2006-1471: PARTNERS IN ENGINEERING: OUTREACH EFFORTS PROVIDE HOLISTIC ENGINEERING EDUCATION FOR MIDDLE SCHOOL GIRLS

Jan DeWaters, Clarkson University

Jan DeWaters, PE is currently pursuing a PhD degree in Environmental Science and Engineering at Clarkson University, with a focus on energy and environmental education. She has several years of experience as the curriculum coordinator for Clarkson's Project-Based Learning Partnership Program and is director of the Partners in Engineering Program that provides mentoring and engineering activities for eighth grade girls.

Susan Powers, Clarkson University

Susan E. Powers, PhD, PE is a Professor of Civil and Environmental Engineering and Associate Dean in Engineering for Research and Graduate studies at Clarkson University. She has directed an NSF-Funded GK-12 Program - Project-Based Learning Partnership Program for the past six years and received the NSF Directors Award for Distinguished Teaching Scholars in 2004.

Mary Graham, Clarkson University

Mary Graham, PhD is an Associate Professor in Organizational Studies at Clarkson University. Her research interests include gender-related employment discrimination. Dr. Graham was the external evaluator for the Partners in Engineering Program during the period AY01 through AY03.

Partners in Engineering: Outreach efforts provide holistic engineering education for middle school girls

Abstract

The Partners in Engineering (PIE) program brings together 8th grade girls and female engineering students from Clarkson University to experience mentoring, leadership, and real-life engineering problem solving. The program aims to empower young women to make informed and educated choices for advanced coursework and careers in engineering and technology-related fields. A team of female engineering student mentors teaches a three-week long engineering problem solving unit to 8th grade technology classes, in which students apply an engineering problem solving process to address and solve an issue that is relevant to their school or community. Students are exposed to the creative side of engineering problem solving and the breadth of the engineering disciplines. The holistic nature of the problem solving activity emphasizes the relevance of engineering problem solving to community, society, humanity, and the environment. Extracurricular mentoring activities provide participants with opportunities to interact more closely and to develop stronger personal relationships. Evaluations have consistently shown that the mentoring/role model component is the most widely appreciated aspect of the program, valued highly by the college mentors, the 8th grade girls, and their parents.

While the overall assessment plan includes a combination of quantitative and qualitative instruments to provide an in-depth understanding of the program's impacts, this paper reports findings from the qualitative aspects of the program evaluation. The assessment has shown that the program improves participants' understanding and appreciation of engineering problem solving, increases the younger girls' general understanding of engineering and the potential role of women in engineering careers, provides leadership opportunities and opportunities for increasing self confidence and self-efficacy, and provides positive role model and mentoring experiences. Positive feedback from teachers and parents supports these findings. Comments indicate that the 8th grade girls benefit from their participation in the PIE program - through their contact with the women engineering students, the breath of exposure to professional women in general, and the experience of using math and science to solve a meaningful problem.

Introduction

The underrepresentation of women and minorities in engineering, science and technical (SET) fields is well documented.[1-5] Women and minorities (both sexes) comprise about two thirds of the entire U.S. workforce, but account for only 25 percent of the technical workforce,[2] while minority and non-minority females represent a mere16 to 17 percent of the SET workforce.[6] Trends in the composition of the U.S. workforce show a steady decline of white male representation and an increase in female and minorities, yet representation of women and minorities in the SET fields remains flat.[3, 7]

The need for scientists, engineers and advanced-degree technologists in the U.S. workforce is expected to grow as the economic and cultural aspects of our society become increasingly grounded in technological advances. The U.S. Department of Labor projects that the growth of

jobs requiring technical degrees will grow at three times the rate of occupations in general, while twenty-five percent of our current scientists and engineers are expected to reach retirement age by 2010.[2, 6] The net result will be an anticipated two million new jobs in science and engineering by 2010. If the number of American women and minorities obtaining degrees in quantitative disciplines such as math, engineering, computer and physical sciences were representative of their proportion in the general population, it is estimated that there would now be over a million more qualified workers in those fields.[1] Efforts to bring the composition of the SET labor market more in line with that of the general U.S. workforce will help to avoid the projected severe shortages in SET professionals. The operative question is: *where* do women and minorities disappear from the pool?

Engineering enrollment vs. bachelors degree data indicate that the problem of female scarcity is one of enrollment into, rather than one of dropping out of, engineering programs.[8] Once enrolled, women are more likely than their male counterparts to complete a science/engineering program rather than dropping out or switching to a different major.[7, 9] Still, the fraction of all engineering degrees awarded to women has remained at or below 20 percent since the mid 1990's, and recent enrollment data indicate that these stable patterns are not expected to change in the near future.[4, 5]

The science and engineering gender gap has more to do with perceptions and beliefs than it does with achievement levels.[7, 8] According to data from the College Board,[10-12] with few exceptions, sex differences in high school math and science achievement levels and course selection are by now minimal, yet differences in SET college and career aspirations are great. Thus, young women – particularly non-minority women – are qualified to pursue SET studies, but are choosing not to. The reasons for this are varied and complex, and likely stem from a number of complex issues that permeate throughout family, school, and society, including for example the lack of exposure to technology-based toys and experiences as children, teacher expectations and classroom climate, lack of encouragement, gender-biased literature, subtle parental and societal influences, lack of female professional role models, peer pressure to avoid academic subjects deemed decidedly "unfeminine," feelings of isolation, lack of confidence in math and science, and a perception that SET subjects are the domain of "white boys"[7] and are not particularly useful to themselves or to humanity in general.[2, 7, 13-20]

Aside from negative perceptions of or lack of confidence in engineering and science, many girls approaching college age have only a vague notion, or no notion at all, of what engineers actually *do*, or of the breadth and variety of engineering disciplines. Efforts to attract girls to engineering need to include the promotion of engineering as a "normal" choice, not just an "outstanding" choice reserved for the top girls in the class. Moreover, girls need to be made aware that science and engineering are social endeavors that involve working with and helping people and communities.[8, 21] In focus group interviews, representatives from Simmons School of Management found that middle school girls generally held high career aspirations, expecting to work full time, but highly rated the importance of helping others and making the world a better place, as well as living a balanced life.[22] Engineering is seen largely as a solitary, rather than a social, occupation. Efforts to frame engineering and technical careers in a broader, more holistic light, emphasizing the usefulness of engineering to social, environmental, medical, and other people-related needs, will help to make engineering a more female-friendly option.

Interventions have been implemented throughout the U.S. to help increase pre-college girls' participation in SET studies, beginning largely with the National Science Foundation's (NSF) Program for Women and Girls, created in 1993, and continuing to the present day.[8, 23] Strategies have included exposure to role models and mentors, job shadowing, providing career information, the introduction of more "female friendly" instruction methods, summer camps, parent activities, and both in-school and out-of-school experiential programs related to science and math. For example, the WISE (Women in Science and Engineering) program at the State University of New York in Stony Brook matches 20 college students with 55 middle school girls for a two-week summer program, followed by continued work on a science project during the school year.[24] Single gender science and technology clubs provide opportunities for students to participate in hands-on, team-based activities within a non-threatening environment, and in two Massachusetts schools the clubs were shown to improve girls' participation in the co-ed classroom.[25] Likewise, a variety of summer programs bring girls from middle and high schools to college campuses throughout the country to participate in engineering, math, and technology-related activities, and are reported to improve girls' confidence, independence, and problem solving skills.[23] A summer camp run by North Carolina State's Center for Research in Mathematics and Science Education engages middle school girls in mathematical investigations of community problems, to help show math's relevance to their lives and community.[26]

High quality after-school, weekend, and summer programs have been shown to strengthen education and career aspirations.[27] However, scheduling and recruiting constraints often limit participant enrollment. Programs are most effective when implemented within the school system, preferable integrated into the existing curriculum.[2, 15] Similarly, programs that introduce girls to science, math, and engineering through experiencing the creative, community-oriented aspects of engineering problem solving, within a supportive, team-based environment, will give them a more positive and inviting impression of engineering studies and careers.

This paper provides a descriptive analysis of an outreach program conducted at Clarkson University that brings female engineering students into a local middle school classroom to experience mentoring, leadership, and multidisciplinary problem solving within the context of the regular school curriculum. The program capitalizes on the holistic problem-solving nature of all engineering disciplines as a means to engage girls in the relevance of technology-based careers to people and community. A thorough description of the full assessment plan is provided, with results from the qualitative portion of the evaluation. The program's value is demonstrated with a combination of summative and cumulative assessment results.

Program Description

The Partners in Engineering (PIE) program was piloted in 1999 with seed funding from the Engineering Information Foundation, an agency located in New York, NY that works to improve engineering education and practice and to increase women's role in engineering; and was further developed with additional funding from the National Science Foundation's Program for Gender Equity, housed in NSF's Division of Human Resources Department, Directorate for Education and Human Resources (DUE-9979279). The full-scale program was funded by NSF from 2000 through 2003, and continues to operate as part of Clarkson's more general K-12 outreach efforts.

The overall goals of the program are to increase the interest and participation of middle school girls in SET studies and activities, to positively alter their impression of the engineering career field, and ultimately to empower the young women to make informed and educated choices for advanced coursework and careers in SET. The project design has been guided by the following objectives:

1. Provide both middle school girls and college women with an appreciation of the holistic nature of engineering problem solving required to tackle real-world problems;

2. Increase critical-thinking and problem-solving skills;

3. Foster an understanding of engineering as a profession, and the role of women in engineering and technology-related careers;

4. Provide both middle school girls and college women positive mentoring experiences and opportunities to work with role models;

5. Provide leadership opportunities for both college women and middle school girls; and,

6. Provide opportunities for increasing self-esteem and self-confidence.

The PIE program relies on a combination of in-school and out-of-school components to achieve our overall goals. The mainstay of the program consists of a series of regular classroom sessions at the middle school where students explore active, hands-on learning in a team setting as they tackle the solution of a real-world problem under the direction of a team of Clarkson's female engineering students. These college-age mentors are trained as part of a semester-long directed-study course at Clarkson, which provides them with basic skills in classroom instruction, lesson plan preparation and interpretation, project management, and content knowledge regarding the particular middle school curriculum that they will teach. In addition to basic instruction and skill development, the training component of the program emphasizes the importance of teamwork and commitment, and provides an opportunity for the mentors to form a cohesive group as they practice lessons, seek guidance, and work through problems as they arise.

The Clarkson mentors work with a dedicated partner teacher from the technology department of a nearby middle school to plan the details of their instructional unit. They then teach this three-week long project-based unit on problem solving to selected 8th grade technology classes at the school. Middle school girls are recruited during the spring of their 7th grade year, and girls who enroll in the program are scheduled, to the extent possible, into one of the mentor-instructed technology periods. This program structure has evolved through a series of changes since the program's inception. The program was initially offered to 8th grade girls as an enrichment activity, whereby participants were allowed to leave their regularly scheduled technology classes to work with mentors for the three-week long problem solving unit. While transition into the regular, mixed-group classroom meant the loss of what many appreciated as a "safe, supportive" single-sex environment, there were many benefits realized by the move, including: increased learning opportunities for more students; opportunities for 8th grade boys to work with bright, professional women involved in non-traditional careers; increased support from the partner teacher; and increased exposure and recognition for the program in general.

Clarkson mentors also arrange and host a program orientation, a final dinner/panel discussion with area engineers or additional female engineering students, and several extracurricular activities for the middle school girls. The additional mentoring events have included a variety of evening and weekend activities such as teambuilding and leadership experiences, game nights, bowling, crafts, movie nights, and pizza dinners. These gatherings provide opportunities for interaction and communication between the participants in a setting that fosters the development of role-modeling and peer-like relationships between the two groups of students. In fact, many of the participants over the years have come to value this aspect of the program as particularly important – besides the enjoyable social aspects for 8th graders and college women alike, several mentors have attributed the successful development of their strong connections with the 8th graders, as peers and as mentors, to the opportunities provided by the mentoring events. Many of our mentors have exchanged phone numbers, email, and IM addresses with the girls over the years, which has encouraged them to communicate and become personally involved with some of the girls.

Participant numbers have varied over the years (Table 1). To date the program has involved 30 Clarkson women engineering students and 116 8th grade girls. Since technology classes are typically fairly well balanced in terms of male/female student ratio, the in-class PIE component usually reaches roughly twice as many students (boys and girls combined) as the participant numbers indicate. Additionally, the technology teacher uses the PIE problem solving curriculum in his non-mentored sections, so the total number of students exposed to the problem-solving project is on the order of 115 to 125 students per year.

Table 1. Summary of Participant numbers

Program Year†	Middle school participants	Clarkson mentors
AY01	21	8
AY02	23	10
AY03	19	2
AY04	17	4
AY05	19	2
AY06	17	4

†AY01 refers to program year 2000-2001, and so on.

Problem Solving Curriculum

While mentoring and role model concepts are an important part of any program designed to encourage young women to consider engineering careers, the application of a project-based learning approach integrated with holistic engineering problem solving brings an added dimension to this gender equity program. The concept of project-based learning incorporates a *big-picture* approach to enhancing science, math, and technology knowledge, critical thinking, and problem solving skills, and nicely demonstrates "engineering in action." Under the direction of their college student mentors, the 8th graders gain first-hand experience with tackling a real-world engineering project as they work toward solving a problem that is relevant to their school and community. A problem assignment that illustrates the positive social benefits of science and technology is particularly appealing to women and girls; not only does it demonstrate the connections between math, science, and technology and their application for problem solving in general, but moreover, it exposes students to the potential connections engineering can have to human and societal issues.

The three-week curriculum outlined in Table 2 brings students through the stages of a formalized problem solving process that mirrors an approach used by practicing engineers and professionals. Students begin the unit with a problem assignment – in this case, the problem is concerned with waste minimization. Students are tasked with developing a usable product that incorporates non-

biodegradable solid waste as a raw material. Students then enter the problem solving process, starting with problem identification and investigation. Students investigate the nature of the assigned problem, assess current disposal practices, and identify critical issues and constraints stemming from environmental, community, or other impacts. Students then explore potential solutions to their problem. Through guided discussions facilitated by the college mentors, the students arrive at the idea of using waste materials as aggregates in a concrete mix. This conclusion necessitates more learning: students must gather basic information about concrete, including how it is made and its potential uses; explore material properties of concrete and of different types of waste materials; learn about different types of production and materials processing methods; and finally, with respect to concrete, they need to understand compressive and tensile forces and stresses. Students construct concrete test cylinders using different types of waste materials as fine and coarse aggregates, and measure their compressive strength during a field trip to Clarkson University's Civil Engineering testing laboratory. The strength results are evaluated, together with additional qualitative criteria, with a matrix approach that demonstrates the use of a multi-criteria engineering decision making process. Students ultimately select their best choice of waste aggregate material and produce their final product.

Table 2. Environmental Problem Solving Curriculum: Converting nonbiodegradable solid waste into a usable product

1. Define our problem: Introduction to Problems associated with Solid Waste
• Definitions and statistics about solid waste generation, including an historical perspective of the impacts technology and society have had on waste generation • Understanding the composition of solid waste - biodegradable and non-biodegradable components • Current technological solutions: landfills, 3-R's
2. Brainstorm and Investigate Possible Solutions
• Defining products we can make from non-biodegradable solid waste • Identify concrete as potential for reusing solid waste
3. Evaluate Potential Solutions: Non-biodegradable Wastes as Aggregates in Concrete
• Concrete basics, internet research • Material properties • Making concrete – materials, tools, safety • What is compression/tension? tests with pasta • Testing for engineering decisions – compressive strength of concrete test cylinders • Weighted objectives table for engineering decisions – criteria and evaluation
4. Implement our Solution: Putting the Waste-amended Concrete to Use
• Concrete product - production and evaluation
5. Evaluate our Solution: Marketing Our Product
• Introduction to marketing • Importance of communication in engineering • Understanding the value of our products • Developing & presenting a marketing plan

During the past two years students have produced waste-amended concrete stepping stones, which they have sold to raise money for a local charity. This has allowed the students to follow through with a real-life marketing lesson. Students were required to create posters and

advertisements for their product, and in the process learned essential elements of a marketing plan and an effective advertisement.

Assessment Procedures

Program assessment follows a mixed-methods quantitative/qualitative design that uses a variety of written and verbal instruments intended to measure our success in meeting the six program objectives outlined above. On-going assessment activities to date have included pre/post questionnaires, problem solving worksheets, and focus group discussions with both middle school and college student participants, as well as questionnaires administered to parents of the middle school participants. The assessment plan has varied throughout the lifetime of the program (Table 3), with a higher degree of formalized assessment during the period of NSF funding, specifically AY01 and AY02. The initial assessment program was designed and implemented with the assistance of Dr. Mary Graham, Associate Professor in Clarkson's School of Business. More recently, our approach to assessment has been much less formal, using a combination of exit interviews and post program questionnaires that are primarily designed to provide sufficient information to ensure that the program continues to meet our original objectives and continues to improve from year to year.

Table 3. Assessment Program, by Year: Instrument Used and Area Surveyed

Area Surveyed \ Assessment Instrument (years used)	Mentor pre/post questionnaire (1,2,6)†	Mentor pre/post problem solving quiz (1,2)	Mentor post focus group (2)	Student pre/post questionnaire (1,2,4,6)†	Student pre/post problem solving quiz (1,2)	Student post focus group (2,3)	Parent post questionnaire (1,2,6)
Perception of engineers	x		x	x		x	
Number of engineers known				x			
Problem-solving knowledge	x	x	x	x	x	x	
Engineering capability				x		x	
Student consider engineering career				x		x	x
Self-esteem[28]	x		x	x		x	
Self-efficacy[29]	x		x	x		x	
College activities, leadership	x						
Program satisfaction‡	x		x	x		x	x

†pre-post program assessment and 8th grade control group used only during AY01 and AY02; other years used post-only, no control group.

‡ Program satisfaction measured post program only.

Questionnaires contain a combination of Likert-scale and free-response questions. Most survey items were generated by the authors, with existing survey instruments used where possible (e.g., self-esteem[28] and self-efficacy[29] scales). Focus group interviews with PIE participants were

conducted by Dr. Mary Graham and her assistant. Questions for participants focused on participant likes and dislikes about the program, self-perceived impacts, and suggestions for improvement. Interview sessions were voice-recorded and transcribed by the evaluator; issues that were identified in the focus group discussions are discussed within the appropriate context of the analysis, below.

Assessment Results

As described above, the assessment results consist of a combination of quantitative and qualitative data collected from Clarkson mentors, middle school participants, parents, and teachers. The results presented and discussed in this paper focus primarily on qualitative data gleaned from questionnaires and focus group discussions.

Appreciation of holistic nature of engineering problem solving, critical thinking skills. Mentors receive formal training, through the directed study course, that reinforces their understanding of and ability to apply a formal problem solving process that most of them learn in their other engineering courses at Clarkson. These problem-solving skills are further reinforced throughout the program, as they teach this process to the middle school technology students.

Questionnaire and focus group responses from mentors regarding the program's impact on their problem solving skills have varied with group characteristics. Mentors who reported feeling well-grounded in problem solving capabilities generally did not see this as a major benefit of their experience in the program. On the other hand, mentors with lower aptitude for problem solving reported that they felt their problem solving skills had improved through the program, and some added that they felt they improved in their ability to teach problem solving to other students. Thus it seems that, where there is room for improvement, the PIE program strengthens problem solving capabilities for the college mentors.

Focus group discussions with 8th grade PIE participants suggest that the opportunities to experience first hand the application of a formalized problem solving process to a real-life problem positively impacted their understanding of problem solving, which was not realized in the standard technology curriculum. Participants cited *problem solving* and *teamwork* as the most significant curricular benefits of the program. They noted the importance of spending a long time on one problem, learning to work as a team, and learning a lot of different things along the way. One participant (AY01) stated: the "problem solving process is something that middle school students learn to memorize in their technology and science classes," but through the "PIE program students get a chance to experience first hand how that process is actually *used*" (to solve a problem).

Survey and focus group results indicate that middle school participants and parents both agreed: through the program the participants learned more about engineering, and the collaboration and teamwork involved in the project was a particularly valuable learning experience for the participants. One focus group participant (AY02) reported that she learned, "… how to talk it out with people without having to get in an argument and that actually causes negotiating, agreeing, and compromising." And from another participant: "I really like PIE because it was interactive, and hands on. We made stuff and weren't just told what to do."

Understanding of engineering as a profession, and the potential role of women as engineering professionals. Working through the solution of a holistic engineering problem, in close collaboration with college students who are themselves studying various disciplines of engineering, fosters an understanding of what engineering is all about and helps to make the prospect of an engineering career more tangible to the students. Additionally, the final dinner and panel discussion held each year with female engineering professionals and college engineering students is consistently well attended (typically all participants attend). Discussion at these dinners typically focuses on such topics as lifestyle, outside interests and hobbies, engineering studies, what courses to take in high school in preparation for engineering, college life, family life for working mothers, college and job atmosphere among mostly men, possibilities for job transfer and promotion, part-time flexible hours, and so on.

PIE participants have reported an increased exposure to female engineers, more conversations with adults about engineering careers, and more discussions with guidance counselors as a result of their participation in the program. The technology teacher reported (AY03) that he felt the program encourages students to pursue science and technology careers. Many students have indicated that they would consider the profession. Focus group discussions further revealed that while all participants felt they had the skills needed to pursue engineering, their decision of whether or not to choose engineering was just a matter of interest. Many students lack an interest in math, which – according to the technology teacher – may have more to do with the "drill/practice/test" mode of teaching that is practiced at this particular school. The technology teacher indicated that more girls than boys are discouraged by this teaching approach. This observation is supported by the literature (e.g., [30]). Thus, while girls feel they are capable of becoming engineers, many opt not to pursue engineering because they are turned off by the way in which math (and, at this particular school, science) is taught. He stressed the importance of teaching students the application of math to technology as a way of attracting and maintaining their interest in math.

Focus group comments and post-program questionnaire responses indicate that participants did indeed receive the message that women can be engineers. For at least some of the middle school PIE participants, this was new information:

- "I learned that there are so many females out there that have actually made a difference… there are girls that are doing engineering."
- "I thought engineering was working with mechanics and that I would be treated different if I wanted to be/was a girl in engineering. I found out about engineering… now I might do it."
- "The PIE program has made me less scared of engineering."
- "We're learning how to do all kinds of awesome things that I never knew you did in engineering. I thought it was just drawing pictures of buildings and doing "boring" stuff like that."
- "I thought [engineering] was only for guys. But I learned girls can have fun and like engineering, too."

- "I thought engineering was pretty cool and it wasn't just for (like) dorks."

In fact, out of 15 post-survey respondents (AY06), 14 girls indicated that the program helped to improve their understanding of what engineering is about, including such specific comments as:

- "…insight as to many aspects of engineering… it broadened my horizons in the engineering career."
- " didn't really know what it was… now I know.."
- "…engineering is fun… loved engineering after this program…"
- And finally – *"I am now thinking about a possible career in engineering."*

Thus, overall, it appears while PIE may not be overwhelmingly successful in convincing participants to study SET and become engineers, the program is effectively educating girls about possible careers in engineering, knowledge that they may not have otherwise had access to.

Informal feedback from parents consistently provides a clear message: the most significant value of the program from their perspective appears to be the contact it affords their 8th grade daughters with women studying science and engineering, and the increased breadth and depth of exposure to professional women in general. Particular curriculum content is interesting, but secondary. "…[T]he PIE program enriched my daughter's academic program…her exposure to goal-oriented women and the opportunities available had a positive impact on her outlook for career choices," (parent, AY02). Parent surveys generally indicate that, while parents would support their daughter's potential desire to become an engineer, they would be equally supportive of other career options and appreciate the emphasis on removing gender-stereotypes from potential careers:

- "It is her decision. She is swinging between a career in engineering and health care."
- "Her artistic ability may develop through engineering/design."
- "…[I]t would have good job opportunities but her career is up to her. If she isn't happy with what she's doing she won't be good at it."
- "I … supported my daughter's interest from the perspective that women need to remove themselves from gender bias and support each other."
- "I want her to do what interests her…"
- "Her career is her choice. I would like her to consider as many options as possible"
- "I'm trying to encourage my daughter to get exposure to different job fields so she can find out what she likes. I don't want her to be constrained by gender."

Positive mentoring and role model experiences. "Partners in Engineering was such a rewarding experience because you were able to see young girls first learn about science and engineering

and then allow them to experience it first hand on their own. It's such a great feeling to see how you are actually a part of shaping their lives and helping them to be successful in the future," (mentor, AY01). Indeed, the main reason PIE applicants generally give for wanting to enroll in the program is to "make a difference in the life of a younger girl," and every year at least one or two cite that they hope to play out the role of a mentor that they themselves benefited from knowing as a middle school or high school student.

Mentoring experiences are integral to the program design, both through the classroom lesson structure, which incorporates small group and team-based work, and the extra-curricular mentoring activities, which are largely social but usually include some directed activity that is often engineering-related. These mentoring events are consistently well attended and have become particularly important for fostering relationships since the in-school component of the program has been moved to the mixed technology classes. When possible, stronger relationships are fostered each year by assigning each PIE mentor to a subset of 8th grade participants, to encourage closer and more frequent contact. They often exchange phone numbers, email addresses, and IM screen names. Over the years several mentors have become involved with the 8th graders on a more personal level, and have continued to maintain contact well after the program has ended. Because of the small-town environment and the proximity of the middle school to Clarkson University, it is not unusual for mentors to report meeting their 8th grade students in town or at college sporting events (whereby the mentors are typically embarrassed by being addressed as "Miss …"). Mentors have gone into the technology classroom to spend time after their teaching session is over, have taken small groups of girls out for ice cream, and have become involved in middle school sports teams.

Mentors consistently report strong satisfaction with their mentoring experiences. When asked the greatest benefit of the PIE experience, the vast majority of mentors identify working with the middle school girls (6 out of 9 focus group responses, all post-program written responses):

- "The greatest benefit was the ability to have an effect on someone else's life. Hopefully I was able to help another student out and they learned from me being there."

- "As a PIE mentor I was able to positively affect the lives of 23 younger girls. I know they will carry most of the knowledge and experience with them for the rest of their lives."

- "….knowing [the girls] are enjoying this program. I hope it will inspire them to make good decisions about what they wish to do in life."

- "I enjoyed the mentoring activities just because we were able to foster relationships with the girls. These times I feel like we were able to make the most impact. I think in these situations our true colors were able to shine through. I think this made us *people* in their eyes, as opposed to college kids."

- "It just made me feel so good about myself, the fact that I really was making a difference in these girls' lives, it made me feel like I was doing something important."

- "The greatest benefit was working with the girls and the relationships that we formed with them. I think that they understand that you can be smart and be part of a field that is seen as male dominated. I also think that each of us will keep in contact with many of the girls after the program is over."

- "…I feel like most of the effort we put into this class paled in comparison to how rewarding the relationships are."

In turn, the middle school participants consistently report that they are highly satisfied regarding their experiences with the mentors. Girls have reported in focus group discussions that they consider the female Clarkson mentors to be "friends" with whom they can talk about PIE-related and personal topics. Students value the hands-on teaching style, technical knowledge, opportunities to work together with their friends and the mentors, and the relationships they formed with the mentors. Students typically identify working with the mentors, and especially attending the mentoring activities, as their favorite aspect of the program. Several middle school students have reported that they would have liked to attend more mentoring activities and/or would have liked the program to last longer through the year.

Responses from parents generally mirror their daughters' high satisfaction levels, and parents consistently provide positive feedback, both formally and informally, regarding the program's mentoring aspects. One parent (AY06) writes: "[My daughter] had an amazing experience with the PIE program… [Her] grades improved a lot this marking period and we feel that PIE actually helped her to achieve better grades…"

Leadership opportunities, self-esteem, self-efficacy. By its very nature, the PIE program forces each of the mentors to take on a leadership role. This is particularly valuable for PIE mentors who had not previously held a leadership position at Clarkson (e.g., 4 in AY02). Mentors have provided variable responses regarding the program's impact on their self-esteem and self-confidence and have generally reported having a high level of self-esteem at the start of the program. Self-efficacy, which is a measure of a person's confidence in her ability to take action, is closely related to self confidence. Mentors have reported that they are more comfortable speaking in front of a group and performing in an active role as part of a team as a result of their mentoring experience.

Middle school girls are given the opportunity to perform in leadership roles through the collaborative group project work in the classroom, as well as at various presentations to teachers, parents, and school board members. Focus group discussions indicate that the PIE program provides leadership opportunities that seem to be otherwise lacking in participants' technology classes. One participant observed, "… if you actually look at the tech room, the guys are… in control. They're the first ones at the machines…" As with the mentors, middle school participants reported high levels of self-esteem at the start of the program and did not report appreciable gains in self-esteem. Gains in self-efficacy can be closely tied to their strong feelings of being capable of studying engineering: "[Girls doing technology or engineering] is a surprise to them. It's a reality check… we are capable of everything," (focus group comment).

Program satisfaction and miscellaneous self-reported benefits. Written survey responses and focus group discussions consistently indicate overall satisfaction with the program by all

stakeholder groups, including college student mentors, 8th grade girls, and parents. Mentor comments provide additional support:

- "The team/group work was a great experience. There were a lot of team challenges, ups and downs. It was very realistic because it was not just for a grade like other group projects at Clarkson. What we did or did not do affected the classroom and others."

- "Learning things for myself; more about engineering, time management skills, interpersonal relations and being able to communicate in front of a group…"

- "It just made me feel so good about myself, the fact that I really was making a difference in these girls' lives, it made me feel like I was doing something important… for me it was more about how I felt afterwards. It just makes you feel so good about yourself and that would make me do it again and again."

- "I absolutely loved this class. I wish I could take it over and over again for the rest of my time here. It might be the… most worthwhile thing I have done thus far in my life."

Conclusions and Recommendations

Overall, the PIE program has provided learning and leadership opportunities for 30 college student mentors and 116 8th grade girls over the past six years. Qualitative assessment data indicate that the program continues to meet our original objectives. A particular strength of the program lies in the opportunities for mentoring and role model relationships, the interactions between participants during extra curricular events, and – specifically for the 8th grade participants – the breadth of contact with and exposure to talented, focused young women pursuing a technical education. The program has been successful in exposing young women to the holistic nature of engineering problem solving and the variety of opportunities that exist for women who choose to pursue engineering studies and/or careers. The program has received positive local publicity, and is appreciated by the middle school faculty, staff, and administrators. Relationships that have been fostered between Clarkson University and the local public school system will help to ensure that the Partners in Engineering Program continues in the years to come.

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