at GRADE Camp.	4.58	79
18	I enjoyed eating lunch with engineering mentors.	4.75	81
19	I enjoyed eating lunch with engineering faculty.	4.71	80

Figure 5. Post-GRADE Camp assessment administered at the end of the fourth day. Questions 1-14 are identical to statements in the pre-camp assessment. Items 2, 10, and 15-19 correspond to Kirkpatrick's first level of program evaluation, "Reactions", whereas the other items address the second level, "Learning". Participants were asked to use a Likert Scale to evaluate their agreement with the statements. [a] Rating of 5-0 were assigned to the responses "strongly agree", "agree somewhat", "not sure", "disagree somewhat", "strongly disagree", respectively. [b] Number of students with rating ≥ 4 ("agree"); N = total number of students who completed the survey. **Statistical significance as compared to pre-camp assessment, determined from T-Tests at $p<0.01$ level. *Statistical significance as compared to pre-camp assessment, determined from T-Tests with $p<0.05$ level.

Student's paired T-tests were performed at 95 and 99% confidence intervals to determine statistical significance in differences in girls' responses to pre- and post-camp assessment statements. A single asterisk (*) indicates statistically significance differences in pre- and post-camp assessment results at the $p<0.05$ level, whereas a double asterisk (**) indicates statistically significance differences in pre- and post-camp assessment results at the $p<0.01$ level. Results show that the girls' confidence in pursuing degrees in engineering, science, technology, and math degree (Items 11, 12, 13, and 14, respectively) improved as a result of participation in GRADE Camp. In fact, in the post-camp assessment, 70 out of 85 girls reported agreement or strong agreement with the statement "I will be more confident to pursue a degree in engineering as

result of having attended GRADE Camp," compared to 49 out of 85 responses in the pre-camp assessment. We anxiously anticipate tracking these girls into their college years to determine the next level of program evaluation, "Transfer".

The "Transfer" level of program evaluation involves querying past GRADE Camp participants six months after camp and then every year thereafter for seven years. These evaluations are designed to indicate the degree to which the GRADE participant has transferred her camp experience into her everyday life, particularly her self-efficacy about pursuing a career in engineering or other STEM discipline. Since our program is relatively new, this data is currently limited. This assessment gauges continuing STEM interest levels, and the nature of any increase or decrease in the girls' level of interest in pursuing a career in a science, mathematics, engineering, or technology field. These assessments are accomplished through tracking documents emailed to the former participants and also placed on the CoP website.

The "Results" level of assessment is ultimately the "bottom line" in recruiting these females into engineering or related fields. Our plan is to continue to track former GRADE campers through college to determine how GRADE Camp participation affects their choice of high school courses and ultimate college major. These assessments, available on the CoP website, are also mailed if necessary to students via email or regular mail. Typical questions tap science and math courses taken, college major, reasons for changing major (if applicable), and follow up beliefs about confidence to pursue a STEM degree. Five former GRADE participants enrolled in a STEM discipline in fall 2004; four at the University of Houston, and one at a community college. As of February 2005, the Cullen College of Engineering at the University of Houston has received four applications from former GRADE participants for the 2005-2006 academic year.

GRADE Camp participants and parents are asked to complete an exit questionnaire on the last day of camp. We share two student and two parent quotes from these surveys which illustrate the positive effect the program has had on past participants:

- "I learned more about engineering than I ever knew before while attending GRADE Camp. Through GRADE Camp, I was able to make my decision to pursue a degree in Electrical Engineering." – GRADE Participant
- "The most fun for me was talking to all the engineers and asking them questions I needed to know about the field or fields I am thinking about going into. Their advice helped me out a lot!" – GRADE Participant
- "Teamwork learned and practiced here will benefit campers throughout high school, higher education, and in the workplace." – GRADE Parent
- "My daughter enjoyed the camp and it has helped her in deciding a future career. The final presentation was very informative and showed how much material was covered in just a few days." – GRADE Parent

Conclusions

While we recognize that the group is to some extent self-selected by their participation in GRADE Camp, our initial goal in providing these camps is to provide early engineering exposure to females. We consider our program to be a particular success if these participants go on to major in engineering or other STEM disciplines at the college level. At the level of current

assessment, our data indicate that many of these young women are majoring in engineering, mathematics, science or technology once they reach college age, and that their participation in GRADE Camp has positively influenced their view of their own ability to be successful in one of these fields. Increasing the self-efficacy of these young women may prove to be the ultimate accomplishment of the GRADE Camps.

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