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ABSTRACT

This report describes activities and accomplishments of a 3-year pilot project conducted by the Center for Women in Engineering (California) to improve the classroom climate for girls at the K-12 level. Project programs included workshops for K-12 teachers, three educational outreach programs for teachers and students, and laboratory research/mentorship opportunities for female high school and undergraduate students. The programs reached an estimated 8,000 students and teachers and several of the programs are being institutionalized. Program evaluation indicated that teachers and students benefited when teachers collaborated in presenting hands-on and gender-equitable teaching techniques. Students received information about engineering as a career and came in contact with female engineering role models. Some students developed mentoring relationships with faculty and graduate students while experiencing scientific research firsthand. Individual sections of the report include an overview; the project's purpose, background and origins; project description, an evaluation, and results. A summary section offers recommendations for workshops and outreach programs. The extensive appendices include: an interinstitutional project profile, the project handbook, additional evaluation materials, and a list of project dissemination activities. Three papers resulting from the project are attached. They are: (1) "Perspectives on Evaluating Classroom Climate Programs for Women" (Mary Margaret Bland); (2) "Priming the Pump: Getting More Girls into the Engineering Pipeline" (Elizabeth Gillis Raley); and (3) "How Things Work: Helping Girls Explore Technology, Engineering Education for Elementary Teachers" (Judi Kusnick and others). (DB)

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A Model Project to Improve the Climate for Women in Engineering

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A Model Project to Improve the Climate for Women in Engineering

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Project Summary

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Project Presentations

Judi Kusnick	October 1991	"Girl-Friendly Science." Workshop at California Science Teachers Association Meeting (CSTA), San Jose, CA.
Judi Kusnick and Debra Desrochers	August 1992	Hands-on demonstration and presentation to the Science Textbook Adoption Committee, San Juan Unified School District (SJUSD), Carmichael, CA.
Judi Kusnick	June 1993	"How Things Work: Helping Girls Explore Technology." Workshop for 7-12 grade teachers at Schools and Colleges for the Advancement of Teaching Science (SCATS), Sacramento, CA.
Elizabeth Gillis Raley	June 1994	"Priming the Pump: Getting More Girls into the Engineering Pipeline." Presentation and poster session, Society of Women Engineers (SWE) National Conference, Pittsburgh, PA.

Judi Kusnick	June 1994	"How Things Work: Engineering Education for Elementary Teachers." Presentation at Women in Engineering Program Advocates Network (WEPAN) conference, Washington, D.C.
Mary Margaret Bland	June 1994	"Perspectives on Evaluating Classroom Climate Programs for Women." Presentation at WEPAN conference, Washington, D.C.
Judi Kusnick	October 1994	"How Things Work: Helping Girls Explore Technology." Workshop for K-8 teachers at CSTA Meeting, Palm Springs, CA.

Project Papers

Bland, Mary Margaret. "Perspectives on Evaluating Classroom Climate Programs for Women." WEPAN Conference Proceedings, Washington, DC: 1994.

Gillis Raley, Elizabeth. "Priming the Pump: Getting More Girls into the Engineering Pipeline." SWE National conference Proceedings, Pittsburgh, PA: 1994.

Kusnick, Judi, Desrochers, Debra and Darby, Jeannie. "How Things Work: Engineering Education for Elementary Teachers." WEPAN Conference Proceedings, Washington, DC: 1994.

Kusnick, Judi. "How Things Work: Helping Girls Explore Technology," paper in preparation for submittal to Children and Science.

Project Handbook

"How Universities Can Help Teachers Introduce Girls To Engineering: A How-To Manual," Center for Women in Engineering, UC Davis, Davis, CA.

A Model Project to Improve the Climate for Women in Engineering

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Executive Summary

A. Project Overview

This report presents a description of the programs, activities and results from a three-year pilot project conducted by the Center for Women in Engineering (WIE) at UC Davis. This project aimed at improving the classroom climate for K-12 girls, and built upon a complementary project funded by NSF that targeted classroom climate issues pertaining to undergraduate engineering women. Five programs were developed, modified, and evaluated. Four of these were pilot programs: a workshop series for K-12 educators, and three educational outreach programs for teachers and students (Speakers Bureau, Luncheons with Engineers and Day on Campus). The fifth program provided laboratory research/mentorship opportunities for female high school and undergraduate students through an existing program. These five programs were successful in reaching an estimated 8,000 students and teachers during the three-year period. The program activities have been refined and several programs will be institutionalized. Information about the project has been widely disseminated through presentations, papers, and the creation of a program activities handbook.

B. Purpose

Only a small percentage of engineering students and professional engineers are women. The number of institutionalized programs that recruit, retain and graduate women in engineering is also small. One fundamental problem is that girls exit the math and science pipeline prior to graduating from high school and therefore are lacking the requisite academic background or technical interests to pursue engineering degrees. Among the factors which contribute to this exodus from the math and science pipeline is a "chilly classroom climate."

WIE recognized a need to develop pre-college programs that addressed this "chilly classroom climate" and the associated educational factors diverting girls from math and science. Five programs were developed for elementary and secondary students and teachers.

C. Background and Origins

Instituted in 1990, WIE took as its mission the development, testing and evaluation of programs to increase the number of women completing engineering degrees. Since 1990, WIE has expanded into providing gender equity advising, counseling and outreach programs to the UC Davis community. Funds from NSF and FIPSE allowed WIE to bring together a staff of talented professionals to develop

programs, from K-12 through undergraduate levels, designed to increase the number of women in engineering.

Each project team member helped create a cohesive project network by bringing with her, her existing relationships with individuals and institutions outside of WIE to help develop and implement the K-12 programs. Ultimately this network included school districts, professional organizations and a neighboring university. The relationships with these individuals and institutions changed throughout the project, causing some modifications to be made to continue development of the programs.

D. Project Descriptions

After developing specific program goals, and strategies for achieving and evaluating these goals, each of the five programs in this project was planned, developed, implemented, evaluated and modified over the three-year period.

The first program, Workshops for K-12 Educators, was implemented over the second and third years of the project. The Workshop program had three components: an Initial Workshop, Teacher Collaboration, and a Follow-up Workshop. Separate workshops were developed for elementary and for secondary teachers to address their specific curricular needs. The workshops had three goals: to help teachers learn how to improve the classroom climate for girls in math and science, to encourage teachers to use everyday technology in their classrooms, and to educate teachers about the field of engineering.

Three outreach programs addressed the dearth of female engineering role models available to girls by providing interactions with some of the few who exist. These programs were Speakers Bureau, Luncheons with Female Engineers and Day on Campus. Speakers Bureau brought female engineers into classrooms; Luncheons brought small groups of 9-12th grade girls and female engineers together in an informal setting; and Day on Campus offered groups of mostly female high school students an opportunity to spend a day on the campus of UC Davis, where they could attend engineering classes and labs, meet with female undergraduate engineering students, tour the campus and obtain admissions information.

The fifth program, the Undergraduate Research/Mentorship program, provided high school and undergraduate women with opportunities to conduct research in an engineering laboratory while benefitting from mentorship relationships with female engineering faculty and graduate students. Funding from NSF and FIPSE allowed these female students to participate in an existing program for minority students at UC Davis, Minority Opportunities for Research in Education (MORE), which ordinarily does not specifically target women as a minority or underrepresented group.

A major change in inter-institutional collaboration occurred midway through the project. The San Juan Unified School District co-sponsored the first series of K-12 Educator Workshops. Administrative problems and budget cuts led to a co-sponsorship of the second series of workshops through a regional science association. This change in collaboration also affected participants in the Outreach Programs, as many student participants were recruited by teachers who participated in the workshops.

E. Evaluation and Project Results

An evaluation was designed to collect information to meet a variety of needs. This information was used for ongoing program modification, program documentation, and institutionalization and dissemination efforts. The size of our programs allowed trained staff members to use a spectrum of qualitative evaluation techniques. Our participants were able to define and express their attitudinal and behavioral changes themselves, and a rich picture of the programs' effects emerged. Evaluation results led to the development of quantitative measures of program activities. Cumulative results were

also used to write several articles about program activities, for program institutionalization efforts, and to develop a how-to handbook for three of the programs.

During a three-year period, these five pilot programs benefitted approximately 8,000 students and their teachers. We discovered that teachers and students profited when teachers collaborated in presenting hands-on and gender-equitable teaching techniques in the classroom. After attending workshops, teachers gained confidence in using technology and gender equitable teaching strategies in their classrooms. Students participating in outreach programs learned about engineering as a career and came in contact with female engineering role models. Some students were involved in both classroom technology activities and outreach activities, reinforcing their exposure to engineering. Students who participated in laboratory research/mentorships developed mentoring relationships with faculty and graduate students, while learning about opportunities for graduate work and experiencing scientific research firsthand.

Avenues for continuing dissemination of each of the five programs have been sought. K-12 Educator Workshops may be offered in the future by the Sacramento Science Center. We will also discuss with the Division of Education at UC Davis incorporating gender equitable teaching strategies into their teacher education program. SWE will continue to coordinate both Speakers Bureau and Luncheons, and WIE and the UC Davis student section of SWE will continue to coordinate the Day on Campus at UC Davis. The MORE program will continue to seek funding to offer more laboratory research and mentorship opportunities for women.

F. Summary and Conclusions

Teachers and students benefitted when teachers collaborated in presenting hands-on and gender-equitable teaching techniques in the classroom. Teachers attending workshops developed confidence in using technology and gender equitable teaching strategies in their classrooms. Students participating in outreach programs received information about engineering as a career and came in contact with female engineering role models; many ultimately participated in more than one program. Students who participated in laboratory research/mentorships had the opportunity to develop mentoring relationships with faculty and graduate students, while experiencing scientific research firsthand. We can share much of what our project team learned about obstacles we encountered as we developed these programs, both at administrative and attitudinal levels. Based on our experiences and successes, we offer recommendations to others interested in undertaking similar programs.

G. Appendices

Appendix 1: Inter-Institutional Project Profile
Appendix 2: Project Handbook
Appendix 3: Additional Evaluation Materials
Appendix 4: Project Dissemination Activities
Appendix 5: Papers
Appendix 6: Information for FIPSE

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We also wish to thank a number of individuals and organizations outside the UC Davis educational community: Tom Smithson and Mike Shea at SCATS; Louise Chiatovich, gender equity consultant with the California Department of Education; the curriculum coordinators and director of research for the San Juan Unified School District; and the Sacramento Valley and Foothills sections of SWE.

A Model Project to Improve the Climate for Women in Engineering

A. PROJECT OVERVIEW

In 1990 the College of Engineering at UC Davis, recognizing the severe shortages of women enrolling in Engineering, began a Center for Women in Engineering (WIE). WIE initiated programs for undergraduate women and began to focus on the pre-college experiences of girls who were being funnelled away from math and science, the precursors to engineering. With funding primarily from FIPSE[1] and a strong commitment from the College of Engineering and many other institutions, the staff of WIE developed A Model Project to Improve the Climate for Women in Engineering.

The three-year project included five main programs: workshops for K-12 teachers; three outreach programs for K-12 grade students (Speakers Bureau, Luncheons with Engineers, and Day on Campus); and engineering lab research mentorships for high school and undergraduate women. During the first year of the project, team members conducted literature reviews, researched programs at other institutions, identified program goals, planned program activities to address each goal, and designed evaluation strategies for all programs. Several programs were offered, evaluated and revised. Dissemination activity was begun in the form of outside workshops and presentations. In the second year, all programs were offered, evaluated and revised, with dissemination activities continued. Evaluation results were used for ongoing program modification, as well as for program description and institutionalization and dissemination efforts. In the last year of the project, four of the five programs were offered and were evaluated a final time. The project team continued to disseminate information about the programs through workshops, conference presentations and proceedings, papers, and through the creation of a project how-to handbook.

The programs served pre-college level students and their teachers, and several undergraduate female engineering students. Speakers Bureau sent speakers to thirty high schools and several other groups of students. Thirty high school girls attended luncheons and approximately 150 students attended a Day on Campus. Sixty-three K-12 teachers attended workshops and used the techniques in their classrooms. Six high school students and nine undergraduate students were placed in laboratory mentorships. An estimated seven thousand K-12 students were served directly or indirectly in the three years of the project. Additional teachers and their students have also been served through project dissemination efforts.

We discovered that teachers and students benefitted when teachers collaborated in presenting hands-on and gender-equitable teaching techniques in the classroom. Teachers attending the workshops reported that they developed confidence in using technology and gender equitable teaching strategies in their classrooms. Students participating in outreach programs received information about engineering as a career and came in contact with female engineering role models; many ultimately participated in more than one program. Students who participated in laboratory research/mentorships had the opportunity to develop mentoring relationships with faculty and graduate students, while experiencing scientific research firsthand.

[1] NSF Grant No. HRD9053903 funded several related programs for undergraduate women that were developed during the same time period as those funded by FIPSE. The results of these NSF-funded programs were used to develop activities for several of the programs described in this report.

B. PURPOSE

Women constitute an untapped population of potential scientists and engineers. Only 15.7% of undergraduate, 15.5% of masters and 9.9% of doctoral engineering degrees are currently awarded to women (Engineering Manpower Bulletin, 1992). Additionally, only 8.5% of all working engineers are women (Engineering Workforce Bulletin, 1993). Many formal programs have been instituted to recruit, retain and graduate engineering students from ethnic minority groups. Fewer efforts have been undertaken to do the same for women, and these efforts have taken place only within the last five years.

A fundamental problem in recruiting women into engineering programs is that few women leave high school with the academic background or technical interests needed for a college major in engineering. While the reasons for girls' exodus from the math and science pipeline are complex, several important contributory factors have been identified. Some of these include: early childhood socialization by parents, teachers and the media; sex-biased curriculum materials; differential treatment between the sexes in the classroom; the relationship of sex-role stereotyping, by girls and their counselors, to girls' selection of occupations; peer pressure; and poor (or lack of) role models. These factors compound the problem of the "chilly classroom climate" experienced by many girls and women (Ehrhardt and Sandler, 1987).

To address these factors and the "chilly classroom climate," WIE recognized the need to develop not only programs for undergraduate women but also pre-college programs. To retain more girls on the math/science track, programs were needed to combat their lack of academic preparation. Students as well as teachers needed education on the rewards and benefits of engineering careers. Providing role models and mentoring relationships for girls and women could encourage more girls and women to become professional and academic engineers, ultimately increasing the number of female role models in the future.

This project consisted of the development of four pilot programs for K-12 teachers and students by a team of experts, and the expansion of a fifth program, an existing undergraduate research program for students targeted from ethnic minority groups, to include women from other groups. The project goals included:

- Working with K-12 educators and students to create awareness of and interest in engineering and technology, using information about and exposure to engineers, engineering and technology
- Improving classroom climate through awareness and demonstration of gender equitable teaching
- Providing students with female engineers as role models
- Improving the recruitment and retention of girls in the math, science and engineering pipeline through all of the above activities
- Institutionalizing programs where feasible
- Disseminating our experiences and results to other individuals and institutions

In undertaking the development of these pilot programs, the project team recognized that remedying the underrepresentation of women in engineering is an enormous effort. Addressing all of the potential factors was far beyond the scope of this project. Instead, great care was taken during the first year of the project to focus on and pursue goals that could be realistically addressed through the expertise of the project team members and within a three-year framework. Despite the difficulty of making institutional reforms in such a short time frame, the team laid the foundation for change. Program participants reported changes in their awareness of engineering, their understanding of the "chilly climate" problem, and their own behavior in addressing the problem. Our efforts in disseminating and institutionalizing our programs will continue to build on that foundation.

C. BACKGROUND AND ORIGINS

In November 1990, concerned about the low numbers of women in engineering, the College of Engineering at UC Davis opened a Center for Women in Engineering (WIE). The original mission of WIE was to develop, test and evaluate programs designed to increase and retain the number of women entering the engineering profession. Over the past four years, WIE has expanded from its original vision into providing gender equity advising, counseling and outreach programs to the UC Davis community, through a network which includes both industry, and individuals and programs at many other institutions. Today, the mission of WIE is threefold: to provide support and encouragement to women currently enrolled in engineering; to encourage young women to pursue math and science courses during their pre-college years; and to research and address the social and institutional barriers that inhibit women from becoming engineers and persisting in engineering careers.

In 1991, WIE received funds from NSF supporting the initial development of several programs aimed at recruiting and retaining undergraduate women in engineering. These programs included the development of a hands-on course for first and second-year women engineering students, a workshop for engineering faculty on the effect on women of the "chilly classroom climate," a job shadowing program, informal brown bag luncheons for female undergraduate and graduate students, and funding for several engineering laboratory research experiences for undergraduate women. Funds from FIPSE then allowed WIE to "piggyback" on these original undergraduate programs to address engineering pipeline issues at the precollege level. FIPSE grant funding allowed WIE to use what was learned from the pre-college programs to develop programs specifically aimed at the recruitment and retention of girls into math and science in the K-12 grades. Funds from the grant also provided additional opportunities for several high school and undergraduate women to receive laboratory research experience, giving them a greater incentive to continue their education through graduate school. This was done through MORE (Minority Opportunities for Research in Engineering), an existing research program for minorities in the College of Engineering at UC Davis.

Project Network

At the onset of the project, staff members of WIE and the College of Engineering already had existing relationships with the Science Curriculum Coordinator of the San Juan Unified School District (SJUSD) in Sacramento County, the American Society of Engineering Education (ASEE); the Society of Women Engineers (SWE)[2] ; the Women in Engineering Program Advocates Network (WEPAN); the National Science Teachers Association (NSTA); California State University, Sacramento (CSUS) College of Engineering and Computer Science/Women's Programs; and Schools and Colleges for the Advancement of the Teaching of Science (SCATS), a regional science teachers' association[3] (see Appendix 1 for a table showing how these organizations interacted with and provided support for our project).

[2] SWE included SWE National, and SWE Region A (Northern California), including the Sacramento Valley Section, the Foothill Section, and the CSUS and UC Davis Student Chapters.
[3] SCATS is a regional consortium of schools and colleges involved in enhancing science education in Northern California. The consortium includes California State University, Sacramento; five community colleges (Sierra, Yuba, American River, Sacramento City, and Cosumnes River); the Sacramento County Department of Education; the California State Department of Education; and all of the school districts in the region, including three of the ten largest in the state of California (Sacramento City, Elk Grove, and San Juan). SCATS has a mailing list of 3000 7th-12th grade science teachers and 1200 elementary teachers.

Organizational Changes

WIE and the UC Davis College of Engineering offered several areas of organizational strength that enhanced the success of the project. WIE's pursuit of equity in engineering education kept the project focused on that goal. The reputation of UC Davis as an institution, with its highly regarded College of Engineering, attracted participants to these programs. Finally, the project was carefully staffed with team members who brought to the project a wide range of expertise and a pre-existing network of relationships with K-12 educators and other individuals and institutions involved in the project. The team was cohesive, and its members were creative, innovative and flexible, qualities which proved essential when developing and modifying the pilot programs.

However, because the project originated outside the state-run K-12 educational system, we encountered numerous administrative problems in dealing with school districts. Because of the problems described under Project Description, Section 2, we changed our co-sponsor in the third year of the project from SJUSD to SCATS.

D. PROJECT DESCRIPTION

The project consists of five programs: workshops for K-12 educators; three outreach programs for K-12 students (Speakers Bureau, Luncheons with Engineers, and Day on Campus); and lab researcher/faculty mentorship opportunities for high school and undergraduate women.

Part I: Program Descriptions

Section I: Workshops for K-12 Educators

The K-12 educator workshops had three goals:

1. Help teachers learn how to improve the classroom climate for girls in math and science
2. Encourage teachers to use everyday technology in their classrooms
3. Educate teachers about engineering

Our underlying assumption in designing the workshops was that if we wished to effect a change in teacher behavior, we must respect the teachers' expertise and regard them as peers and collaborators in educational reform. Through these workshops, we supplied the teachers with ideas and opportunity for experimentation, and the teachers provided the expertise for implementing these ideas in the classroom. We also believe that teachers construct their own meaning for the concepts they teach, and for them to teach in a more equitable way or use technology in the classroom, they need an opportunity to experience these methods of teaching. Therefore, our workshops were designed to let hands-on experience be the primary teacher. Additionally, because teachers interact with hundreds of students, we felt that the program could achieve the greatest impact by training teachers to incorporate new techniques into their curricula and their teaching style through the program.

Each of the two workshop series, offered in years two and three of the project, consisted of the three components outlined below:

Component	Purpose	Duration
Initial Workshop	Introduce concepts, hands-on activities and gender equitable teaching strategies	1 meeting: 6 hours
Teacher Collaboration	Opportunities to experiment with activities and teaching strategies in the classroom	3 to 6 months between workshops
Follow-up Workshop	Explore success of classroom approaches and teacher collaboration, share concerns, discuss future plans	1 meeting: 4 hours

During the first year, when we planned the workshops, we decided to offer separate workshops for K-6 and for 7-12 educators. We felt that the needs of the two groups were sufficiently different to warrant separate workshops: elementary school teachers needed classroom activities that were simple and had broad applications, while secondary teachers, who teach specific science subjects, needed activities that could be utilized in a specific curriculum, i.e. chemistry. With regard to gender equity, we felt that elementary teachers already paid a great deal of attention to developing self

esteem in their students as part of their daily approach, and were therefore already a receptive audience. Secondary teachers, who were required to be very content-oriented and who could not support self-esteem as directly for the 150+ students they encountered each week, might benefit from a different approach to gender equitable teaching. Although we targeted the groups separately, the workshops and activities in which each group participated followed the same basic format, while the content and approach to teaching strategies varied slightly to address the presumed needs of each group.

Workshop Component 1: Initial Workshop

The initial workshops were composed of a series of structured activities highlighting each of the goals of the project. Each activity emphasized teachers' awareness of each of the goals. Most activities had written exercises that were used both to foster discussion at the workshop and to form part of the workshop evaluation. Some of the activities were developed using material from EQUALS. The activities are as follows (see also Appendix 2, Project Handbook):

Research Assignments: Teachers and their students completed the assignments prior to the teachers attending the workshop. Students described how they viewed a typical day when they are 30 years old. Teachers compiled information about what careers students depicted and how they described family roles. Teachers also were asked to have a colleague or student keep track of whom they called on and which students received most of the teacher's attention. Results of both assignments were discussed at the beginning of the initial workshop.

Images of Engineers: Teachers wrote about and discussed in groups their ideas of a typical day, skills and talents of an engineer. They compared their ideas with descriptions written by actual engineers.

Technical Autobiographies: Teachers wrote descriptions of their prior experiences and attitudes/inhibitions towards tools and machines and discussed them with the group.

How Things Work: Working in small groups, teachers took apart a varietyt of devices, including engines, small appliances and toys, and explored how these devices worked. They presented their findings to the large group. Teachers were assigned roles in their small groups to ensure that everyone had an equal chance to use tools and explore machines. After completing the activity, teachers discussed how it might work within their classrooms.

Problems and Solutions: Teachers wrote about and discussed the obstacles they perceived in their own school that keep girls from persisting in math and science, then wrote about and discussed strategies for overcoming the obstacles they identified. These strategies were compared with successful strategies for gender equitable teaching identified by educational research.

Workshop Components 2 and 3: Follow-up Workshops and Teacher Peer Collaboration

In the first year of workshops, teacher peer collaboration was not deliberately included as an element of the workshop series. However, the school district we worked with sent teams of several teachers from each elementary school to the K-6 workshops. These teams spontaneously collaborated to produce some of our most exciting results. We also noted that these collaborative teams were the ones who most diligently completed all of the tasks we set for them. This experience persuaded us that having our workshop participants collaborate with one another might inspire more teachers to remain in the program and help them achieve the goals. We therefore decided to schedule our second series of workshops through SCATS on Saturdays rather than on weekdays, and use the

money originally set aside for substitute teachers to allow each teacher one day of release time to collaborate with a peer on classroom activities. This strategy produced both wonderful results and some unforeseen problems, which are described in Project Evaluation and Results.

Between the two workshops during the first year, teachers were asked to fill out Teaching Logs[4] as a way to document their experiences teaching the hands-on activities and trying out gender-equitable teaching strategies. We asked teachers during the second year to fill out Logs out as well, and include a description of their collaborative relationship. At the beginning of the follow-up workshop in the second year, we paired up teachers who had not collaborated with one another and asked them to interview each other about their teaching and collaboration experiences. This taped interview then acted as a springboard for discussion.

The rest of the follow-up workshops were spent in activities chosen by the teachers themselves. Teachers in these follow-up workshops chose a variety of activities. One group of teachers chose to dissect more machines, and learned specifically about gears and motors. Another group chose to discuss obstacles to change. All four follow-up workshops included discussion of the teachers' classroom experiments in gender equity and with everyday technology.

Section II: Outreach Programs for K-12 Students

A lack of role models is often cited as a reason for the low numbers of women engineering students and of girls who even consider engineering. Many K-12 female students are underexposed to situations that provide them with a clear image of careers utilizing science and math skills. Many students and teachers have never met a woman engineer. Therefore, the purpose of the outreach programs was to give girls contact with female engineers.

Three distinct programs incorporating female engineers as role models were developed to encourage girls to consider engineering as a viable career choice: Speakers Bureau, Luncheons with Engineers and Day on Campus. One source of participants was the teachers who participated in a K-12 Teacher Workshop. They heard about the outreach programs there, and then arranged for their students to hear a speaker, attend a luncheon and/or participate in a Day on Campus. Some teachers took advantage of all three programs.

OUTREACH PROGRAM 1: Speakers Bureau

Speakers Bureau utilized women engineers as role models by bringing them into classrooms, teachers' meetings, math/science conferences, career days, and meetings of student groups as invited speakers. Project team members and members of the local sections of SWE were the speakers/role models. The speakers represented the fields of Civil, Environmental, Electrical, Mechanical and Computer Science Engineering and have spoken to a variety of student groups over the past three years, including:

- Career Day of Northern California Girl Scouts
- Expanding Your Horizons (Math/Science Saturday Conference for Girls)
- All-male high school career day (requested a female speaker)
- Classes at approximately ten area schools each year, in several school districts, and including two private schools

[4] The Teaching Logs were adapted from an instrument originally developed in 1991 as part of an evaluation of teacher workshops, "Women's History, Literature, and Art: Samples from the World," funded by the Center for Cooperative Research and Extension Services for Schools (CRESS), Division of Education, and the Humanities Institute, UC Davis.

OUTREACH PROGRAM 2: Luncheons with Engineers

Professional engineers from SWE were brought together with small groups of 9-12th grade girls at a restaurant. Two luncheons were held, both during the second year of the project, with fifteen girls attending each time. These were informal meetings where interested girls could discuss in depth what it is like to be an engineer. Typically, the girls had already indicated some interest in engineering, math or science. The number of participants at each luncheon was kept small to encourage a level of intimacy and sharing that does not occur as readily in the classroom or in larger groups. A variety of engineering disciplines was represented, including Civil, Mechanical, Environmental, Electrical, and Computer Science, so that students obtained a deeper understanding of what these professionals do for a living. Students were given a chance to privately discuss some of their fears and concerns, and to receive some personal attention within an interactive format.

OUTREACH PROGRAM 3: Day on Campus

We believe that one of the most effective ways of demonstrating the wide range of possibilities offered by a career in engineering, and demystifying both university life and engineering, is bringing students onto campus. The Day on Campus program brought groups of interested students, mostly female, from local schools to the UC Davis campus to learn about engineering.

Days on Campus were held during the academic school year, usually on Fridays. They began at 9:00 am and lasted until 2:00 or 3:00 p.m., which allowed students to meet at their school and return home at approximately their normal arrival and departure times. An agenda, map and pre-visit questionnaires for students were mailed to the teacher in charge approximately two weeks prior to the Day on Campus.

Each Day on Campus included several activities. After a welcome by program staff, students typically took a bus tour of the campus; interacted with a group of female undergraduate engineering students (occasionally having lunch with them as well); attended and participated in an engineering class, lab or demonstration; visited other parts of campus; and received detailed admissions information (for a complete description of these activities see the Project Handbook, Appendix 2).

Section III: Laboratory Research/Mentorship Program

The College of Engineering at UC Davis has a well-established program called Minority Opportunities for Research in Engineering (MORE), which provides minority undergraduate engineering students with laboratory research experiences. The program focuses on providing mentors for students and encouraging them to consider graduate school (and ultimately faculty positions) by providing experiences that help demystify the process of conducting research. Although some of the minority students are female, MORE does not specifically target women as a minority or underrepresented group, so funds from FIPSE and NSF were used to target undergraduate and high school aged women.

To find mentors for the undergraduates, a survey was sent out to female engineering faculty members at UC Davis, informing them of an opportunity to sponsor a female undergraduate researcher for ten weeks during the summer. Interested faculty were requested to provide WIE with a description of the research project and related activities expected of the student. A committee used these surveys to determine placements for researchers each summer. Although their selection process was different, the female researchers were included in the same general orientation, activities and evaluation as traditional MORE program researchers. High school student researchers were selected by the Principal Investigator, who contacted Davis High School and matched interested students to interested faculty.

Part II: Planning the programs

The first six months of the project were spent assembling the project team experts, gathering information about the problem at hand, researching other programs, developing possible evaluation strategies, forming support networks, and setting up working relationships with the San Juan School District. The project team of the Director of the Center for Women in Engineering, program planners, and the program evaluator met frequently during the second six months, to establish an overall framework of project guidelines. Project goals and objectives were confirmed and specific activities that would accomplish these goals were identified. Finally, an initial evaluation design was created to yield information during and after the end of the project about whether the goals were met.

After careful consideration of the original proposal and through its meetings, the team selected the following as feasible project goals, activities and evaluation strategies:

Step I: Project Goals

1. To create Awareness of engineering as a career option by:
   a. K-12 Teachers
   b. K-12 Students

2. To Attract and Recruit students into the engineering fields:
   a. K-12 students into math and science classes
   b. 9-12 students into university engineering curricula

3. To increase Retention of undergraduate students in engineering programs:
   a. K-12 teachers can increase eventual retention of students by informed instruction and communication skills
   b. Retention of high school and undergraduate students can be increased in college and graduate school through research/mentorship opportunities

4. To achieve Permanence of each component

Step II: Program Objectives and Evaluation Activities

1. ***K-12 Teacher Workshops***	
Awareness:	Teachers will be able to explain a typical engineer's day and describe skills and talents of an engineer.
Recruitment:	Staff will develop a package to be disseminated to teachers on engineering as a career option.
Retention:	Teachers will recognize teaching strategies that produce gender equitable classrooms (including peer mentoring).
Evaluation Activities:	Pre and post questionnaires; technical autobiographies; problems and solutions; images of engineers; teaching log; peer interviews; workshop evaluation form; staff observation and reflection.

2. ***Speakers Bureau***	
Awareness:	Disseminate information to students and teachers regarding engineering as a career, the attributes of an engineer, what a typical day is like, High School prerequisites necessary to enter an engineering program, salaries, career opportunities and growth potential and information on the various disciplines of engineering.
Recruitment:	Provide role models of professional women engineers and engineering students for both teachers and students.
Evaluation Activities:	Pre and post questionnaires; staff observation and reflection; informal feedback from participating teachers and parents

3. ***Luncheons***	
Awareness:	Disseminate information to students and teachers regarding engineering as a career, the attributes of an engineer, what a typical day is like, High School prerequisites necessary to enter an engineering program, salaries, career opportunities and growth potential and information on the various disciplines of information.
Recruitment:	Provide role models of professional women engineers and engineering students for both teachers and students; provide an opportunity for personal interaction between students and engineers; all students can explore particular disciplines.
Evaluation Activities:	Pre and post questionnaires; staff observation and reflection; informal feedback from participating teachers and parents

4. ***Day on Campus***	
Recruitment:	Expose students and teachers to university and campus climate, faculty and engineering students; expose students to engineering curricula, class activities and labs; provide students with information regarding entrance requirements for attending UC Davis.
Evaluation Activities:	Pre and post questionnaires; staff observation and reflection; informal feedback from participating teachers and parents

5. ***Laboratory Research/Mentorship Program***	
Attract and Recruit:	Educate high school students through information, demystification and exposure to role models in a lab research setting
Retention:	Undergraduate students through information, demystification and exposure to role models in a lab research setting
Evaluation Activities:	Site visits, pre and post questionnaires, feedback from faculty

The team continued to meet on a regular basis during the second and third years of the project, to discuss problems and concerns, feedback received from ongoing evaluation, and to use this feedback to make further modifications to program activities and evaluation.

Part III: Changes in Inter-institutional Collaboration During the Project

The San Juan Unified School District (SJUSD) in Sacramento County cosponsored the K-12 workshops during the first year. This district was chosen because of its size (one of the top five in California), its commitment to improving the quality of its math and science education, and because of an existing relationship between the District's Science Curriculum Coordinator and the WIE Center at UC Davis. The district provided a location for the workshop, distributed workshop brochures, and enlisted interested teachers for participation in each workshop.

During the first year, however, the district received a number of budget cuts, laying off personnel and limiting resources. Also, the Science Curriculum Coordinator who had originally championed our programs left the district, leaving us without an "evangelist." These changes greatly reduced the level of communication we had with the district. The workshops had to be rescheduled for later in the school year than originally planned, which disrupted our schedule. We were unable to effectively advertise the workshops to teachers. In the end, the grade level curriculum coordinators for the district directly recruited teachers for the program. We received no information about our participants before each workshop, which made it difficult to plan both workshop activities and evaluation measures. Some of the teachers recruited, especially at the secondary level, appeared to be unaware of the nature of the project and uncommitted to its goals. For this reason the first series of workshops for secondary school teachers taught us a great deal, but was not very effective in changing teacher attitudes or behavior.

These difficulties, among others, convinced us to change our cosponsor for the second year of the teacher workshops. We collaborated with SCATS to directly reach teachers who were interested in the teaching of science. SCATS offered a receptive audience of reform-minded science teachers, a well-established and efficient means of advertising the workshops, and administrative support in producing the workshops. SCATS sponsorship also enhanced the credibility of the project in the eyes of local science teachers, and connected the project to the overall educational reform effort in the Sacramento area.

This change in collaboration and co-sponsorship affected who participated in the outreach programs. Although flyers containing information about our outreach activities were distributed throughout SJUSD from the beginning of the project, most of the students who participated in the outreach programs were referred by teachers who participated in a workshop. These teachers heard about outreach activities while at a workshop, and many of them subsequently asked us to provide them with a speaker for their classroom, set up a luncheon, or bring their students onto our campus for the day. This was true during the third year of the project as well, when we administered the second set of workshops through SCATS.

E. PROJECT EVALUATION AND RESULTS

As the project team targeted goals, activities and evaluation strategies, it became evident that the project evaluation would have to yield a variety of types of information. We needed ongoing feedback about whether we were meeting our goals so we could modify programs and activities to best serve the needs of our participants. We also needed data for annual project reporting, information for institutional decisionmakers, and descriptive information about our programs for dissemination to a wide variety of audiences, both during and at the conclusion of the project. Finally, wherever possible, we wanted to use evaluation measures that were closely linked to the program and were easy to administer and interpret.

Project Evaluation Design

We chose an evaluation design that incorporated multiple methods of inquiry and both qualitative and quantitative approaches. This design was appropriate for several reasons. Different kinds of information about the programs were needed by a variety of audiences, during the project and at its conclusion. We needed to be able continuously to understand and describe the qualities of our programs and participants in order to make changes during the project. Finally, information gathered by a variety of methods strengthened our conclusions about the programs.

At the onset of the project, a review of the literature and of other programs revealed no existing quantitative measures, such as behavioral scales or tests, that could be used "as is" with our pilot programs. Also, program participants were for the most part few in number and self-selected. Therefore, quantifying their attitudinal and behavioral changes early in the project was not possible. Traditional quantitative instruments, we felt, could only measure attitudinal changes expected by and defined by the investigator, and the program participants might neither recognize nor concur with them. Using qualitative approaches instead allowed the program participants themselves to define and express their attitudinal and behavioral changes. These techniques helped us to avoid misinterpretation of our program results due to any preconceptions on the part of the evaluator, and allowed a much richer picture of the program's effects to emerge.

The small size of our programs allowed us to use a spectrum of qualitative evaluation techniques, such as questionnaires with open-ended questions, free writing by participants, peer interviews and ethnographic observation. The previous training of our staff (one member is an evaluator experienced in a range of qualitative techniques and one is a workshop leader and a trained ethnographer) allowed us to rigorously evaluate our program and develop insights into both the problems and our proposed solutions that a differently trained staff, using only quantitative surveys, might not have attained. Our approach to evaluation is becoming the standard in educational research, using qualitative methodology in the evaluation of professional development programs for teachers.[5]

Part I: Evaluation Methodology

K-12 Teacher Workshops

The evaluation of the K-12 Teacher Workshops focused on the assessment of changes in behaviors and attitudes of teachers, rather than of their students, because our direct contact was only with the teachers themselves. Descriptive feedback from teachers about what happened in the classroom workshops was sought to make ongoing program changes.

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[5] For example, the State of California is using ethnographic participant observation in evaluating the State's subject matter projects, as is the University of Michigan in its large study of the current California mathematics reforms.

The first K-12 teacher workshop series was evaluated primarily through analyses of written components of specific workshop activities, including the Technical Autobiography, Images of Engineers, and Problems and Solutions exercises. The evaluator reviewed these during the workshops, providing staff with immediate feedback so that on-the-spot workshop modifications could be made, and then performed a more in-depth content analysis which led to more changes in both the written measures and the structure of the next workshops. Participants were asked to fill out a written evaluation of the initial workshop at its conclusion, and the evaluator analysed these to suggest modifications in the second series. The workshops were observed and audiotaped, and audiotaped feedback sessions with project team members were held immediately following each workshop, giving the evaluator more data for analysis..

A Likert-type pre- and post-questionnaire, Teaching Logs and taped peer interviews were added to the evaluation data of the second workshop series. The evaluator devised questions for these additional measures, using results from the first series; the qualitative data from observations, written components of workshop activities and evaluations was coded by the evaluator and categories of responses were identified, leading to more narrowly focused questions.

The pre- and post-questionnaire asked teachers to rate themselves on their knowledge of engineering and use of a number of classroom teaching strategies at the beginning of the initial workshops, and again at the beginning of the follow-up workshops. The purpose of the questionnaire was to show whether teachers' attitudes or behaviors changed in the time period between workshops. The Teaching Logs, filled out by teachers between workshops, asked teachers to write descriptions of their experiences with the new teaching strategies and with teacher peer collaboration. The Logs provided information about teachers' successes and difficulties with these experiences, allowing us to provide them with additional support, resources and suggestions. Peer interviews paired teachers (who were not collaborative partners between workshops) at the beginning of the follow-up workshop, and provided them with another opportunity to discuss both their collaboration experience and their experiences using gender equitable teaching strategies and hands-on technology activities in their classrooms. One result of these peer interviews was the immediate generation of group discussion at the follow-up workshop and a determination of the agenda to be pursued that day. The data resulting from the evaluator's in-depth analysis of the transcribed interviews was used to confirm the validity of the responses in the Teaching Logs and observations of the workshop discussion.

Speakers Bureau, Luncheons and Day on Campus

All three outreach programs were evaluated using the comparison and compilation of results from pre- and post-event questionnaires administered to students,[6] oral and written feedback obtained from participating teachers and parents, and staff observation and discussion following each program offering. The questionnaires, which included both closed- and open-ended questions, asked students for background information about academic interests, attitudes and beliefs, and also asked them how they viewed various aspects of engineering before and after participating in one of the programs. The evaluator's analysis of this information, confirmed by the feedback from teachers and parents and staff observations, was used to make changes to the programs themselves to better suit the needs and interests of students, and to assess changes in students' understanding of engineering.

[6] These questionnaires were developed from, and based in part on, examples found in the book Evaluation Counts: A Guide to Evaluating Math and Science Programs for Women, by Barbara Gross Davis and Sheila Humphreys, published by the Math and Science Network, 1983..

Laboratory Research/Mentorship Program

All high school researchers' responses were evaluated using open-ended questionnaires administered before and after their experience in a lab. Students were asked to describe their projects, interactions with faculty and graduate students, future educational plans, and ideas for program improvements. The students were also observed by the project investigator. The results of the evaluator's analysis were used to modify the program to make the experience more worthwhile for subsequent students.

The undergraduate researchers were included in the evaluation by MORE of all responses of student researchers participating in that program. During the first year of the project, the evaluator conducted an independent evaluation of the female researchers' experiences, making site visits and administering a separate questionnaire at the end of the summer. The results were compared to those collected by MORE to see if there were any differences. Because the results were very similar, we concluded this independent evaluation effort on our part was not necessary in years two and three, and we then used MORE's data for the remainder of the program's evaluation.

Part II: Project Results

We estimate that our program activities potentially impacted as many as 8,000 students and educators during the past three years[7] :

Year 1:	Students:	Teachers:
Speakers Bureau:	380*	
Day on Campus (1):	8	
High school lab researchers:	4	
Undergraduate lab researchers:	3	
	395	
Year 2:		
17 K-6 teachers and science specialists x 30 students/teacher:	510*	17
17 7-12 teachers (10 math, 7 science) x 150 students/teacher:	2550*	17
Speakers Bureau:	380*	
Luncheons (2), 15 students/luncheon:	30	
Days on Campus (3):	62	
High school lab researchers:	3	
Undergraduate lab researchers:	3	
	3446	34
Year 3:		
15 K-6 teachers x 30 students/teacher:	450*	15
14 7-12 science teachers x 150 students/year:	2100*	14
Speakers Bureau:	1380*	
Days on Campus (4):	69	
Undergraduate lab researchers:	3	
	4002	29
TOTAL:	7843 students, 63 teachers	

*Estimated numbers

[7] Project dissemination activities also impacted many educators and potential students (see Appendix 4).

The next sections present individual program results.

K-12 Teacher Workshops

We had no prior knowledge about our participants in the first series of workshops as they were selected for us by the school district. Teams of teachers from several elementary schools participated in the K-6 workshop. This collaboration was found to be an effective approach to reaching our goals. We discovered that the K-6 teachers wholeheartedly embraced gender-equitable teaching strategies, and believed they had the power to make these changes in their own classrooms, because they were already engaged in teaching activities that supported students' self-esteem. The team approach allowed teachers to explore the machine activities together in a safe environment, then return to their schools to help each other implement the activities and teaching strategies in their classrooms.

The participants for the first 7-12 workshop series were also selected by the district. Unexpectedly, two-thirds were math teachers and only one-third taught science. We discovered that, while our workshop activities and gender-equitable strategies were appropriate for use with science teachers, they did not work well with math teachers. Several math teachers said they had difficulty believing that factors other than lack of natural ability kept girls from pursuing math and science. Unlike the science teachers, most of the math teachers could not see a connection between the use of hands-on activities and their curriculum. Secondary school teachers, unlike elementary school teachers, felt that the power to change the climate of their classrooms lay not within themselves but instead within their administrations.

Obtaining participants for the second series of workshops through SCATS helped to eliminate some of the administrative problems encountered while working with the school district and allowed us to solicit participants with an interest in teaching science. Including a collaboration component for all participants met with mixed results. Some teachers, despite being provided with funds for substitutes, were unable to collaborate because of administrative difficulties in finding substitutes or getting together with other colleagues. In other situations, however, teacher collaboration produced some exciting results:

- Teachers who collaborated with one another did more together than they could alone, because they were able to share their equipment, tools and knowledge.
- Teachers were more likely to try hands-on activities when they had each other's support.
- Some collaborative teams went on to conduct their own workshops.
- Students from one teacher's class often taught students in another's, for example, 3rd grade students taught 1st grade students.

Teaching logs, peer interviews, and discussion in follow-up workshops revealed that caution needs to be taken when students are working with tools, machines and potentially hazardous materials in the classroom. Recommendations for such precautions are included in the Project Handbook (see Appendix 2).

Based on information from the first set of workshops, a pre- and post-questionnaire was designed and administered to participants in each of the second set of workshops. Participants filled out the questionnaires at the beginning of the initial and follow-up workshops. These instruments used Likert-type scales and asked participants to rate factors that may be obstacles to girls' persistence in math and science, and to rate themselves on the use of various classroom strategies. Although the sample sizes were small, several questions indicated there were significant changes ($p \leq .05$) in teachers' responses after the initial workshops and subsequent collaboration, as shown below.

After the initial workshop and subsequent collaboration, K-6 teachers:

- knew more about how to help their students plan their education for engineering

- knew more about classroom strategies for engaging girls
- found it less difficult to examine how machines work in their classrooms
- believed classroom climate is a greater obstacle to girls' persistence in math and science than before the workshop

After the initial workshop and subsequent collaboration, 7-12 teachers:

- used more cooperative work groups in their classrooms
- used more tools (hammers, screwdrivers, etc.) in their classrooms
- found it less difficult to do real world problem solving in their classrooms

Strong feelings of frustration also emerged from the workshops. Both elementary and secondary teachers emphasized during the workshop discussions that influences outside of the classroom also must be addressed before gender equitable education can be achieved. They felt strongly that the influence of parents and the media on girls' attitudes and self-esteem inevitably shapes the education of girls.[8]

Speakers Bureau and Luncheons with Engineers

Both Speakers Bureau and Luncheons were difficult programs to evaluate. In the case of Speakers Bureau, pre and post questionnaires were given to the speakers, who in turn relied on teachers to hand them out and return them. We received very few of them back. Also, the short duration of a speaker's presentation left little time for a written evaluation, and some schools already had their own evaluations for presentations. We relied instead on positive verbal feedback from speakers and teachers, as well as receiving continued requests for more speakers, as indicators of the success of Speakers Bureau. In some cases, speakers also became informal mentors for students.

Luncheons were less successful than Speakers Bureau because of the logistics required to get engineers and students together during a work day. These logistical problems, detailed in Summary and Conclusions, led to the decision to discontinue Luncheons in the third year of the project. Again, although pre and post questionnaires were used, verbal feedback from students, teachers and engineers gave us most of our information about this program. One positive outcome was that the teachers who attended both of the luncheons later brought groups of students to a Day on Campus.

Day on Campus

Of the three outreach programs, the Day on Campus provided students with the most exposure to engineers and engineering. Day on Campus was easy to administer, and was also the easiest of the three programs to evaluate. The WIE Outreach Programs coordinator directly handled the distribution and collection of the pre and post questionnaires for each participating group of students, so a greater return rate was achieved for this program. Project staff was also often able to attend and observe the activities. Most of the students who attended a Day on Campus were female high school students, with one sixth-grade class attending.

There were two particular areas that yielded significant results ($p \leq .0001$, $n = 114$):

- When asked, "How much do you know about engineering?" students rated their self-knowledge as significantly higher after attending a Day on Campus.
- Students were given a list, before and after participating in a Day on Campus, and asked to check of fall of the engineering related areas in which they might want more information. After participating,

[8] We feel this is an area that needs broader examination and approach in the future. See Appendix 6: Information for FIPSE.

students chose significantly fewer items from the list, suggesting that they received much of the information they wanted from the program.

Responses from the questionnaires also showed that:

- 96% of all respondents learned something about engineering they had not known before
- 79% of respondents did not know any female engineers prior to the Day on Campus.
- 27% of respondents had attended a Luncheon.
- 21% had had a Speaker in their classroom.

When asked what they liked most about attending the Day on Campus, students mentioned all of the activities, but particularly enjoyed meeting with undergraduate female engineering students. Students also enjoyed participating in hands-on work in engineering labs and many wrote that they appreciated receiving detailed university admissions information.

Laboratory Researcher/Mentorship Program

Our evaluation results were similar to those obtained by the MORE program for undergraduates in the first year, so evaluation of the second and third year was done only by MORE. Students are monitored by MORE staff throughout their lab research projects and are asked to evaluate the program at the conclusion of their participation. Participants felt the program was very beneficial. They were excited about their lab research projects, and greatly valued their close contacts with graduate students in the laboratories. They felt that their lab experiences helped them understand the connection between their classwork and actual research. Many students also had higher goals for continuing their education by the end of the program, saying that the experience made them consider pursuing graduate school. Participating professors are also asked to evaluate the students and the program, and their response, too, was overwhelmingly positive. Several of the professors have continued to act as mentors for the participants.

High school students were primarily monitored and evaluated by the Principal Investigator throughout their research experience. They, too, greatly valued participating in labs with graduate students, and felt the experience helped them overcome some of their stereotypes about "typical engineers." Students mentioned learning specific skills such as computer skills, and as a result of the experience were not only interested in pursuing an engineering major in college but also in considering graduate work beyond.

Part III: Plans for Project Continuation and Dissemination: Next Steps

To achieve our project goals of permanence, we have sought avenues for institutionalization of each program and dissemination of our research results. We will meet with the Sacramento Science Center in Fall 1994 to explore how they can continue future teacher workshops. We will also work with the Division of Education at UC Davis to discuss including the gender equitable teaching strategies and How Things Work activities from the workshops as part of their teacher education program. For the outreach programs, student SWE and WIE at UC Davis will continue the Day on Campus. The professional sections of SWE will continue to coordinate both Speakers Bureau and the Luncheons. The MORE program will continue to seek funding in order to continue offering female students opportunities for laboratory research mentorships.

The project team has compiled a handbook of those programs we believe are most readily duplicated elsewhere. The handbook (Appendix 2) includes information about planning and evaluation of K-12 Workshops, Speakers Bureau and Day on Campus. As of October 1994, over 400 requests had been

received for the handbook from groups across the nation. The WIE staff has also disseminated information about the project through presentations and published proceedings at the 1994 WEPAN conference and the 1994 SWE National Convention, and through workshops for CSTA (California Science Teacher's Association), NSTA (National Science Teacher's Association) and SCATS (Appendices 4 and 5). Additionally, a number of the teachers participating in the second series of workshops will, in turn, conduct workshops in their districts and schools.

F. SUMMARY AND CONCLUSIONS

We have gained many insights through the development, administration and evaluation of these programs. To summarize what we have learned and offer advice to others wanting to offer similar programs, we have developed a Project Handbook, which can be found in Appendix 2. This summary section highlights a few of the lessons learned from our project, and our recommendations to others.

Lessons Learned

K-12 Teacher Workshops

It became clear that the first obstacle to changing the classroom is having teachers admit that a problem exists. An even greater obstacle is having teachers recognize their power to change the classroom climate. Teachers tend to identify curriculum solutions rather than solutions centered in the way they teach. We succeeded in getting teachers to consider new ways of teaching (especially at the K-6 level) and in having teachers experiment with curricular solutions (How Things Work) that can lead to changes in the classroom climate.

We also learned that co-sponsorship with a school district or a professional teacher's organization was vital in giving our project credibility. The first series of workshops was offered through a large school district, and the second through a professional teacher's association. From our experience, a small school district would probably work better than a large one such as San Juan Unified, which is among the 5 largest in the state of California. Obtaining a multi-year, written commitment from the top management in the district would also create a stronger foundation for such a project. Working with an "evangelist" or school coordinator within the district is essential in ensuring that participants can be solicited and that administrative details are handled smoothly and in a timely manner. While an outside professional organization such as SCATS offers credibility to the workshops, provides a receptive audience of teachers, and can aid in handling administrative details, it can not offer release time and financial support, as a school district can.

Outreach Programs

Day on Campus proved to be an extremely effective and efficient means of successfully creating awareness of engineering in female students. Speakers Bureau was also a relatively easy program to administer with assistance from SWE. However, we generally found that the Luncheons were difficult and time consuming to put together. It was difficult to find four to six professional women who could take two or more hours out of their busy work day to participate. Transportation for the students was also problematic: typically, parents, teachers and older students had to be recruited for transportation. Finally, there was the question of how to pay for the lunch. Project guidelines did not allow for funds to be used for meal purchases. The original intent was to host the students and make the experience special for them so it would have been inappropriate to ask them to pay for their meals. Ultimately, the SWE section picked up the tab. And even with gratis meals, there were complaints about the meal choice. Therefore, while this program was effective in providing one-on-one interaction between professionals and high school students, we discovered that the time and effort required to organize a luncheon was not justified by the relatively few students reached, and do not recommend it to others.

Laboratory Researcher/Mentorship Program

Of the five programs, the laboratory researcher/mentorship program provided the most in-depth, long-term, individualized attention to students. As expected, students reacted very positively to their experiences. However, the cost of providing this highly individualized experience was high in comparison to the other programs, despite being able to serve students through an existing program.

It is unclear whether the benefits of this program merit its cost. Finally, concerns about program were raised when students at Davis High School protested its stipulation that participation was limited to female students.

Recommendations

K-12 Teacher Workshops

Elementary teachers, with their orientation towards enhancing student self-esteem, are an eager and receptive audience for gender equity reforms. However, because of their own inexperience with and apprehensions about science, math and technology, they are poorly positioned to encourage girls in non-traditional fields like engineering. We recommend that any gender equity training for this group be tied to specific science and technology subject content to allow teachers to develop confidence in these areas. Secondary teachers are more focused on subject areas, and need specific intensive exposure to gender equity issues. The needs of these teachers may be best met through long-term gender equity programs such as GESA (Gender Ethnic Student Achievement), with model lessons featuring math, science and technology topics.

We offer the following advice to others:

- Work with a small school district. Try to reach all teachers in the district through school-based grade level teams.
- Keep teachers focused on gender questions, and always tie curriculum innovations back to the goal of improving classroom climate.
- Address math teachers separately from science teachers. There is an enormous need for reform in math education to encourage teachers to use more real-world problems and to anchor their curriculum in practical applications. Math teachers need to learn how to use cooperative techniques and how to foster gender equity in their classrooms.

We expected that elementary teachers would be the most difficult to reach, but they were some of the most daring experimenters in the project. In the original proposal, the gender equity and the how-things-work components were conceptualized as separate parts of the project. We learned that the two were inseparable - that teachers needed the technology lessons as a vehicle for demonstrating gender equitable teaching.

Outreach programs

We feel that we were doing something with K-12 students that is not usually done in the schools: training and teaching them about careers. Schools follow a curriculum, and do not necessarily teach skills that readily translate to employment and careers. We noticed that most of the female students we encountered in our programs did not seem to have given much thought to their careers.

We believe that our approach of taking on the whole pipeline, through addressing both teachers and students, was important. Our efforts were most effective for those students who participated in all of the program components. Through repeated exposure to engineering, these girls are more likely to see themselves as potential engineers.

References

Ehrhardt, Julie Kuhn and Sandler, Bernice R. *Looking for More Than a Few Good Women in Traditionally Male Fields.* Project for the Status and Education of Women (PSEW), Association of American Colleges, 1987.

Engineering Manpower Bulletin, *Engineering Degree Trends, 1992*. American Association of Engineering Societies, Inc., no. Washington, D.C.: 1992.

Engineering Workforce Bulletin, *Women in Engineering*, American Association of Engineering Societies, Inc., no. 125, Washington, D.C.: 1993.

Table of Contents: Appendices

Appendix 1: Inter-Institutional Project Profile

	SJUSD	SCATS	SWE: Sacramento Valley, Foothills sections	UCD: Student SWE chapters, MORE staff, Engineering faculty	Davis High School Teachers
K-12 Teacher Workshops	Administrative Support, Yr. 1 Participants, Yr. 2	Administrative support, Yr. 2 Participants, Yr. 2	Provided information on engineering careers		
Speakers Bureau	Teachers and student participants	Teachers and student participants	Provided speakers		
Luncheons with Engineers	Teachers and student participants		Attended and interacted with students		
Day on Campus	Teachers and student participants		Spoke as professional engineers	Provided speakers, facilitators, campus tour guides	
Laboratory Researchers				Provided undergraduates, engr. faculty as mentors	Provided H.S. students for program

Table 1: Inter-institutional Project Profile

Appendix 2: Project Handbook

This appendix contains the following handbook, resulting from the project:

"How Universities Can Help Teachers Introduce Girls To Engineering: A How-To Manual," Center for Women in Engineering, UC Davis, Davis, CA.

HOW UNIVERSITIES CAN HELP TEACHERS INTRODUCE GIRLS TO ENGINEERING:
A How-To Manual

HOW UNIVERSITIES CAN HELP TEACHERS INTRODUCE GIRLS TO ENGINEERING: A How-To Manual

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One of the fundamental problems in recruiting women into engineering is that so few young women leave high school with the academic background or technical interests needed for a college career in engineering. While the reasons for girls' exodus from the math and science pipeline are complex, factors include a classroom climate that discourages girls from participating in math and science and a lack of role models.

In 1991, the Center for Women in Engineering (WIE) at the University of California, Davis received a three year grant from the U.S. Department of Education's Fund for the Improvement of Post Secondary Education (FIPSE). This grant funded the development of several pilot programs to address the issue of low retention of girls in math and science at the K-12 level. These programs were developed for use in the Sacramento County area but can serve as models for similar programs in other school districts.

This handbook offers guidelines for how to plan, implement and evaluate three of the programs that the project produced.

PROGRAMS OUTLINED IN THIS MANUAL

- A gender equity and technology workshop series for K-12 grade teachers,
- A "Day on Campus" outreach program that brings students to visit a College of Engineering, and
- A Speakers Bureau that brings female engineers into classrooms to talk to students.

PROJECT GOALS

- To educate girls and teachers about engineering
- To allow girls to experience everyday technology so that engineering seems less alien to them
- To improve the classroom climate for girls thus increasing their retention in math and science classes
- To introduce girls to female engineering role models

This handbook is comprised of three sections, one for each program. Each section is divided into subsections including:

- Overview: General description of the program
- Planning: Administrative suggestions
- Activities: Details for carrying out each part of the program
- Evaluation: Suggestions for evaluating the program.

The Appendices contain sample agendas, handouts for activities, evaluation instruments, and a reference list.

K-12 WORKSHOP SERIES

OVERVIEW

The workshop series addresses three goals:

- *Improving classroom climate through gender equitable teaching,*
- *Helping to dispel myths and stereotypes about engineers, and*
- *Encouraging teachers to use everyday technology in their classrooms.*

Introductory Workshop

The first workshop of the series is composed of five structured activities that highlight the goals of the project. These activities include Research Assignments, a Technical Autobiography, Images of Engineers, a How Things Work project, and Problems and Solutions. Each of these activities is described in detail. The appropriate handouts can be found in Appendix A. This full-day workshop is orchestrated by the project staff, though it is designed to solicit input from the teacher participants.

Follow-Up Workshop

The second workshop is designed to track and assist the teachers' progress in implementing both gender-equitable teaching strategies and how-things-work activities. We recommend planning workshop activities based on suggestions from the participants.

Teacher Peer Collaboration

Collaboration gives teachers confidence as they experiment with changing their teaching. We have found that this added support results in improved participation from the teachers.

PLANNING

Philosophy

We believe that teachers, like students, learn through experience. If we want teachers to teach in a more equitable way, they must experience that kind of teaching. If we want them to teach about technology, they must have an opportunity to explore technology. The workshops are designed to let experience be the primary teacher. We view the program as a collaboration between our staff and the participating teachers in which we supply some ideas and the opportunity for the teachers to experiment with them. The teachers provide the know-how to implement those ideas. The workshop activities are designed to solicit teacher input and to instill a sense of ownership in the project.

Co-sponsorship

We highly recommend that any organization outside the K-12 educational structure seek a co-sponsor for the workshop series. We believe that a small school district may be the most effective co-sponsor. Small school districts are often overlooked by organizations seeking school partnerships, and may therefore be eager to cooperate. In a small school district, the workshops may reach most or even all the teachers, giving the program a synergistic energy as teachers within schools collaborate. Finally, school district co-sponsorship helps avoid potential administrative problems.

Grouping

We recommend separate workshops for K-6 and 7-12 teachers. We found that elementary teachers tend to be focused on self-esteem issues and are thus open to learning more equitable ways of teaching, but need help in developing confidence with math, science, and technology. Secondary science teachers see themselves as specialists in their subject. They have confidence with technology activities, but must be convinced of the need for gender equitable teaching.

Logistics

We ran the workshops at a university, though a public school site would also be appropriate. Our workshops ran from 9 AM to 3 PM. We provided lunch to keep the participants focused and on campus. Our largest workshop session had 17 participants. We recommend no more than 24. We found it best to offer the introductory workshop fairly early in the school year. This allows teachers to fit the activities into their plans for the year, and avoids the holiday rush. The follow-up workshop is probably best scheduled in March or early April so teachers have time to try the activities. We found that the late spring tends to be busy and should be avoided.

Materials for planning and implementing the workshops can be found in Appendix A. Evaluation materials are located in Appendix D.

INTRODUCTORY WORKSHOP ACTIVITIES

Research Assignments

Purpose: to give teachers a chance to explore both their relationships with their students and their students' hopes for the future.

Description and Implementation: Before attending the first workshop, the teachers are sent two research assignments. In the first assignment, the teacher asks students to write an essay (or for young students, draw a picture) illustrating a typical day when the student is thirty years old. The teacher then analyzes the essays, compiling information about what careers are depicted and how students describe family roles. Each teacher brings the compiled results and a three sentence summary to share at the first workshop. During the lunch period at the introductory workshop, teachers compile the results of their research on their students using a large chart. This chart can be used to launch a group discussion of the results. Our experience is that participants have found this research to be very useful, giving them a much clearer view of how their pupils view themselves and their futures.

For their second assignment, the teachers have a colleague or student keep track of which students the teacher calls on and spends the most time with. Some teachers find that they are very even-handed in calling on their pupils, but most discover some gender bias. Typically, a few students are using most of the teacher's time and attention. This assignment proved useful to teachers not only in assessing their teaching, but in opening up communication with students about classroom interaction. We found that teachers were more reluctant to discuss their results from this research project than they were to talk about their research on their students, but the activity served an important function in establishing the need for new solutions.

INTRODUCTORY WORKSHOP ACTIVITIES

Technical Autobiography

Purpose: to allow teachers to confront and discuss their fears and anxieties about exploring technology.

Description and Implementation: Before exploring how machines work, teachers individually fill out a Technical Autobiography form that consists of questions about their experience with and attitudes about tools and machines. Then they discuss their answers with their working group. This activity helps teachers start to overcome inhibitions they have about exploring technology, and helps develop a sense of trust within their group.

Images of Engineers

Purpose: to help broaden teachers' and students' images of engineering

Description and Implementation: Teachers write about their images of an engineer's typical day. They share these images in groups of three. The teachers then read the descriptions of a typical day written by six engineers. We solicited descriptions of an engineer's typical day from the local chapter of the Society of Women Engineers. In Appendix A are descriptions that we obtained from women in consulting, educational, or regulatory positions. We recommend that you solicit information from female engineers in many fields to obtain a broader variety of descriptions.

Next, the teachers write about the skills and talents that they think are necessary for engineers, and compare their ideas to those supplied by the engineers. Finally, the participants reflect on how this experience may have changed their images of engineers.

We found that teachers are surprised at the amount of communicative work described by the engineers: meetings, telephone calls, and writing projects. Likewise, they are surprised by the emphasis that engineers put on communication skills. As in the rest of the workshop activities, there are no right answers to the questions asked in this exercise. We encourage teachers to share their personal experience of engineering, and we always include a female engineer on our workshop staff to answer questions and share her own work experiences.

INTRODUCTORY WORKSHOP ACTIVITIES

How Things Work

Purpose: to allow teachers to explore household technology, to develop confidence with machines and tools, and to learn how to integrate household technology into their curriculum.

Description and Implementation: In this activity teachers explore how household devices work. A wide variety of common machines work well for this exploration: bathroom scales, electric mixers, toasters, cameras, tape recorders, and mechanical toys. Such exploration into technology can be appropriate for any grade level, depending upon the educational goals of the teacher. With this in mind, we prepared a handout for teachers with suggested goals and strategies for carrying out the exercise in their classroom (see Appendix A).

The participating teachers take apart their device, learn as much as they can about how the device works, present their findings to the group, and then reassemble the device. Here are some of the strategies we have discovered that help the activity run smoothly.

- Provide enough devices so that teachers can work in groups of three.
- Supply tool kits for each group: wrenches, pliers, slotted and Phillips-head screwdrivers, and a set of jeweler's screwdrivers.
- Supply cardboard trays from cartons of soft drinks for containing parts and tools and supply plastic bags for "extra" parts.
- Supply butcher paper and markers for preparing presentations.
- Assign tasks within the group: reporter, recorder, facilitator.
- If male teachers take over machines and tools, stop work to discuss equity issues.
- Specify times for disassembly (30 minutes for simple devices).
- Schedule report times (3-5 minutes per group).
- Provide reference books for consultation (see Appendix E).

After completing the activity, the teachers discuss how the activity might work in their classroom. Some topics to introduce are: how technology activities fit into existing curricula, problems the teachers foresee in managing the activity, and gender equity issues introduced by the activity, especially the use of single sex groups. In these discussions staff act as facilitators, giving the teachers a chance to benefit from the experiences of the other participants. Some of our participants reported that having parents or relatives of the students help out in the classroom during the activity was beneficial to both the students and teachers.

WARNING: *Some older devices such as telephones, hair dryers and irons contain hazardous materials. Check these devices before taking them apart in a workshop and inform teachers of these dangers.*

INTRODUCTORY WORKSHOP ACTIVITIES

Problems and Solutions

Purpose: to tap the experience of participating teachers in gender equity, and to identify gender equitable teaching strategies.

Description and Implementation: The teachers write about and discuss the obstacles they perceive in their own school that keep girls from persisting in math and science. They then write about and discuss strategies for overcoming the obstacles they have identified. After all the groups have presented their ideas, we distribute a handout on four successful gender-equitable teaching strategies identified by educational researchers: cooperative groups, pro-active classroom management, hands-on learning, and active career guidance in the classroom (see Appendix A). We usually find that our participants have already identified most of our proposed teaching strategies as well as providing some other creative methods of increasing girls' interest in math and science.

FOLLOW-UP WORKSHOP

Purpose: to track the teachers' progress in implementing both gender-equitable teaching strategies and how-things-work activities.

Description and Implementation: Prior to this workshop, we ask participating teachers how they would like to use the workshop time. Possible topics and activities include: demonstrations by participating teachers of technology-oriented lessons, machine dissections with specific instruction about some aspect of technology such as gears or electric motors, and discussions of extensions across the curriculum. Teachers should also discuss the progress they have made in implementing a more hospitable classroom climate for girls.

TEACHER PEER COLLABORATION

Purpose: to give teachers support as they experiment with changing their teaching; to keep teachers involved in the program; to help teachers form a professional network interested in gender equity.

Description and Implementation: Teachers come to the workshops with a partner or find a partner at the workshops. They collaborate with their partner in achieving the program goals. Some ways in which the partners might work together include: team-teaching technology activities, working together to plan technology lessons, monitoring each other's teaching to help achieve gender equity goals, and providing support and connections within the teaching community. Teachers can collaborate on their own time, or the organization sponsoring the workshops can pay for substitute teachers so that teachers may collaborate during the school day.

Providing substitute teachers can lead to administrative and logistical problems. Setting up contracts and making payments to many school districts can be an administrative nightmare. Teachers may also find that they are low on the priority list for substitute teachers. These difficulties can be minimized if the program is co-sponsored by a local school district. Without school district sponsorship, the administrative overhead outweighs the benefit of school day collaboration.

EVALUATION

Feedback about this program can be obtained in several ways, including observation of the workshops and review of written workshop activities and teachers' "homework" assignments. Ongoing evaluation will enable you to tailor program activities to the needs of participants and their students. Some suggestions include:

1. Have program staff observe the introductory and follow-up workshops as they are implemented, then meet soon afterwards to discuss their observations. If possible, have someone attend the workshops simply to observe and take notes.

2. Between workshops, have program staff observe teacher collaboration on-site. Staff can observe teachers' implementation of gender-equitable teaching strategies and how-things-work activities. These observations can be discussed with participants in the follow-up workshop, allowing any concerns to be addressed by staff.

3. Review participant's written contributions to workshop activities, so that these activities can be modified to better address teachers' needs. Handouts for these activities can be found in Appendix A. The following describes the type of information that can be obtained from each activity:

Research Assignments: Can provide an understanding of various teaching biases and insights into students' ideas about their futures.

Technical Autobiography: Can provide information about the anxieties and fears of exploring technology that may affect or hinder teaching.

Images of Engineers: Offer insight into teachers' concepts about engineering work and the skills required to perform it.

Problems and Solutions: Offer evidence as to whether the workshop has helped teachers identify both obstacles that hinder girls' participation in math and science and solutions to overcoming these obstacles.

4. Have participants evaluate the workshop with a questionnaire at the end of the introductory and/or follow-up workshop. An example can be found in Appendix D.

DAY ON CAMPUS

OVERVIEW

The Day on Campus addresses three goals:

- *Educating girls and teachers about engineering,*
- *Allowing girls to experience everyday technology, and*
- *Introducing girls to female engineering student role models.*

The Day on Campus brings students, preferably high school girls, from local schools to a university campus to learn about engineering. Students tour the campus, attend an engineering lecture or presentation, visit a lab, talk with engineering students, and meet with an admissions advisor. Lunch can be an unsupervised affair, where visiting students mingle with university students and experience the university atmosphere. By the end of the day, the students have a better understanding of life on a college campus. They also have a better idea of what an engineer does for a living, what it is like to attend a university and study engineering, and what kind of classes to take in high school to prepare for an engineering major.

PLANNING

The Day on Campus requires a campus sponsor who has access to people and resources. It may be an administrator, a professor or a student. The sponsor should be responsible for arranging bus tours, reserving conference rooms, scheduling speakers and panels, etc. An escort for the visitors, who may or may not be the same person as the sponsor, is also important. The escort greets the guests and accompanies them throughout the day. It is possible to split this duty between two people. Our program reimbursed visitors for transportation costs and substitute time. If your program will fund these expenses, someone will need to make the contractual and payment arrangements within the university.

All of our tours began at 9:00 a.m. and ended at 2:00 or 3:00 p.m. This schedule allowed the students to meet at their school and return home at approximately their regular time. An agenda, map, and pre-event questionnaire were mailed to the teacher-in-charge approximately two weeks prior to the tour date. A sample agenda can be found in Appendix B. Visiting students were given a homework assignment two weeks before coming to campus. The assignment was discussed with a professor at their Day on Campus. A sample assignment and agenda can be found in Appendix B.

Our visitors ranged from 6th to 12th graders. Although all groups enjoyed their visits, we found that the ideal age group for meeting our goals is ninth and tenth grade high school students. These students are old enough to appreciate the information and young enough to make choices in their high school program to pursue engineering. We recommend modifying the program for younger students (grades 7 and below) by eliminating specific discussion of college entrance requirements and providing more general discussions, videos and specific hands on activities.

Parents were invited to attend, provided there was space available. We found that the number of guests was limited by the size of the labs. We kept our groups to between twenty and twentyfive total visitors, including parents and teachers. We were sometimes required to split the groups to visit the labs.

Materials for planning and implementing a Day on Campus can be found in Appendix B. Evaluation materials are located in Appendix D.

ACTIVITIES

Welcome and Campus Tour

Purpose: to welcome students and introduce staff; to give students a general impression of campus and the opportunities offered on campus; to give students the "Big Picture."

Implementation and Description: Students are given an open-air bus or walking tour of the campus. The tour works well as the first activity of the day, allowing students to be better oriented and to settle down before entering labs and classrooms.

"What is Engineering?" Presentation

Purpose: to communicate to students what an engineer does and what types of engineering exist.

Implementation and Description: A female professor, staff member, professional engineer, or student makes a presentation describing the different types of engineering, contributions of engineers, and the problem solving method of thinking. This presentation is most effective if the speaker talks to students on their level and uses an interactive style rather than lecturing. Visual aids such as videos or posters are helpful. Videos are available from The Society of Women Engineers (SWE), The American Society of Mechanical Engineers (ASME), the National Society of Professional Engineer (NSPE), as well as others. Addresses for the national headquarters for these societies are located in Appendix E.

ACTIVITIES

Engineering Exercise

Purpose: to show students that engineering and problem solving are within their grasp; to experience a college classroom and meet a professor.

Implementation and Description: Ask a professor (female if possible) to talk a little about herself and her work and then discuss an assignment that the students were given prior to the "Day on Campus." If the students have not completed an assignment, they can do the paper clip design described below. We found that this presentation is more effective with a professor who is comfortable with younger students and one who has some understanding of female engineering students. A professor is the preferred lecturer, as it adds authenticity, but a staff member, a professional engineer or a student can also make the presentation.

• A design homework assignment is included in the Appendix B. This should be mailed to the visiting teachers along with the agenda, map, and questionnaires. The students bring their prototype designs with them.

• For an impromptu activity, the professor can ask students to design something using 3-5 paper clips. She can then examine the designs and talk about strength, materials, design, reliability, creativity, etc.

Engineering Lab or Class Visit and Presentation

Purpose: to contribute to students' understanding of engineering; to give students an image of what engineers do.

Implementation and Description: The students, sometimes in small groups, are escorted through engineering laboratories. Simply walking through the laboratories is not as effective as having someone explain what is going on in the lab. Students particularly enjoyed attending labs where they could see exciting, real world activities such as a bob-sled simulator and mountain bike performance testing equipment. Ideally, the students participate in a lab and get some hands on experience.

ACTIVITIES

Meet with Female Undergraduate Engineering Students

Purpose: to introduce students to role models, to allow visiting students to ask questions of student engineers.

Implementation and Description: Invite a panel of 3-6 female engineering students to speak briefly on why they chose engineering, what path they took to the university, what they like least and most about their major. Invite students from different majors, ages, ethnicity, junior college backgrounds, etc. High school students can ask questions after the engineering students have spoken. We found that meeting and talking with the engineering students is a very important part of the experience for the visiting students.

Admissions Information

Purpose: to inform students about how to prepare for entrance into college, specifically engineering programs.

Implementation and Description: This works well at the end of the day, when students are excited about engineering. Ask an Admissions Department representative to give a presentation to the students including what classes to take, what GPA and SAT scores are needed, when to apply, etc.

EVALUATION

Evaluation of the Day on Campus program can include observation and analysis by staff of written and oral feedback from participating students and written and oral feedback from teachers and parents who attend. This observation and feedback analysis can offer a better understanding about the needs of students, so that subsequent offerings can include activities that meet these needs. We recommend the following as evaluation activities:

1. Have program staff observe the Day on Campus and meet shortly after the activity concludes to discuss these observations. If possible, have someone attend a Day on Campus one or more times simply to note students' reactions to and participation in activities, record any oral comments, and share these observations with the staff.

2. Administer a student evaluation of the Day on Campus at the end of the day. The subject matter of the questions can include their feedback on specific activities encountered in the field trip, or whether their needs for certain types of information were met. An evaluation form can be given out to attending parents and teachers as well. See Appendix D for sample evaluation forms.

3. Ask teachers to discuss the Day on Campus with their students and to fill out and return an evaluation a few weeks after the field trip. The passage of time will allow both students and teachers to think about the day and a second evaluation may provide additional insights.

SPEAKERS BUREAU

OVERVIEW

The Speakers Bureau addresses two goals:

- *Educating girls and teachers about engineering, and*
- *Introducing girls to female engineering role models.*

The primary purpose of the Speakers Bureau is to bring female engineering role models into contact with teachers and students, by fulfilling requests for speakers in the classroom, at teachers' meetings, math or science conferences, and career days. Most students and many teachers have never met a female engineer. Speakers can disseminate information on the engineering profession, such as what an engineer does, the different kinds of engineers, and the contributions engineers have made to society. The high school preparation needed to be an engineering student and the typical engineering undergraduate curriculum may also be discussed. If a workshop format is requested, the participants can be asked to solve a problem that requires them to use engineering principles.

We enlisted members of the local sections of the Society of Women Engineers as our primary speakers and role models. A Speakers Bureau Packet is included in Appendix C to aid speakers. Programs can be adapted for different age levels and different forums. To ensure regular utilization of the Speakers Bureau, it is important to advertise its availability to the community regularly.

PLANNING

This program needs a coordinator who can act as a point of contact for schools who need speakers. Since members of the Society of Women Engineers(SWE) make excellent speakers, a good choice for coordinator would be a SWE member. The local SWE section may already have a Speakers Bureau in place. If possible, the contact phone number or address for the coordinator should remain the same so the coordinator should serve for a number of years or a designated Speaker Bureau's post office box or message phone should be set up.

Once a coordinator is selected,she needs to identify and train speakers. To assist speakers in preparing for the task of educating youth on the engineering profession, see the Speakers Bureau Packet in Appendix C. The packet contains a description of engineering and itsmany disciplines, helpful statistics, hands-on activities, and suggestions on the presentation. Pertinent references are located in Appendix E. We hope that the Speakers Bureau Packet will provide a starting point for speakers.

The Speakers Bureau should be advertised to the local school districts regularly. Flyers and word of mouth are effective. Engineer's Week, held every February throughout the United States, is a good time to have speakers available; this availability should be advertised six weeks ahead.

Materials for planning and implementing the Speakers Bureau can be found in Appendix C. Evaluation materials are located in Appendix D.

EVALUATION

Speakers Bureau is a program that can provide a concentrated amount of information to many people in a short time. However, the effectiveness of a Speakers Bureau can be difficult to evaluate. There can be a wide range of types of speakers. Speakers may address very different types of groups on diverse topics. There may be little time at the end of a speaking engagement for obtaining feedback. Some suggestions for evaluation include:

1. Prepare a simple, short evaluation that the speaker can distribute and return to the coordinator, asking participants for feedback on the information presented. An example can be found in Appendix D. Analyze these and keep on file.

2. Have the coordinator ask each speaker for her impressions of the presentation shortly after it has been made and record these for assisting future speakers.

3. If the audience is students, the teacher should discuss the speaker with the students after the speaking engagement and provide the coordinator with feedback. The coordinator should record the feedback to share with the evaluator

4. Word of mouth response, such as requests for future speakers or a Day on Campus, is an indicator of positive responses to speakers.

APPENDICES

K-12 WORKSHOP MATERIALS

This appendix contains: a sample agenda, homework for the participants to complete before the workshop, hand-outs to be used during the workshop, and materials to assist participants in carrying out workshop objectives. The following list includes suggestions on how to use the materials found in this appendix.

1. **Sample Agenda**

2. **Teacher Assignments, Research Questions, and Data Collection:**
   Photocopy and mail all three sheets to participating teachers prior to workshop.

3. **Technical Autobiography:**
   Ask teachers to fill out form and discuss during the workshop.

4. **Images Of Engineers:**
   Ask teachers to complete worksheet at the workshop.
   Engineer's Typical Day and Engineering Skills:
   Cut out descriptions of a typical day and engineering skills and paste on cards. Distribute cards for discussion after participants have filled out "Images" worksheets. Our participants wanted copies of these cards to use in their classroom.

5. **Preparation for How Things Work Activity:**
   Give "Preparation" hand-out to teachers to help them plan future "How Things Work" activities in their classroom. The staff can also use this as a guide for the "How Things Work" section of the workshop.

6. **Problems And Solutions:**
   Fill out and discuss worksheets during the workshop.
   Teaching Strategies:
   Distribute "Strategies" hand-out after "Problems and Solutions" have been discussed.

7. **Follow-up Workshop:**
   There are no specific hand-outs for this workshop. However, we suggest bringing in how-things-work books for extra help with more detailed machines, i.e. gears, motors, electronics, etc. See Appendix E for references.

While most of the activities on engineering and technology were developed by the staff of the Center for Women in Engineering, we are much indebted to EQUALS for our activities on gender equitable teaching, which we adapted from their materials.

Sample Agenda

8:30 **Registration**
Coffee and Donuts
Write Technical Autobiography

9:00 **Welcome**
Introduction of Staff
Share Technical Autobiography in small groups

9:30 **Images of Engineers**
Compare your image of engineers and engineering to how engineers describe their job.

10:00 **How Things Work**
Work in groups to discover how simple machines work
Present your findings
Put machine back together

11:30 **Discussion**
Brainstorm on ideas for using machines in the classroom

12:30 **Lunch**
Sandwiches provided

1:00 **Research Results**
Share the results of your classroom research

1:30 **Problems and Solutions**
As a group, investigate obstacles to girls in math and science, and suggest solutions. Discuss "Teaching Strategies" hand-out.

2:30 **Post Workshop Evaluation and Assignments**
Fill out an evaluation
Before next workshop:
- Try out at least one classroom strategy
- Try out at least one machine activity
- Design a How Things Work worksheet

PRE-WORKSHOP TEACHER ASSIGNMENTS

Complete these assignments and bring your results to the workshop.

1. Enclosed you will find a sheet with "Research Question #2" for 3rd through 12th graders and "Research Question #3" for Kindergarten through 3rd. Follow the instructions for the appropriate class level. "Research Question #1" from the copyrighted material is not included.

2. In the second research project you will be investigating the way you interact with students. If they are old enough, ask your students to keep track of whcih students you call on. Before the experiment, ask your students whether they think you call on boys or girls more often. Then ask a student to record separately how often you call on students of each gender. If you run an activity-oriented classroom, you might ask a student to keep track of how much time you spend with boys and with girls. If you don't want to or are unable to ask students to keep track of your interactions, you might ask a colleague to watch you (you might offer to do the same in return). Videotaping your classroom interactions might also be informative. The point is to investigate how you distribute your time and attention on a gender-differentiated basis in the classroom; the details of your investigation are up to you. Then write a one paragraph summary of what you found and bring it to the workshop.

ASSIGNMENT 1: RESEARCH QUESTIONS (EQUALS)

Research Question 1: Not Applicable

Research Question 2: Imagine you are 30 yrs. old. Describe a typical Wednesday in your life. (This survey works well with students from 6th through 12th grades. For 3rd through 5th grade students, substitute the word "grownup" for "30 years old.")

Directions to Researcher: Ask your students to "Imagine you are 30 yrs. old. Describe a typical Wednesday in your life." Give students a full piece of paper so they are free to write as much as they want. Be sure students indicate whether they are male or female.

There are many interesting ways "Typical Wednesdays" could be analyzed. For this research project please focus on these two aspects:

1) occupational choices
2) family responsibility

For both of these, please tally your data by sex on the accompanying chart. Record your students' choices in the most appropriate categories. Look for patterns that emerge. What conclusions can you draw? Prepare a three sentence summary of your findings. Bring all numerical data to the first meeting. Plan to leave a copy of your data with us. Copies of "Typical Wednesdays" stories would be of interest.

Research Question 3: Job Picture Story. (This survey is designed for K-3 students or those for whom writing is difficult.)

Directions to Researcher: Ask your students to "Draw a picture of yourself when you are grown up and at work." Have each student dictate to you some statements about the picture that you record on the picture. Be sure students indicate whether they are male or female.

Please tally your data by sex on the accompanying chart. Record your students' choices in the most appropriate categories. Look for patterns that emerge. What conclusions can you draw? Prepare a three sentence summary of your findings. Bring all numerical data to the first meeting. Plan to leave a copy of your data with us.

DATA COLLECTION FOR RESEARCH QUESTION 2 OR 3

Researcher
School Grade Level # Males # Females

Occupational Categories		TOTAL(By sex)	TOTAL M-F
SCIENTIST(Engineer, Computer Scientist)	M		
	F		
PROFESSIONAL ATHLETE	M		
	F		
TRUCK DRIVER(Carpenter, Mechanic)	M		
	F		
POLICE OFFICER(Military, Firefighter)	M		
	F		
EXECUTIVE(Businessperson, Banker)	M		
	F		
DOCTOR(Lawyer, Architect, Accountant)	M		
	F		
VETERINARIAN(Forest Ranger)	M		
	F		
ROCK STAR(Singer, Disc Jockey, Musician)	M		
	F		
REPORTER(Writer-all media)	M		
	F		
TEACHER	M		
	F		
NURSE(Lab Technician)	M		
	F		
MODEL(Fashion Designer, Movie Star)	M		
	F		
SECRETARY(Flight Attendant, Beautician)	M		
	F		
UNPAID WORKER(Homemaker, Parent)	M		
	F		
WORK MENTIONED BUT NOT SPECIFIED	M		
	F		
NO WORK MENTIONED (Other activities described)	M		
	F		
		TOTAL	

FAMILY RESPONSIBILITIES

	Not Mentioned	Incidental	Shared	Self has major responsibility	Spouse has major resp.
MALE					
FEMALE					
TOTAL					

TECHNICAL AUTOBIOGRAPHY

Name: ______________________ Date: ____________________

I am: ( ) Female ( ) Male

Please take 5-10 minutes to reflect and write briefly on the following questions. Use the back of the page if you need more space.

1. Do you feel comfortable using tools? Please describe.

2. Do you ever take machines apart...
   *... to fix them?

   *... to see how they work?

3. If you ever wanted to take something apart but did not, what stopped you?

4. Were you encouraged to experiment with tools and machines as a child? If so, by whom?

5. Have you ever investigated machines with your students? Please describe.

IMAGES OF ENGINEER'S DAY

Think about what engineers actually do. What do you know about engineering?

Write for 5 minutes about a typical day in the life of an engineer. Where does an engineer work? What would an engineer wear? Who would an engineer work with? What does an engineer do?

Share with your group your ideas of what engineers do.

Read and Listen to how real engineers describe their days. Open the envelope on your table marked **"Typical Day"**. Each group member take one or two descriptions to read to the group.

IMAGES OF ENGINEERS' SKILLS AND TALENTS

Brainstorm with your group. What are the skills and talents you need to be a good engineer? List some ideas here.

Read and Listen to what real engineers say it takes to be a good engineer. Open the envelope on your table marked "**Skills and Talents**". Each group member take one or two descriptions to read to the group.

Reflect upon your concept of engineering. Did anything that the engineers said about their jobs surprise you? Has your concept of engineers changed? Write a one sentence summary of what an engineer does.

AN ENGINEER'S TYPICAL DAY

Responses from members of the Society of Women Engineers

Cut out descriptions of "a typical day" and paste on cards. Place cards in an envelope. Supply one envelope for every three people.

Environmental Engineer:

I get a lot of phone calls from our customers asking how to dispose of hazardous waste. I give suggestions on alternate disposal methods, i.e., recycling. I attend a lot of meetings and work with other professionals to solve the current "crisis".

Software Engineer:

In a day, I work on defining processes for handling customer feedback and getting problems to the person who can help. I arrange visits to customers to collect their opinions directly. I consolidate all of the information I collect, and report trends to management to help set business plans. I talk on the phone frequently to people all over the world, and use computers and electronic mail to communicate.

Water Resource Engineer:

Typical Day: Answer phone messages, attend meetings with clients regarding progress of clients design work. Do design work on pipelines. Work with draftsmen and word processors on presentation of work. Attend city council meetings twice/month on behalf of client. Some public speaking to city council and press regarding sewer, water, storm drainage systems.

AN ENGINEER'S TYPICAL DAY CONT'D

Professor of Computer Engineering:

A typical day as a professor includes teaching, answering students' questions, advising students and conducting research. Research involves keeping track of the latest work in my research area (computer vision), conducting experiments (programming) and writing reports that communicate the findings.

Design Engineer for the State Architect:

I spend part of each day communicating with other engineers and building managers to design heating and air conditioning systems and plumbing for state-owned office buildings. I may spend a day or a day and a half per week inputting and running computer programs to help with the designs. I spend 2-3 hours at a drafting table drawing construction plans. Occasionally I go to a building to measure and talk to users about their needs.

Water Quality Control Engineer working in regulation:

Go through mail, distribute to staff. Review staff correspondence, discuss with staff if needed. Make phone calls and go to meetings with other agencies and with regulated community. Review and comment on technical reports on pollution investigations and cleanup.

ENGINEERING SKILLS

Responses from members of the Society of Women Engineers

Cut out descriptions of "engineering skills" and paste on cards. Place cards in an envelope. Supply one envelope for every three people.

Water Quality Control Engineer:

Good writing skills. Good communication skills. Ability to work well with other people, including those with whom you don't agree.

Computer Engineer:

Confidence that you can DO ANYTHING. Desire to learn new skills. What's NOT necessary: superb math skills, superb physics skills.

Environmental Engineer:

Communication - the ability to look beyond a problem.

Software Engineer:

Creativity - looking at things in a new way. Problem-solving - do things the best way. Attention to detail - do all the steps, follow through to completion, document the process, communicate results.

Water Resource Engineer:

Technically competent, able to communicate with any level of technical expertise. Ability to write technical reports.

Design Engineer for State Architect:

Logical thinking, enjoy solving puzzles, working with people to determine what solutions will work best for them. Good communication skills, ability to work independently sometimes and with others on a team at other times.

PREPARATION FOR HOW THINGS WORK ACTIVITIES: Teacher's Guide

Finding Devices

Save items that no longer work. These can be found in your home, or those of your friends or your students. A letter could be sent to your PTA requesting devices, tools, and other necessary materials. Another good place to find devices is at yard sales. Choose items that are screwed together, not glued. Examples of suitable devices include:

Typewriters (manual or electric)	Stereos
Toasters*	Waffle irons
Clocks	Wind-up things
Kitchen timers	Rotary telephones*
Flashlights	Things with cranks (i.e. music boxes)
Answering machines	Cassette players/ tape recorders
Compact disc players	Electric sanders
Electric can openers	Scales
Photocopiers	Hair dryers*
Drills	Electric shavers

Which devices are chosen for a particular activity depends on the availability of the item, the ages of the students, and the goals of the activity (discussed below). The first ten items have been used successfully in a preschool, and the others have been used in a lower-division engineering course.

**WARNING: Some older devices such as phones, hair dryers and irons contain hazardous materials. Check these devices before taking them apart. We recommend using devices that are less than five years old to avoid such hazards.*

Tools

You can have students bring tools in from home, or you could invest in a low-cost classroom toolbox.

Other Materials Needed

- Smocks.
- Soap, solvent, paper towels or wet towelettes for clean-up.
- Flat box that soft drinks or canned goods are packaged in for students to work in (keeps parts from escaping).
- Ziploc bags for loose pieces. Have children who are not reassembling devices put all parts in the bags before returning them.

PREPARATION FOR HOW THINGS WORK ACTIVITIES

Using the Activities

Choosing Goals

These projects can be used to meet several different kinds of goals. The way in which you implement the activities will be influenced by the goals you choose. Here are a few goals and some suggestions on how to shape the projects to meet those goals. You will probably find that the goals you choose depend on the age of the children you teach, the children's previous experience with machines and the theme you are using to relate the projects to the rest of your curriculum.

Gaining confidence with tools:
Many children, especially girls, have little experience in using tools. You may want to start out by explaining what the tools can be used for and then letting the kids experiment with different tools on a device. Should they use a screwdriver or a hammer? Why are there different kinds of screwdrivers? Your focus would be on the process of tool use, not on disassembling or understanding a device.

Gaining confidence with machines:
Many children, especially girls, are not encouraged to experiment with machines. You might want to focus on the joy of discovering what is inside machines. In this case, you may want the children to just dig in without worrying about what happens to the parts they take off, or how to put the machine back together.

Understanding the device:
If you want the children to understand how the machine they are studying works, you will need to focus them on comprehending the function of the parts rather than simply removing the parts. You may want the children to sketch parts and describe their functions in a notebook, to other group members or to the entire class.

Reassembling the machine:
You may want the students to be able to put the machine back together. This is an effective way to teach the scientific process skills of observation, comparison, communication, and relation. The students will need some system to help them keep track of parts, such as sketches, instruction lists, or part maps. You can illustrate some strategies, or you can let the students discover their own strategies. Allow the students to tear a machine apart, then ask, "What could you do differently next time to make it easier to put this machine back together?" On the next project, let them implement their strategies and then discuss them.

PREPARATION FOR HOW THINGS WORK ACTIVITIES

Choosing a Format

These activities can be used for the whole class, or as learning center projects. We present each activity as if you will be using it with a whole class. The projects are easily adapted by writing *focus, challenge*, and *apply* instructions on cards to keep in a box with tools and devices at a learning center.

Cooperative Learning Model

Assign roles for participants in each group. Possible roles include:

A. *Facilitator* makes sure everyone understands the instructions. Makes sure all group members participate. Calls the teacher if no one knows the answer.

B. *Recorder* makes sure group has notes or diagram from the discussion. Makes sure everyone can complete individual report.

C. *Reporter* organizes the group's report for the class. Briefly summarizes the activity to introduce the report to the class.

D. *Resource person* looks up additional information, e.g., looks up unfamiliar words in a dictionary. Makes sure the information is then shared with all group members. Serves as scientific resource expert who can answer questions about materials.

E. *Harmonizer* makes sure communication lines are open. Makes sure there are no put downs. Encourages positive responses.

F. *Materials Manager* collects whatever materials are needed to complete the activity. Makes sure everyone helps to clean up and that all materials are back where they belong. Has chief responsibility for handling the items in the container and returning all items.

An advantage of this model is that it distributes tasks evenly over a series of activities, ensuring that each student performs each role over the course of six activities.

PREPARATION FOR HOW THINGS WORK ACTIVITIES

Teaching Framework

1. *Focus* students on activity by asking them about the device:
   - Have you ever seen a __________?
   - How do you think one works?
   - What types of ________s are there?

2. *Challenge* students' ideas about how the device works by having groups of students take devices apart to discover how they work. Here the student has an opportunity to create new ideas and reconstruct old ones. Carefully encourage participation by all students.
   - After focusing activity, arrange students in groups of 3-6.
   - Assign roles, pass out devices and tools, make sure students have materials to document how the device works
   - Instruct students to take the devices apart with the tools provided, being careful to work within their area and save all the parts.

3. *Apply* this newly-acquired knowledge. This activity should encourage the students to test out newly-acquired or revised knowledge. It includes applications and extensions of the primary lesson. Have students discuss what they saw and, if necessary, collectively build a new theory on how a _________ works.
   - What did the inside of the device look like?
   - Draw a picture of the inside of the device and label the parts.
   - What tools did you need to take the device apart?
   - Describe any problems you had in taking the device apart and how you solved them.
   - How did you keep track of the parts so you can put the device back together?
   - How does the device work?
   - How does this device use, transform, or store energy?
   - How could we improve this device? What changes would you need to make?
   - Can you design a device that works in a completely different way yet does the same job?
   - What parts of this device are similar to parts of other device we have studied?
   - What would happen if we left a spring (a screw, a cam, etc.) out of this device when we put it back together? How would that affect the way it works?
   - What other devices do you have at home that do a job similar to this device or have similar parts? Do you think they work the same way?

PREPARATION FOR HOW THINGS WORK ACTIVITIES

Focus and Apply activities can be handled in many ways:

- Discuss selected questions in small groups, then have each group report to the class or discuss as a class, encouraging participation by all students.
- Keep How Things Work journals, and have the students write for five minutes about a question.
- Have small groups prepare share sheets on butcher paper illustrating their answer to the question using drawings, cartoons, or words.
- Make a worksheet with pertinent questions to be filled cut during or after taking the device apart.

PROBLEMS AND SOLUTIONS

Write for five minutes about this question:

In your school, what is the biggest problem (or problems) to be overcome in preparing girls to stay in math and science (elementary level) or keeping girls in math and science (secondary level)?

Share your answer with your group. On a piece of butcher paper, make three headings: **Participation, Performance** and **Attitudes**. As a group, sort your answers into those three categories and record them on your chart. Present your chart to the whole class.

PROBLEMS AND SOLUTIONS CONT'D

Think about effective strategies you have used to keep girls interested in math and science. This can be a strategy you have used with one student, one class, or a whole school.

Write your effective strategy here.

Share your strategy with your group. On a new piece of butcher paper write the same headings - **Participation**, **Performance**, **Attitudes** - and sort your strategies into those categories. Brainstorm more strategies that address the specific problems your group identified. Present your chart to the whole class.

Listen to some teaching strategies researchers have identified as being common in classrooms where girls have high interest and performance in math and science.

Reflect on the strategies you have discussed. How do these compare with your own teaching strategies? Write here one change you would like to make in your own teaching to help girls persist in math and science. Finish up with your success story: what is the best thing you do in your own teaching that encourages girls to stay in math and science?

GENDER EQUITABLE CLASSROOMS: TEACHING STRATEGIES

What makes some classrooms places where girls are enthusiastic and successful in math and science? Researchers have studied many of these gender equitable classrooms and have identified several key teaching strategies that encourage interest and good performance in math and science for **all** students.

1. **Cooperative learning:** Gender equitable classrooms stress cooperative learning in small groups. Teachers in these classrooms tend not to use competition as a motivational tool.

2. **Classroom management:** Teachers tend to be proactive rather than reactive, carefully planning management techniques that promote equitable student participation. These techniques include:

   - calling upon all students, whether their hands are up or not,
   - interacting more with students in small groups or individually, rather than in whole class discussions or by public drill, and
   - structuring activities so that equipment and leadership responsibilities are shared equally by all students.

3. **Hands-on learning:** These teachers use fewer book and worksheet exercises, and use more hands-on activities with open-ended learning opportunities. Their students respond well to problems with practical applications that allow creative problem-solving.

4. **Career guidance:** Teachers provide active career guidance in the classroom as part of the regular curriculum, relating skills students are learning to careers in which those skills are needed. Female role models in the form of speakers, books and posters help counter biased textbooks and increase awareness of women's potential by students of both genders.

DAY ON CAMPUS

We suggest sending participating teachers an agenda, a campus map, a homework assignment for the students, and a pre-event questionaire a few weeks before the scheduled Day on Campus. This appendix contains a sample agenda and a design assignment for the students. A sample questionaire can be found in Appendix D: Evaluation.

DAY ON CAMPUS

University of ABC

XYZ HIGH SCHOOL

9:00-10:00 a.m.	Campus Bus Tour Meet at Visitors' Center
10:00-11:30	"What is Engineering?" Engineering Session with professor Engineering Lab Demonstrations
11:30-1:00	Lunch at Student Union
1:00-2:00	Panel Discussion with female engineering students
2:00-3:00	Presentation from Undergraduate Admissions

Please wear comfortable clothes and shoes; shoes should cover feet (no sandals, etc.) for lab demonstration. Bring money for lunch. There are a number of food vendors, priced for the student's budget, at the Student Union.

DESIGN ASSIGNMENT

Have you ever thought about how things are packaged? For instance, how do they design the package around a light bulb to ensure that it doesn't break? Or who thought up those "peanuts" that cushion so many of the items that we mail?

Or have you ever wondered who figures out how strong a clothes hanger should be? You want it to be strong enough to support the clothes, but you don't want the hanger to cost too much to make or to be too heavy.

Your assignment is to make a hanger out of notebook paper. You can use glue, staples, or tape to keep the hanger together. You don't need to worry about the hook part of the hanger; you can use a regular hanger part for that. However, you will have to figure out how to attach your hanger to the hook. Try to use the smallest amount of notebook paper possible.

You can try to build your notebook paper hanger like the metal ones you are used to, or you can come up with something slightly different. Perhaps there is another version of a hanger that will work.

Bring your hangers to campus. We'll have a special class with an engineering professor when we will test the hangers and see which designs work best and why. We will also look at which hangers use the smallest amount of paper.

CAREERS IN ENGINEERING

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SPEAKERS BUREAU PRESENTATION PACKET

This packet contains information, suggestions, resources, and exercises for speakers who will be addressing student audiences about the subject of engineering, particularly careers in engineering.

Information about Engineers and Engineering Preparation

- What is an engineer?
- What does an engineer do?
- What are the different types of engineers?
- What do they do?
- How do I prepare in high school to go to an engineering school?
- What is the college program leading to an engineering degree?
- What are typical starting salaries for an engineer?

Helpful Statistics

- Startling Statements
- Starting Salaries for New College Graduates
- Gender Equity Information

Suggestions on Your Presentation

Sample Classroom Exercises

- Marshmallow Bridges
- Drafting Exercise
- NASA Exercise

Selected Resources

You will want to tailor your presentation to your audience and use your own personal experiences to add color to your talk. We have included what we hope will provide a starting point.

Prepared by the Center for Women in Engineering
University of California, Davis
through a grant from the Fund for the Improvement of Post Secondary Education

Engineers Turn Ideas Into Reality

Engineers are problem solvers--people who make things work better, more efficiently, quicker and less expensively. They serve humanity with skill and dedication and search for better ways to solve problems.

Engineers help satisfy the most basic needs of humanity: food, water, clothing, shelter, transportation, communication and medical systems. Engineers are team members who transform abstract scientific discoveries into practical applications. Engineers are innovators who take a fresh look at science and technology in order to apply their knowledge to finding feasible solutions to new human problems.

What do Engineers do?

Engineers today work on tomorrow's problems.

Engineers design new roads, deciding which is the best path from one point to another. For instance, should the road go over a mountain, around it or through it? Which is the safest route? The most economical? The prettiest? The most useful? ***(Civil Engineers)***

Engineers design power plants to produce electricity. They must decide which type of plant is the best: a coal burning plant, a hydro electric plant, a geothermal plant, or a nuclear plant? How big does it need to be to meet today's needs? What about tomorrow's needs? Where should it be built? Once the power is generated, how should it be brought to our factories, offices and homes? What will be it's impact on the environment? ***(Electrical/Mechanical/Environmental Engineers)***

Engineers design better mountain bikes. They design special metals and plastics that are light weight but strong and durable. They look at how the bike is shaped and how it operates. What seat height and handle bar configuration is the most comfortable for the riders, but lets them get the most power? What are the optimum gearing ratios? ***(Materials/Chemical/Mechanical Engineers)***

Engineers design the pacemakers implanted in our heart patients, wheel chairs for the disabled, artificial blood and better gloves for our surgeons. Engineers study the human body and develop ways to measure and improve the performance of our athletes. ***(Biomedical Engineers)***

Engineers design video games, the equipment used in recording, mixing and producing music, stage lighting, as well as robots and communication systems. ***(Computer Science/Electrical Engineers)***

Engineers look at every part of our society and try to make it better: our food, water, clothing, housing, transportation, communication, and medical systems.

Career Fields in Engineering

Because of the vast amount of technical information, engineers specialize in a field of engineering. Engineering specialties include:

- Aerospace
- Agricultural
- Architectural
- Biomedical
- Biological
- Chemical
- Civil
- Computer
- Construction
- Electrical
- Environmental
- Industrial
- Manufacturing
- Materials
- Mechanical
- Mining
- Nuclear
- Petroleum

Within each field or specialty of engineering, there exist many types of positions, including:

Research: A research engineer finds a practical use for new scientific discoveries. They are typically on the 'cutting edge' of technology and work in a laboratory.

Development: A development engineer is interested in producing a process, an assembly, or a system that will work. This involves actually building a prototype and testing models.

Design: A design engineer bridges the gap between the laboratory and the production line, working out details that will allow a product to be mass produced and integrated into larger systems, as well as to be made in a style and at a price that will attract customers. Design engineers may also work on such items as bridges or buildings where only one item is made.

Production and Construction: These engineers take the design engineer's drawings and supervise the assembly or construction of the project. They are concerned with costs, schedules, workers, and proper construction.

Operations: An operations engineer performs maintenance, repair, replacement, and upgrade operations at a manufacturing plant or a power generation plant.

Sales: A sales engineer presents new products to prospective customers and assists in assuring their satisfaction after delivery.

Management: An engineering manager uses engineering and business principles to manage a company's equipment, labor force, and financial assets to produce a desirable product in a competitive market.

How do you know if you'd make a good engineer?

Do you like to solve puzzles?

Do you like to take things apart and find out how they work?

Do you think about how to make things better? Or why things are built a certain way?

Are you the one in your family who ends up fixing the broken toys or lawnmower, etc.?

Preparing in High School

Engineers solve problems by relying on their creative and analytic skills. You should enjoy problem solving and be challenged by the effort it requires. High school courses should include:

At least three, but preferably four years of math. Calculus is not required, though it is preferred.

Algebra I & II
Trigonometry
Geometry

Two, though preferably three years of laboratory science , for example:

Biology
Physics
Chemistry

Four years of English

One year of history

Two years of a foreign language

Four years of college preparatory electives

Most colleges require SAT or ACT tests, as well as achievement tests.

After High School

A bachelor's degree in engineering can be obtained through:

A four or five year program at an accredited college or university;

Two years in a community college engineering transfer program plus two or three years in a college or university engineering program;

Five to six years in an engineering co-op program; or

Eight to ten years in an evening engineering school.

Engineering Salaries

The 1993 survey by the National Society of Professional Engineers shows that the median starting salary for women engineers with bachelors degrees was $36,057, for men it was $31,399.

Related Opportunities

Technicians and technologists play an important part in the technical team. The ***technician*** performs routine equipment checks and maintenance, carries out plans and designs of engineers, and sets up scientific experiments.

The engineering ***technologist*** applies engineering principles for industrial production, construction, and operation.

Technicians and technologist obtain their training in apprenticeship programs and 1 and 2 year degree programs.

Startling Statements

Women are 52% of the U. S. population.

What percentage of American women aged 25 - 34 are in the labor force? **80%**

How many years will the average college graduate, class of 2000 work? **30 years**

What percentage of American women with pre-school children are in the workforce today? **53%**

What percentage of secretaries are women? **97%**

What percentage of salesclerks are women? **75%**

What percentage of lawyers are women? **20%**

What percentage of Supreme Court Justices are women? **11% or 1 in 9**

What percentage of doctors are women? **18%**

What percentage of dental assistants, are women? **98%** What percentage of dentists are women? **8%**

What percentage of engineers are women? **7%**

What is the average salary of women working full-time in the United States? **$18,096**

What is the average starting salary of engineers in the United States? **$35,064**

Adapted from 1992 Women in Engineering Program Advocates Network (WEPAN) National Conference materials. Source: U. S. Department of Labor

Estimated Starting Salaries
For New College Graduates

Academic Majors
Bachelor's Degree Graduates

Chemical Engineering	$ 40,341
Mechanical Engineering	$ 35,369
Electrical Engineering	$ 34,979
Industrial Engineering	$ 33,348
Computer Science	$ 32,446
Nursing	$ 29,868
Civil Engineering	$ 29,547
Geology	$ 28,414
Chemistry	$ 28,386
Accounting	$ 27,787
Physics	$ 27,087
Financial Admin.	$ 26,630
Mathematics	$ 26,416
Marketing/Sales	$ 24,607
Agriculture	$ 24,134
General Business Admin	$ 23,760
Hotel,Rest,Inst. Mgmt.	$ 23,713
Personnel Admin.	$ 22,923
Education	$ 22,685
Natural Resources	$ 22,554
Social Science	$ 22,333
Retailing	$ 22,002
Communications	$ 21,640
Advertising	$ 21,627
Home Economics	$ 21,053
Liberal Arts	$ 20,860
Telecommunications	$ 20,680
Journalism	$ 20,587

Averages for Graduate Degree

MBA	$ 37,530
Other Master's	$ 35,582
Ph.D.	$ 38,612

SOURCE: Average annual starting salaries for 1992-93 were used from the Collegiate Employment Research Institute. 1993. Salary Report 1992-93 (Interim Report for October 31, 1993). East Lansing, Michigan: Career Development and Placement Services, Michigan State University; and the College Placement Council's Salary Survey for 1992-93. September 1993. Bethlehem, Pennsylvania: College Placement Council, Inc.

Gender Equity Information

"Women represent the single, largest untapped resource for engineering, science, and technical careers." Madeline Mixer, Regional Administrator Women's Bureau, U. S. Department of Labor

"It behooves our society to take full advantage of all our potential resources--of what everyone can offer. As our society moves out into the global arena we can't afford to waste resources with Neanderthal thinking. If we are to remain competitive, at the forefront, we have to utilize all our resources-- Hispanic, black, women, individuals with disabilities. Everybody can contribute and we can't afford to waste these resources any longer." Manuel Hernandes, National Vice-President, Society of Hispanic Professional Engineers.

By the year 2000 (just 5 years away), 2 out of 3 new entrants to the labor force will be women. Moreover, 80% of women ages 25-54 will be in the labor force.

For the first time in history, a majority of all new jobs will require education or training beyond high school. In fact, it is estimated that by the year 2000, 80% of all jobs will require post secondary education or training. Nearly 90% of jobs created will be in the service sector with about half of these projected occupations to be in traditionally female fields with median wages below the poverty level.

In 1990, 60% of all professional women worked in two traditionally female occupations: Teaching and Nursing.

From 1983 to 1988, the number of women in nontraditional jobs remained stable -- 4% to the total work force. Since 1988 there has been an increase to around 9%. The definition of nontraditional jobs are those in which women comprise "25% or less of the workers in a particular occupation". Nontraditional jobs for women fall into numerous and diverse categories (e.g. managerial, technical, crafts, construction trades, fire fighting, etc.)

What are the benefits of a nontraditional occupation?

1. Ability to choose a job based upon one's abilities and interests, rather than on one's gender.
2. Greater earnings and benefits.
3. A wider variety of work schedules and greater job security because of skills acquired.
4. Personal satisfaction.
5. A pathway to economic self-sufficiency and family stability for women who are family heads, displaced homemakers, or who are otherwise at an economic disadvantage.

Suggestions on Your Presentation

You might be asked to give different kinds of presentations. You may be requested to lecture or give a workshop, or perhaps participate in a panel discussion or a career fair. You may be asked to bring along videos, pictures, models, other engineers, students or faculty. Whatever the request, we have included in this packet information that we hope will act as a springboard for your own creative presentation. Below please find some suggestions that we hope will make your presentation more successful.

Know Your Audience

What is the age group? What is the gender (mixed, all girls, all boys)? Is this a special club, regular class, or hand picked group? Did the students volunteer to come or has it been scheduled for them? Is this presentation in conjunction with material covered in class? Is this part of a career day? Will there be other speakers? What will the other speakers discuss?

What kind of presentation is expected? How much time will you have? What is the room like? (size, audio/visual available, seating arrangement, chalkboard or dry board, podium, etc.)

Gather as much information as you can about your audience. You will be better able to plan your presentation and you will avoid last minute problems.

We have found that your presentation should be modified depending upon the age group. Below are some suggestions:

- K - 4 Lecture portion should be extremely brief, use examples of engineers like astronauts and Star Trek's Jordi LaForge, do a hands-on exercise or bring models, or videos.
- 5-8 The discussion on engineering can be more technical and can include information on specialties and high school preparation.
- 9-12 The discussion can include college curriculum, post graduate options, cost of college, etc.

Props and visual aids are always helpful, regardless of the age group.

Plan Your Presentation

At a minimum, write an outline of your presentation. Consider including personal information. Try to include a little information on why you chose engineering, what you liked in high school, what you didn't like, where you work now, what you do at your job and what kind of hobbies you have, etc. You may want to write your opening remarks out completely, to assure a steady start. If you need to, write out the entire presentation. However, avoid reading the prepared speech verbatim; you will loose your audience very quickly. If you're inexperienced, practice your presentation a couple of times. If you are part of a panel, watch your time allotment. Be courteous to your fellow panel members and leave them their allotted time.

What ever the forum, your presentation should follow the following format:

Introduction Tell them what you're going to tell them and why its important to them

Body Types of specific organization

1. Chronological
2. Spatial
3. Order of importance

Types of supportive subject matter

1. Specific instances or illustrations
2. Personal experiences
3. Opinions
4. Comparisons and contrasts
5. Statistics and facts
6. Quotations
7. Jokes and anecdotes

Conclusion Tell them what you just told them and why

The conclusion has three major functions:

1. Provide a brief summary of the information presented
2. Restate the importance or value of the information
3. Close the speech with a clear, strong final sentence which leaves the audience with the impression that they have heard something worthwhile.

Questions & Answers

Finally, leave time for questions. I recommend keeping your answers to no more than two minutes. If there is further interest in that particular area, there will be additional questions. Do not be afraid to say, "I don't know, but I can find out for you." If no questions come up (which sometimes happens with the younger groups) you might have a couple questions and answers ready to fill up the remaining time. Perhaps you can discuss a current event that relates to engineering, or a typical day on the job, a special project, etc.

Sample Classroom Exercises

Many times we are requested to provide a 'hands on' exercise or workshop. Often this comes when we are speaking to younger students, who perhaps need more interactive experiences to absorb information. Below we have included some sample classroom exercises that include math, science or engineering principles, but that do not require a lot of tools or equipment.

Marshmallow Bridges

Groups of students are issued toothpicks and 15 large marshmallows. The students are tasked with building a bridge that will span 6 inches. A discussion about the strengths of different shapes highlighting the strength of the triangular shape should be included. After the students have worked on their bridges for about 20 minutes, the bridges are tested. The bridges span two desks and are loaded with pennies until failure. Discuss why some of the bridge designs are more successful than others.

Drafting Exercise

This exercise can be prefaced with a discussion on how engineers communicate with graphics and drafting. A little reflection serves to convince one it would be an impossible task to describe in oral or written language a machine like the simplest gas engine, with data and dimensions sufficient to make possible its construction in the machine shop. Engineering drawings supply the needed information with the exactness and detail required.

Prepare a handout with several projections and ask students to draw the front, side and top views. The projections can be whatever shape you wish including small pieces that your company may manufacture or use. For our exercise we asked students to draw the three views of four easy projections and four difficult ones. The problems got more complicated and built on the previous problem.

Before beginning the actual exercise, a discussion on projection should be included. (Geometric Projection: the representation of three dimensional objects on two dimensional surfaces by means of geometric drawings, such as plans and elevations.) Explain the plane of projection and line of site. Do a few examples before passing out the exercise: show the front, side and top view of a cube, cylinder, and sphere on the board.

We have found it best to go over the problems as they are completed. Problems can include hidden lines or sectioning if desired. Models of the shapes can also be constructed to aid the students in visualizing the front, side and top views.

Moon Survival Exercise

A Decision Form and answer key follow. Apply your science knowledge. This exercise always generates a lot of discussion!

NASA Moon Survival Exercise

By: Jay Hall, The University of Texas

DECISION FORM

Instructions:

You are a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, however, your ship was forced to land at a spot some 200 miles from the rendezvous point. During reentry and landing, much of the equipment aboard was damaged, and since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200 mile trip. Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance in allowing your crew to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15, the least important.

_______ Box of matches

_______ Food concentrate

_______ 50 feet of nylon rope

_______ Parachute silk

_______ Portable heating unit

_______ Two .45 caliber pistols

_______ One case of dehydrated Pet Milk

_______ Two 100 lb. tanks of oxygen

_______ Stellar map (of the moon's constellation)

_______ Life raft

_______ Magnetic compass

_______ Five gallons of water

_______ Signal flares

_______ First aid kit containing injection needle

_______ Solar-powered FM receiver-transmitter

NASA Moon Survival Exercise

(Expert Opinion)

RANK	ITEM	REASON
14	Box of matches	No air
08	Food concentrate	Nourishment
06	50 feet of nylon rope	Traverse ravines, carry supplies
09	Parachute silk	Easily spotted, carry supplies
13	Portable heating unit	Space suits are self-contained
07	Two .45 caliber pistols	Emergency propulsion
12	One case of dehydrated Pet Milk	Can't mix it
01	Two 100 lb. tanks of oxygen	Must breathe
03	Stellar map (of the moon's constellation)	Navigation
10	Life raft	Carry items
15	Magnetic compass	Stellar map better
02	Five gallons of water	Must drink
04	Signal flares	For others to find you
11	First aid kit containing injection needle	Can't open suits
05	Solar-powered FM receiver-transmitter	For others to find you

EVALUATION

This appendix contains evaluation resources and sample evaluation measures. The resources listed in the first section can help you decide which evaluation strategies are best for your program. The second section contains examples of recommended evaluation instruments that have been developed and modified at the Center for Women in Engineering at UC Davis for use with the programs described in this handbook.

1. Introduction
2. Evaluation References
3. K-12 Teacher Workshop - Initial Workshop Evaluation
4. K-12 Teacher Workshop - Follow-up Workshop Evaluation
5. Day on Campus Evaluation Form - Teachers
6. Day on Campus Evaluation Form - Students
7. Speaker Evaluation Form - Teachers
8. Speaker Evaluation Form - Students

INTRODUCTION

Evaluation is an important part of planning and implementing intervention programs. Evaluation activities do not have to be complex, but should be included in early planning efforts and carefully designed so that they provide desired feedback and information about the programs. The original evaluation of this project was designed to provide two types of systematic information: to measure whether the goals of the project were being met, and to provide ongoing information about which program components needed refinement during their development and testing.

Developing evaluation instruments for your program can be time-consuming and costly. Before developing your own evaluation instruments, explore instruments used by others in similar or related programs. These may yield useful results for your program, particularly if you adapt them for your specific needs. Whenever possible, the evaluation instruments you choose should be pilot tested and have reliability and validity established. Also, contact the person(s) who developed the instrument for more information about how and why the instrument was created. Another resource for evaluation instruments and information can be your campus research and evaluation office, or the research offices of local school districts. Finally, it is important to note that not all programs require quantitative evaluation. Some programs, especially those which are new or unique, may not be easily evaluated using established instrumentation. These programs may be evaluated more effectively using qualitative techniques. Examples of these include observation, exploratory interviews, and open-ended questions.

EVALUATION REFERENCES

The following are excellent and useful references for program evaluation. The first book contains a number of evaluation instruments, several resource lists, and contains clear, easy-to-use information on planning and conducting evaluation of a wide variety of math and science programs for women. Several of the evaluation instruments used for these original programs were based on those found in this book. The second reference is a package of general information on how to conduct program evaluation at all stages.

Davis, Barbara Gross and Humphreys, Sheila. Evaluation Counts: A Guide to Evaluating Math and Science Programs for Women. Math and Science Network: 1983. Contact: Math and Science Network, Preservation Park, 678 13th Street, Suite 100, Oakland, CA 94612. (510) 893-MATH.

The Program Evaluation Kit, sponsored by the Center for Study of Evaluation, UCLA Graduate School of Education. Series editor: Joan L. Herman. Published by Sage Publishing, Inc., 2455 Teller Road, Newbury Park, CA 91320-2218. (805) 499-9774.

Vol. 1 Evaluator's Handbook. Joan L. Herman, Lynn Lyons Morris, Carol Taylor Fitz-Gibbon.

Vol. 2 How to Focus an Evaluation. Brian M. Stecher, W. Alan Davis.

Vol. 3 How to Design a Program Evaluation. Carol Taylor Fitz-Gibbon, Lynn Lyons Morris.

Vol. 4 How to Use Qualitative Methods in Evaluation. Michael Quinn Patton.

Vol. 5 How to Assess Program Implementation. Jean A. King, Lynn Lyons Morris, Carol Taylor Fitz-Gibbon.

Vol. 6 How to Measure Attitudes. Merlene E. Henerson, Lynn Lyons Morris, Carol Taylor Fitz-Gibbon.

Vol. 7 How to Measure Performance and Use Tests. Lynn Lyons Morris, Elaine Lindheim, Carol Taylor Fitz-Gibbon.

Vol. 8 How to Analyze Data. Carol Taylor Fitz-Gibbon, Lynn Lyons Morris.

Vol. 9 How to Communicate Evaluation Findings. Lynn Lyons Morris, Carol Taylor Fitz-Gibbon, Marie E. Freeman.

DISCOVERING HOW THINGS WORK: ENCOURAGING GIRLS IN ENGINEERING
Initial Workshop Evaluation

Please take a few minutes and evaluate this workshop. By giving us this valuable feedback, you will help us to plan future workshops. Use the back of this page if you need more room.

---

1. What was the most useful part of today's workshop?

2. What was the least useful part of today's workshop?

3. How can we improve the format or content of this workshop? What revisions do you suggest?

4. Did this workshop and its presenters address your needs? Was it worth your time today?

5. Do you have any other comments or suggestions for us?

	Excellent	Good	Fair	Poor
6. Overall, how would you rate this workshop?	( )	( )	( )	( )

I am: ( ) Female ( ) Male

Subject(s) taught:____

Grade(s) taught: ____

Thank you for your feedback and participation!

DISCOVERING HOW THINGS WORK: ENCOURAGING GIRLS IN ENGINEERING.
Follow-up Workshop Evaluation

Please take a few minutes and evaluate this workshop. By giving us this valuable feedback, you will help us to plan future workshops and programs. Use the back of this page if you need more room.

1. What was the most useful part of today's workshop?

2. What was the least useful part of today's workshop?

3. What were your expectations of this workshop series? Were they met?

4. Were there unexpected rewards (extrinsic or intrinsic) that you gained from participating in this workshop series?

5. This workshop series was sponsored by the Center for Women in Engineering at UC Davis. Are there similar programs or services that you would like to have the Center sponsor?

6. Any final comments? Please use the back of this page.

	Excellent	Good	Fair	Poor
7. Overall, how would you rate this workshop series?	( )	( )	( )	( )

I am: ( ) Female ( ) Male

Thank you for your feedback and participation!

UC DAVIS DAY ON CAMPUS EVALUATION FORM - TEACHERS

Please help us improve our programs by providing us with feedback on this Day on Campus. Attach another sheet of paper if you need more room.

1. What were your overall impressions of the Day on Campus? What did you like, not like, find interesting, etc.?

2. Would you bring students to another Day on Campus? Why or why not?

3. How could this Day on Campus be modified or improved? Was there any information, or were any activities, missing?

4. Are there other types of activities, support services, speakers etc. you are interested in for your students?

5. Do you know of other teachers who would be interested in bringing their students to a Day on Campus? Would you like us to contact them?

6. If your students gave you any feedback about this Day on Campus, would you share it with us?

Name: ______________ School: ____________________

Date of Day on Campus: _________________________

THANK YOU!

UC DAVIS DAY ON CAMPUS EVALUATION FORM - STUDENTS

Please fill out this questionnaire before you leave today. We appreciate your feed-back.

Name: ____

School: ____

Today's Date: ____

1. What did you think about today's field trip? Check one:

( ) Great ( ) Good ( ) O.K. ( ) So so ( ) Dull

2. Did you learn something about engineering today that you didn't know about before?

( ) Yes ( ) No

If Yes, tell us what you learned:

3. What was the most interesting thing that happened today? Why?

4. What was the least interesting thing that happened today? Why?

5. Was there something missing today, that you wanted to do or find out about? What was it?

6. Do you have anything else you'd like to say about your day on campus?

Please hand in this questionnaire when you are done. Thank you!

SPEAKER EVALUATION FORM - TEACHERS

Please help us improve our programs by providing us with feedback on this speaker. Attach another sheet of paper if you need more room.

1. What were your overall impressions of this speaker? What did you like, not like, find interesting, etc.?

2. Would you ask this speaker back? Why or why not?

3. How could this presentation be modified or improved? Was there any information missing?

4. Are there other types of activities, support services, speakers etc. you are interested in for your students?

5. Do you know of other teachers who would be interested in having a speaker come to their classroom? Would you like us to contact them?

6. Did your students give you any feedback about this speaker? Would you share it with us?

Name: ______________ School: ______________________

Name of Speaker: ___________ Date of Presentation: _______

THANK YOU!

SPEAKER EVALUATION FORM - STUDENTS

Please complete the following sentences about today's speaker.

1. WHAT I LIKED BEST ABOUT TODAY'S SPEAKER WAS...

2. THE MOST INTERESTING THING I LEARNED WAS...

3. WHAT I'D STILL LIKE TO KNOW ABOUT ENGINEERING IS...

TODAY'S SPEAKER WAS... (circle one) Excellent Good O.K. So-So Dull

I AM A: (circle one) Male Female

GRADE IN SCHOOL: (circle one) 4 5 6 7 8 9 10 11 12

MY SCHOOL IS: (write in space) ______________________________

MY TEACHER IS: (write in space) ______________________________

TODAY'S DATE IS: (write in space) ______________________________

HAVE YOU ATTENDED: (check if yes and fill in date)

( ) Day on Campus (Approximate date: ________)

THANK YOU!

REFERENCES AND RESOURCES

1. Engineering Activities for the Classroom:
   A. Elementary
   B. Secondary

2. Gender Equitable Classrooms:
   A. Activities for Kids
   B. Research

3. How Things Work: Reference Works

4. National Headquarters for Engineering Societies

1. Engineering Activities for the Classroom:

Available from JETS (Junior Engineering Technical Society)
1420 King St., Suite 405
Alexandria, VA 22314-2715

A. Elementary

Design Technology: Children's Engineering by Susan Dunn and Rob Larson, The Falmer Press, 1990, $21.

Design & Technology 5-12 by Pat Williams and David Jinks, The Falmer Press, 1985, $21.

Both books describe design projects for children, with a dose of philosophy and some specific examples.

B. Secondary

High School Project Engineering, College of Engineering, Colorado State University, 1986, $35.

A progressive design project that leads students from conception to production.

Jets Program Aids by Mary Anne Huntington, JETS, Inc, 1985, $7.50.

Ideas for JETS meetings that can be adapted for the classroom. Many are design challenges that are written as team competitions but could be used in cooperative groups.

Technology Education Activities, Center for Implementing Technology Education, 1988, $100/volume.

Several volumes of projects from mechanical, civil and electrical engineering. They range from fairly simple activities to multi-stage projects.

2. Gender Equitable Classrooms:

A. Activities for Kids

Available from Women's Educational Equity Act (WEEA) Publishing Center:
Education Development Center, Inc.
55 Chapel St., Suite 200
Newton, MA 02160

Add-Ventures for Girls by Dr. Margaret Franklin, WEEA, 1990, $25 each volume
Hands-on math with female role models and real-world problems. Two volumes: elementary and middle school.

Science EQUALS Success by EQUALS, Charlotte NC, WEEA, 1990, $16.
Lots of hands-on science in life, physical and earth science for 4th to 9th grade. The activities emphasize cooperative learning, problem-solving, spatial skills and career awareness.

Available from EQUALS
University of California
Lawrence Hall of Science
Berkeley, CA 94704-9978

Family Math by Jean Kerr Stenmark, Virgina Thompson and Ruth Cossey, Regents of UC, 1986.
Math activities for kids and parents to share that teach problem-solving strategies and spatial skills.

SPACES: Solving Problems of Access to Careers in Engineering and Science by EQUALS, Dale Seymour Publications, 1982.
Activities in design, career awareness, tool use and personal goals.

B. Research

Eccles, J. S. (1989). Bringing young women to math and science. In M. Crawford & M. Gentry (Eds.), Gender and Thought: Psychological Perspectives (pp. 36-58). New York: Springer-Verlag.

Kahle, J. B., & Matyas, M. L. (1987). Equitable science and mathematics education: a discrepancy model. In L. S. Dix (Ed.), Women: Their Under-representation and Career Differentials in Science and Engineering. Washington, D.C.: National Academy Press.

Kelly, A. (1978). Girls and Science. Stockholm: Almqvist & Wiksell International.

3. How Things Work: Reference Works

How Things Work: A guide to how human-made and living things function from Books for Young Readers, Simon and Schuster Inc., 1984.

Machines and How They Work by David Burnie, Dorling Kindersley, 1991.

The Big Book of How Things Work from the Editors of Consumer Guide, Publications International, LTD, 1991.

The Random House Book of How Things Work by Steve Parker, Random House, 1991.

The Way Things Work by David Macaulay, Houghton Mifflin, 1988. Beautifully illustrated, witty text, clearly defines engineering concepts.

4. Addresses for Engineering Societies Which Distribute Videos

American Society of Mechanical Engineers
United Engineering Center
345 East 47th Street
New York, NY 10017
(212) 705-7722
(212) 705-7674 Fax

National Society of Professional Engineers
1420 King Street
Alexandria, VA
(703) 684-2800

Society of Women Engineers
120 Wall Street, 11th Floor
New York, NY 10005-3902
(212) 509-9577
(212) 509-0224 Fax

Appendix 3: Additional Evaluation Materials

Appendix 2, Project Handbook, contains many of the materials and measures used to evaluate three of the programs in the project: K-12 Teacher Workshops, Day on Campus and Speakers Bureau. This appendix includes all additional evaluation materials for these three programs, along with evaluation materials for the Luncheons and Laboratory Researchers programs.

Welcome to today's workshop, "Discovering How Things Work: Encouraging Girls in Engineering". Please take a moment to fill out this questionnaire and return it to the registration table prior to the beginning of the workshop. Thank you.

Name:____

School and District: ________________________________

Grade(s)/Subject(s) taught: ____________________________

Section I.

Please circle *one* number in response to each of the following questions.

	A Little				A Lot
How much do you know about engineering?	1	2	3	4	5
How much do you know about how students need to plan their education for a career in engineering?	1	2	3	4	5
How much do you know about classroom strategies to keep girls interested in math and science?	1	2	3	4	5

Section II.

HOW OFTEN DO YOU DO EACH OF THE FOLLOWING IN YOUR CLASSROOM? (Circle *one* number per response.)

	Never		Infrequently		Frequently
Cooperative work groups	1	2	3	4	5
Real world problem solving	1	2	3	4	5
Hands-on activities	1	2	3	4	5
Have students use tools such as screwdrivers, hammers, etc.	1	2	3	4	5
Have students use lab tools such as meters, balances, etc.	1	2	3	4	5
Examine how machines work	1	2	3	4	5
Relate lessons to career opportunities	1	2	3	4	5
Have scientists visit your classroom	1	2	3	4	5

HOW DIFFICULT DO YOU FIND IT TO DO THE FOLLOWING IN YOUR CLASSROOM? (Circle *one* number per response.)

	Not Difficult				Very Difficult
Cooperative work groups	1	2	3	4	5
Real world problem solving	1	2	3	4	5
Hands-on activities	1	2	3	4	5
Have students use tools such as screwdrivers, hammers, etc.	1	2	3	4	5
Have students use lab tools such as meters, balances, etc.	1	2	3	4	5
Examine how machines work	1	2	3	4	5
Relate lessons to career opportunities	1	2	3	4	5
Have scientists visit your classroom	1	2	3	4	5

Name:____

Section III.

HOW MUCH OF AN OBSTACLE DO YOU THINK EACH OF THESE FACTORS ARE TO GIRLS' PERSISTENCE IN MATH AND SCIENCE? (Please circle *one* number per response.)

	Not an Obstacle				A Big Obstacle
Immediate family members (mother, father, siblings, etc.)	1	2	3	4	5
Other family members (uncles, aunts, grandparents, etc.)	1	2	3	4	5
Media influences	1	2	3	4	5
Classroom environment	1	2	3	4	5
Guidance counselors	1	2	3	4	5
Math and science ability	1	2	3	4	5
Peer pressure	1	2	3	4	5
Teachers' attitudes	1	2	3	4	5
Lack of female role models	1	2	3	4	5
Low self-esteem	1	2	3	4	5
Being smart is socially unacceptable	1	2	3	4	5
Lack of spatial ability	1	2	3	4	5
Math and science are unglamorous	1	2	3	4	5
Lack of mechanical ability	1	2	3	4	5
Lack of competitive behavior	1	2	3	4	5

PLEASE TURN THIS FORM IN AT THE REGISTRATION TABLE. THANK YOU.

TEACHING LOG: K-12 EDUCATORS

This packet represents your personal Teaching Log, which you will be asked to bring with you to the April 9th workshop. You can think of this log as a type of journal. Please use it to record your experiences, feelings and observations as you move through the process of teaching the hands-on activity lesson. Use it also to record the experience of trying a new gender-equitable teaching strategy, which you may or may not be using at the same time that you teach the hands-on activity lesson.

If you wish, you can record the answers to the following questions on your own paper instead, attaching them to the Log; either way, please answer all of the questions. Also include any additional thoughts you have, and date your entries.

Name: ______________________________

Please use as much space as you need to answer the following five questions. Use additional sheets of paper if necessary.

Part I - Hands-On Activity Lesson

1. Describe your hands-on activity lesson. What did you teach, and to whom?

2. When did you teach the lesson, and how long was it? Give date(s), number of class periods, etc.

3. What materials did you use for the lesson (devices, tools, cleanup)? How did you acquire the materials necessary for the lesson?

4. How much time did it take you to plan and prepare this lesson?

5. What adjustments, if any, did you have to make in your regular curriculum in order to use this lesson?

Name: ________________

Please use as much space as you need to answer the following four questions. Use additional sheets of paper if necessary.

Part II - Student Reactions to the Hands-On Activity Lesson

1. How did your students respond to the hands-on activity lesson (acceptance, resistance, excitement, boredom, etc.)?

2. Were there any gender-specific responses to the lesson?

3. Did students perceive the lesson as "a part of the norm," or as a deviation from a typical lesson?

4. Did students understand the material in the lesson?

Name: _______________

Please use as much space as you need to answer the following five questions. Use additional sheets of paper if necessary.

Part III - Your Reactions to the Hands-On Activity Lesson

1. Did you feel comfortable teaching this lesson? Why or why not?

2. Would you do it again? Why or why not?

3. If you would teach it again, what changes would you make?

4. Were there any surprises?

5. When you taught the lesson, did you learn anything about yourself?

Name: ________________

Please use as much space as you need to answer the following four questions. Use additional sheets of paper if necessary.

Part IV - Gender Equitable Teaching Strategies

1. What strategy did you decide to try? Did you use it to teach the hands-on activity lesson, or some other lesson?

2. Describe how you used this strategy. How was this method different from your usual teaching style?

3. How did the students react?

4. How did you feel about the lesson? Would you consider it a success? Would you do it again? If so, what would you do differently next time?

INSTRUCTIONS FOR PAIRED INTERVIEWS: (PEER INTERVIEWS)

* Please begin with one of you taking the role of interviewer and asking your partner the questions below.

* Make a "test" recording at the beginning of the interview to be sure you are recording and that the recorder is working.

* When you are through with the first interview, turn off the tape and switch roles of interviewer and respondent.

* Turn on the recorder and continue recording with the second interview. You shouldn't need to turn over the tape.

* Try to pace yourself so that each person answers all of the questions within about 15 minutes.

==

INTERVIEW QUESTIONS:

1. What teaching strategy did you try in your classroom to increase gender equity?
   How did it go?
   Did anything happen that surprised you?
   What did you learn as you tried this teaching strategy?

2. Which "How Things Work" activity did you try in your classroom?
   How did it go?
   Did anything happen that surprised you?
   What did you learn as you tried this teaching strategy?

3. What did you ask your collaboration partner to do? Did s/he observe you:
   - trying out a new teaching strategy?
   - trying out a "How Things Work" activity?
   - something else?

4. Was this a successful use of your partner?
   Why or why not?
   Based on this experience, would you do something different another time?

5. Will you sustain your collaborative partnership beyond this workshop?
   Why or why not?
   Would you want to develop a partnership with a different teacher?

6. Has your teaching changed as a result of this workshop? Please describe.

7. Is there anything else you want to comment on at this time?

DISCOVERING HOW THINGS WORK: ENCOURAGING GIRLS IN ENGINEERING

Followup Workshop Evaluation

Please take a few minutes and evaluate this workshop. By giving us this valuable feedback, you will help us to plan future workshops and programs. Use the back of this page if you need more room.

---

1. What was the most useful part of today's workshop?

2. What was the least useful part of today's workshop?

3. What were your expectations of this workshop series? Were they met?

4. Were there unexpected rewards (extrinsic or intrinsic) that you gained from participating in this workshop series?

5. This workshop series was sponsored by the Center for Women in Engineering at UC Davis. Are there similar programs or services that you would like to have the Center sponsor?

6. Any final comments? Please use the back of this page.

	Excellent	Good	Fair	Poor
7. Overall, how would you rate this workshop series?	( )	( )	( )	( )

8. I am: ( ) Female ( ) Male

THANK YOU FOR YOUR FEEDBACK AND PARTICIPATION!

LUNCHEON EVALUATION FORM - TEACHERS

Please help us improve our programs by providing us with feedback on this speaker. Attach another sheet of paper if you need more room.

1. What were your overall impressions of this luncheon? What did you like, not like, find interesting, etc.?

2. Would you bring students to another luncheon? Why or why not?

3. How could this luncheon be modified or improved? Was there any information missing?

4. Are there other types of activities, support services, speakers etc. you are interested in for your students?

5. Do you know of other teachers who would be interested in bringing their students to a luncheon? Would you like us to contact them?

6. Did your students give you any feedback about this luncheon? Would you share it with us?

Name: ______________ School: ____________________

Date of Luncheon: ____

THANK YOU!

LUNCHEON EVALUATION FORM - STUDENTS

Please complete the following sentences about today's luncheon.

1. WHAT I LIKED BEST ABOUT TODAY'S LUNCHEON WAS...

2. THE MOST INTERESTING THING I LEARNED WAS...

3. WHAT I'D STILL LIKE TO KNOW ABOUT ENGINEERING IS...

TODAY'S LUNCHEON WAS... (circle one) Excellent Good O.K. So-So Dull

I AM A: (circle one) Male Female

GRADE IN SCHOOL: (circle one) 4 5 6 7 8 9 10 11 12

MY SCHOOL IS: (write in space) ________________________________

MY TEACHER IS: (write in space) ________________________________

TODAY'S DATE IS: (write in space) ________________________________

HAVE YOU ATTENDED A DAY ON CAMPUS? (circle one) Yes No

HAVE YOU EVER HAD AN ENGINEERING SPEAKER IN YOUR CLASSROOM?

(circle one) Yes No

STUDENTS ON CAMPUS
Pre-Field Trip Questionnaire

Please fill this out before Friday, and bring it with you to the field trip.

1. Name: ____________________
   Address: ____________________
   ____
   Phone: ____________________
2. School: ____________________
3. Grade in school (check one): ( ) 9th ( ) 10th ( ) 11th ( ) 12th
4. Are you: ( ) Female ( ) Male
5. Why are you interested in attending this field trip? Please tell us:

6. What are your favorite classes in school so far?

7. Please list all of the math and science classes you have taken in high school so far:

8. After high school, what is the highest degree you plan on getting? Check as many as you want.

   ( ) Junior college ( ) Bachelor's ( ) Master's
   ( ) Doctorate ( ) Professional
   ( ) Other: ____________________

9. Are you thinking about majoring in engineering? Check one:

   ( ) Yes ( ) No ( ) Maybe

   If No or Maybe, what else are you thinking about majoring in? Tell us:

10. How much do you know about engineering? (Circle a number)

1	2	3	4	5
A little <------	------	------	------	------> A lot

11. Do you know any women engineers? ( ) Yes ( ) No

12. Check all of the things that you want to know more about engineering or becoming an engineer:

( ) what engineering classes and labs at the university are like.
( ) how to plan my education to prepare for a career in engineering.
( ) what I need to do to be accepted into a school of engineering.
( ) what the different types of engineers are.
( ) what engineers do on a normal day.
( ) how hard engineering is (and that I could do it if I tried).
( ) if engineering is fun (and that I would like it if I tried).
( ) if I could be an engineer and have a family.
( ) how much money I would make as an engineer.
( ) what kinds of jobs women have found in engineering.
( ) nothing.
( ) something else: ______________________________

13. Do you know yet what you'd like your future job to be?
( ) Yes ( ) No (IF NO, PLEASE SKIP TO QUESTION 16, NEXT PAGE)
If Yes, what is that job? ______________________________
Do you know anybody who has that job now? ( ) Yes ( ) No
Do you know any women who have that job now? ( ) Yes ( ) No

14. How much do you know about how to plan your education for that job? (Circle a number)

1	2	3	4	5
A little <------	------	------	------	------> A lot

15. What else do you want to know about that job? Please tell us:

16. Who or what influences our career and educational plans? Check all that are true:

( ) Mother
( ) Father
( ) Other relative
( ) Teacher
( ) Counselor
( ) Visiting a jobsite
( ) Friend
( ) TV/Newspaper/Radio
( ) Books
( ) Myself
( ) Summer camps
( ) My job
( ) Other: ____

17. Put a circle around the person/thing in Question 16 that has influenced you most.

18. Does your mother do scientific or technical work?

( ) Yes ( ) No ( ) Don't know

Write in the name of her job: ________________________________

19. Does your father do scientific or technical work?

( ) Yes ( ) No ( ) Don't know

Write in the name of his job: ________________________________

Be sure to finish filling out this questionnaire before Friday, May 22nd and bring it with you to hand in at the beginning of the field trip. Thank you!

STUDENTS ON CAMPUS
Evaluation of Field Trip

Please fill out this questionnaire and hand it in before you leave today.

1. Name: ____

2. School: ____

3. What did you think about today's field trip? Check one:

( ) Great ( ) Good ( ) O.K. ( ) So so ( ) Dull

4. Did you learn something about engineering today that you didn't know about before?

( ) Yes ( ) No

If Yes, tell us what you learned:

5. How much do you know about engineering? (Circle a number)

	1	2	3	4	5	
A little	<----------	----------	----------	----------	---------->	A lot

6. Check all of the things that you want to know more about engineering or becoming an engineer:

( ) what engineering classes and labs at the university are like.
( ) how to plan my education to prepare for a career in engineering.
( ) what I need to do to be accepted into a school of engineering.
( ) what the different types of engineers are.
( ) what engineers do on a normal day.
( ) how hard engineering is (and that I could do it if I tried).
( ) if engineering is fun (and that I would like it if I tried).
( ) if I could be an engineer and have a family.
( ) how much money I would make as an engineer.
( ) what kinds of jobs women have found in engineering.
( ) nothing.
( ) something else: ____

7. Are you thinking about majoring in engineering? Check one:

( ) Yes ( ) No ( ) Maybe

If No or Maybe, what else are you thinking about majoring in? Tell us:

8. What was the most interesting thing that happened today? Why?

9. What was the least interesting thing that happened today? Why?

10. Was there something missing today, that you wanted to do or find out about? What was it?

11. Do you have anything else you'd like to say about your day on campus?

Today's Date: ______________________________

Please hand in this questionnaire when you are done. Thank you!

Undergraduate Laboratory Researchers: 1992 (On-Site Interview Schedule)

Name: ______________________________

1. Tell me a little about your project. What do you hope to get out of this experience?

2. What is your image of what an engineer does?

3. What is your image of what a professor does?

4. What is you idea of what conducting research is like?

   - What skills do you need as a good researcher?

5. What are your strengths as an engineering student?

6. What are your weaknesses as an engineering student?

7. Have you ever given a technical presentation before? To whom?

   - If yes, what was it about?

8. Have you had summer jobs in industry in the past?

9. At this point in time, what are you considering more seriously: industry or graduate school? Why?

10. Are there faculty in your department with whom you've talked about your career objectives? Who? Were they helpful?

11. Are there other faculty you've talked with about your career objectives?

12. Where do you see yourself a year from now?

    - In five years?
    - In fifteen years?

Evaluation of Summer 1992 Laboratory Research Experience (Undergraduates)

Name: ______________________________ Major: ____________________________

Title of your lab project: ____

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1. How many quarter(s) have you been working in a lab through the MORE program? (Count each summer as 1 quarter) (________) quarter(s)

2. Have you developed any new skills, or refined any old ones, as a result of your work this summer? ( ) Yes ( ) No

   If yes, please describe:

3. Has your perception of your chosen field of engineering changed as a result of your summer laboratory research experience? ( ) Yes ( ) No

   If yes, how has your perception changed?

4. Have you been encouraged by anyone this summer about going to graduate school? ( ) Yes ( ) No

   If yes, who encouraged you, and how?

5. What do you think you'll do after you receive your bachelor's degree?

   Is this different now than it was before this summer? ( ) Yes ( ) No

   If yes, what changed your plans?

6. How often did you interact with your professor(s) this summer? Check one:

( ) Once a month or less
( ) Twice a month
( ) Once a week
( ) Twice a week
( ) Once a day or more

7. Please rate the amount of interaction you had with your professor(s): (Circle a number)

1	2	3	4	5
Very little interaction				A lot of interaction

8. How often did you interact with the graduate students working on your project this summer? Check one:

( ) Once a month or less
( ) Twice a month
( ) Once a week
( ) Twice a week
( ) Once a day or more
( ) Not applicable

9. Please rate the amount of interaction you had with graduate students, if applicable: (Circle a number)

1	2	3	4	5
Very little interaction				A lot of interaction

10. Please rate the amount of interaction you had with the administrators of the MORE program (people outside of your lab), in terms of explanation of the program and your responsibilities, information given about presentations, accounting procedures, meetings, how to fill out paperwork, etc.:

1	2	3	4	5
Very little interaction				A lot of interaction

11. How much time did you spend filling out administrative paperwork, completing accounting procedures, and attending meetings with MORE administrators prior to starting your lab research experience?

1	2	3	4	5
Very little time				A lot of time

12. How useful was it for you to make a presentation on your project to other students?

1	2	3	4	5
Not very useful				Very useful

13. Any comments on the project presentation exercise?

14. What did you like most about working in your lab experience better?

15. What did you like the least?

16. How could your professor(s) have made your lab experience better?

17. Would you recommend this sort of experience to other students?

( ) Yes ( ) No

18. **Overall, how would you rate your summer lab experience**? (Circle a number)

1	2	3	4	5
Not at all worthwhile				Very worthwhile

19. Do you have any final comments or suggestions for us? Use the back if you need more space.

Please bring this with you to the lunch on September 10, 1992 or return to: Meg Bland, Engineering Dean's Office, 2132 Bainer. Thank you for your help!

HIGH SCHOOL STUDENT RESEARCHERS 1992: INCOMING QUESTIONS

1. Why do you want this job?

2. Do you know any engineers? What do engineers do?

3. What are your career plans?

4. When you think of an engineer, what 5 terms or words come to mind?

5. If you were to describe yourself, what 5 terms or words would you use?

HIGH SCHOOL STUDENT RESEARCHERS 1992: EXIT QUESTIONS

1. What did you get out of this summer job?

2. Has your opinion of engineering or engineers changed as a result of this job? In what way?

3. What did you learn as a result of your work here?

4. Would you recommend this summer job to other students, why? How might the experience have been improved?

5. When you think of an engineer, what 5 terms or words come to mind?

6. If you were to describe yourself, what 5 terms or words would use?

Appendix 4: Project Dissemination Activities

Presentations

Judi Kusnick	October 1991	"Girl-Friendly Science." Workshop at California Science Teachers Association Meeting (CSTA), San Jose, CA.
Judi Kusnick and Debra Desrochers	August 1992	Hands-on demonstration and presentation to the Science Textbook Adoption Committee, San Juan Unified School District, Carmichael, CA.
Judi Kusnick	June 1993	"How Things Work: Helping Girls Explore Technology." Workshop for 7-12 grade teachers at Schools and Colleges for the Advancement of Teaching Science (SCATS), Sacramento, CA.
Elizabeth Gillis Raley	June 1994	"Priming the Pump: Getting More Girls into the Engineering Pipeline." Presentation and poster session, Society for Women in Engineering (SWE) National Conference, Pittsburgh, PA.
Judi Kusnick	June 1994	"How Things Work: Engineering Education for Elementary Teachers." Presentation at WEPAN (Women in Engineering Program Advocates Network), Washington, D.C.
Mary Margaret Bland	June 1994	"Perspectives on Evaluating Classroom Climate Programs for Women." Presentation at WEPAN (Women in Engineering Program Advocates Network), Washington, D.C.
Judi Kusnick	October 1994	"How Things Work: Helping Girls Explore Technology." Workshop for K-8 teachers at CSTA Meeting, Palm Springs, CA.

Papers

Bland, Mary Margaret. "Perspectives on Evaluating Classroom Climate Programs for Women." WEPAN Conference Proceedings, Washington, DC: 1994.

Gillis Raley, Elizabeth. "Priming the Pump: Getting More Girls into the Engineering Pipeline." SWE National Conference Proceedings, Pittsburgh, PA: 1994.

Kusnick, Judi, Desrochers, Debra and Darby, Jeannie. "How Things Work: Engineering Education for Elementary Teachers." WEPAN Conference Proceedings, Washington, DC: 1994.

Kusnick, Judi. "How Things Work: Helping Girls Explore Technology," paper in preparation for submittal to Children and Science.

Project Handbook

"How Universities Can Help Teachers Introduce Girls To Engineering: A How-To Manual," Center for Women in Engineering, UC Davis, Davis, CA, 1994.

Impact of Dissemination Efforts on K-12 Educators

The following dissemination activities impacted additional K-12 educators.

Date	# Impacted	Event
September 1992	30	San Juan Unified School District elementary science teachers science textbook adoption committee
October 1992	50	Workshop at CSTA meeting, San Jose
June 1993	25	SCATS workshop, California State University, Sacramento (CSUS)
October 1993	25	E-SCATS (Elementary Schools and Colleges for the Advancement of Teaching Science) workshop, CSUS
October 1994	30	Workshop at CSTA meeting, Palm Springs
Total impacted:	**160**	

Appendix 5: Papers

The following papers resulting from the project are included in this appendix.

Bland, Mary Margaret. "Perspectives on Evaluating Classroom Climate Programs for Women." WEPAN Conference Proceedings, Washington, DC: 1994.

Gillis Raley, Elizabeth: "Priming the Pump: Getting More Girls into the Engineering Pipeline." SWE National Conference Proceedings, Pittsburgh, PA: 1994.

Kusnick, Judi, Desrochers, Debra and Darby, Jeannie. "How Things Work: Engineering Education for Elementary Teachers." WEPAN Conference Proceedings, Washington, DC: 1994.

PERSPECTIVES ON EVALUATING CLASSROOM CLIMATE PROGRAMS FOR WOMEN

Mary Margaret Bland

Center for Women in Engineering, University of California-Davis, Davis, California

Incorporating evaluation into the process of planning, developing and implementing classroom climate programs for women is important for many reasons. Program evaluation can allow a greater understanding of the impact of a program on its participants, provide information about the success of programs which can attract future funding, and help seed similar programs at other institutions. There are at least as many forms of evaluation as there are types of programs, with wide ranges in complexity. However, there are many different theories and definitions of program evaluation, with no universally accepted approach. This paper discusses one approach to evaluating classroom climate programs for women, based on the evaluation of several model programs for the Center for Women in Engineering (WIE) in the College of Engineering at U.C. Davis.

Introduction

Over the past three years, the staff members of WIE have worked as a team to develop, implement, evaluate and disseminate information about several model programs aimed at improving the climate for women engineering students. These pilot programs, funded by the National Science Foundation (NSF) and the Fund for the Improvement of Post-Secondary Education (FIPSE), were designed to attract, recruit and retain girls and women into the field of engineering while at the same time addressing the impact of the "chilly climate." These programs were developed at two levels, K-12 and university. The K-12 programs include workshops for teachers and outreach activities for students. The university level programs include a "How Things Work" hands-on course for female undergraduate engineering students, and sensitizing workshops for engineering faculty.

The following sections of this paper discuss considerations in planning the evaluation design of these model programs, identification of evaluation challenges, examples of selected data collection methods, and useful program results. Finally, based on this evaluation, recommendations are offered to others who plan to evaluate similar programs for women.

Planning the evaluation

Because our model programs were innovative and unique, it was determined that they required responsive, ongoing evaluation. A formative, process-oriented approach could provide the continual feedback necessary for program refinement to meet participants' needs and the program goals. Undertaking several evaluation steps early in program planning resulted in the selection of a formative evaluation design, and incorporated both qualitative and quantitative data collection methods.

A literature review revealed few other existing programs similar to those proposed at U.C. Davis. A series of meetings with WIE staff and principal investigators were held where program goals and objectives were reviewed and primary evaluation questions were identified for each individual program component. Finally, the group agreed on which questions were possible to answer within a three-year time period.

Some of the information to be sought through evaluation included:

* An understanding of female students' attitudes and feelings toward engineering

* An understanding of K-12 teacher and university faculty attitudes toward classroom climate issues

* Information necessary to modify programs over time to best serve female students

* Annual reporting information for our funding agencies

* Information about the programs for institutional decision makers

* Descriptive program information for dissemination to a wide variety of audiences, both during and at the end of the program

* Evidence of attraction, recruitment, retention or improved performance of female engineering students as a result of the programs.

In order to understand how the program components functioned and how our participants were impacted by them, it became clear that mostly exploratory and descriptive information was needed about our programs and participants. Ongoing feedback about our programs and participants was necessary in order to modify and improve the components each year. At the same time, it was not likely that much information about attraction, recruitment, retention or improved performance of students could be generated in such a short period of time.

Evaluation challenges

There were a number of challenges to be addressed when designing evaluation for each program component:

* There were no prior survey instruments available which could be used "as is" to quantitatively measure the programs

* Some traditional evaluation designs, such as experimental, had to be ruled out because:

    * The programs involved mostly small, self-selected groups of students or teachers, making random sampling impossible

    * There was no one available for control or comparison groups

    * There were too many independent variables that could not be controlled

* Changes in the classroom climate are difficult to identify and affect, and may take a long time to assess

* Long-term program impacts on participants and on retention were not possible to measure in a three-year period

* Obtaining results which served funding needs might be different from those required for internal program information

Furthermore, obtaining accurate assessments of students' thoughts, feelings and attitudes when participating in classroom climate programs through the use of traditional quantitative methods such as surveys was challenging. At the same time, the value of statistical data about our programs for administrators, policy makers, members of the scientific community and funding agencies had to be considered.

The approach to evaluating classroom climate programs for women was, therefore, to incorporate multiple methods of data collection into the evaluation design. The evaluation was designed to generate as much qualitative, descriptive information about our programs and participants as possible before using or developing quantitative measures. Because of the need for some statistical data, quantitative measures were used wherever possible. These were used particularly in the evaluation of the K-12 programs, since there was more information available about similar programs. Quantitative measures were generally developed based on instruments and suggestions found in evaluation reference books, or were developed in the middle of the program from analysis of qualitative data.

Evaluation methodology selected

Each program component was assigned a set of goals and objectives, and evaluation methodology was then tailored to provide the information recognized as most important for each component. Below is a brief description of the two university level program components, targeted participants, goals, and the evaluation methodology selected:

Program:	Faculty Sensitizing Workshops, 1992 and 1993
Level:	University engineering faculty
Primary Goals:	To create faculty awareness of "chilly climate" and provide an environment for faculty to discuss and form a plan of action for addressing this in their own classrooms
Methodology:	Primarily qualitative: faculty presurvey, 1992 Engineering Student Climate Survey, workshop observation, evaluation at end of workshop, project team brainstorming, informal faculty feedback

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Program:	Engineering 25, "How Things Work," hands-on course in mechanical dissection for female engineering students, 1992 and 1993
Level:	University level undergraduate female engineering students
Primary Goals:	To address and overcome fear of hardware and increase confidence through hands-on activities
Methodology:	Primarily qualitative: presurvey, student journals, interviews with TA's and professors, "final exam" evaluation questions, some observation, teaching team brainstorming, focus groups

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For both of these university level components, primarily qualitative methods were selected because of the need for information about changes in attitudes and awareness of participants.

Program results: The role of qualitative data

As expected, using multiple methods to evaluate model classroom climate program components yielded a variety of useful and

complementary information. In particular, some excellent results were obtained from analysis of various qualitative data. One example is the data collected from evaluation of the hands-on engineering course, E25.

In a two-year evaluation of E-25, written student journals emerged as the primary source of information about what happened in E25 and about the attitudes, feelings and behaviors of its female participants. An enormous amount of rich, deep data emerged from content analysis of these student journals. The journals constitute a descriptive record of how students developed throughout each quarter and how they felt they were impacted by the course.

In the first year of the course, students were asked to simply answer several questions each week in their journals, regarding the hands-on activities they encountered in their labs. Analysis of student journal entries led program planners to an understanding of their experiences while taking the course, and allowed for the identification of a number of variables to be studied with the group of students taking the course in the second year. The variables identified included:

* How the women students felt about whether men should be allowed to take the course

* Evidence of increases in students' self esteem and confidence with tools and hardware as a result of taking the course

* Students' increased awareness of the chilly classroom climate

* The value of including female role models in the course (female TA's and guest speakers).

In their journals, students also made many suggestions about the course activities which gave the professor feedback necessary to make modifications and improvements to the course.

In addition to the journals, the findings from each course were then confirmed and strengthened, using results obtained from other data collection methods. Prequestionnaires were given to each group of students prior to taking the course. Interviews were conducted with the professor and TA's immediately following each course. Focus groups of participants were held one year after each course. Like the journals, these methods also sought data about how students developed throughout each course, how they reported feeling about components of the course, and what improvements they would suggest.

The prequestionnaires gave some baseline information about how students coming in to the course initially felt about working with tools and hardware. Interviews with the TA's and professors revealed where there were discrepancies in perceptions of students feelings and course components, and confirmed students' impressions about what

was successful about the course. The focus groups confirmed, for instance, that each group of participants had lasting feelings of increased self esteem and confidence resulting from the course. At the same time, new ideas were generated from the participants. These findings were used to obtain additional funding from NSF, which will be used to offer and evaluate a future courses, with an all-women section and a coed section as comparison groups.

Conclusions from evaluating model classroom climate programs

Based on the experience of evaluating model programs for women at U.C. Davis, here are some recommendations when undertaking evaluations of classroom climate programs:

* Include evaluation from the earliest moment possible in all stages of program planning, development, implementation and dissemination. A clear understanding and agreement of how evaluation results will be used and what questions the evaluation seeks to answer can save a great deal of time, effort, and avert misunderstandings.

* Limit the number of evaluation questions you want to pursue. It is possible to become overwhelmed with too much information, especially when using qualitative methods.

* Take into consideration both limitations and available resources, such as time needed to develop and implement evaluation strategies, money, ease of access to student records, available expertise both in-house and in the education community, and use or modification of existing measures vs. design and testing of new ones.

* Qualitative methods such as interviews, journals and focus groups can also be used to generate data which can lead to the development of survey instruments later in the program.

* Carefully combining qualitative and quantitative methods can strengthen and confirm program evaluation results. They provide more than one way to address evaluation questions.

Our formative, multiple-method approach to evaluating our model classroom climate programs was successful. Our evaluation was designed to be an integral part of program planning, implementation and dissemination. Evaluation methodology provided continuous feedback on program components, which allowed the program administrators to make modifications, continuously meet the needs of participants, and sustain ongoing impressions of what was successful about our programs.

PRIMING THE PUMP: GETTING MORE GIRLS INTO THE ENGINEERING PIPELINE

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ABSTRACT

Much has been written about the changing demographics of our society and how we must increase the number of women and minorities in our technical and professional ranks if we are to remain competitive in the new global economy.

The Center for Women in Engineering at the University of California, Davis, is developing and implementing programs designed to increase the number of women receiving engineering degrees. Funded by the National Science Foundation (NSF) and the Fund for the Improvement of Post Secondary Education (FIPSE) these projects explore ways to attract, recruit, and retain women as engineering students. The projects target students and faculty from kindergarten to the post graduate age. Project elements work to introduce the engineering field to students and faculty at lower grade levels, to ensure that potential engineers do not "leak out of the pipeline" because of poor preparation or lack of encouragement, and to assure that those women enrolled in engineering stay enrolled by developing an institutional infrastructure that is friendly to women.

Despite the ever increasing technological demands of our society, the United States is producing fewer scientists and engineers and some predict that the number will continue to decline. [1] In the United States most occupations are either predominantly male or female in composition. Women traditionally fill low-paying, pink-collar jobs such as clerical, retail sales and service jobs. Approximately 75 percent of the jobs in higher-paying professions are held by men. [2] And the gender gap is higher in engineering than for many of the other professional fields. This sex-segregation of the U.S. work force results in under utilization of a valuable and needed resource, women.

Women represent 15.4 percent of working lawyers and judges and 14.6 percent of our physicians and dentists, but only 5.7 percent of our engineers. [3] Enrollment in the respective degree programs follows similar patterns. About 40 percent of the students in law school and 34 percent of the students in medical school are women. [4] Only 17 percent of the degrees in engineering are currently awarded to women. [5] Why are there so few women in engineering?

Recent studies indicate that many factors contribute to the lack of women in engineering and other technical fields. Early childhood socialization, sex-biased curriculum materials, lower expectations, differential treatment, sex role stereotyping,

the "chilly climate" classroom experience, peer pressure, and poor (or lack of) role models have all been cited as contributory factors. [6]

The Center for Women in Engineering at the University of California, Davis is working with two projects to explore ways to attract, recruit, and retain women as engineering students. These projects are funded by grants from the National Science Foundation (NSF) and the Fund for Improvement of Post Secondary Education (FIPSE). The projects target students and faculty from kindergarten to the post graduate age. The two year long NSF project (HDR-90-53903) is just now finishing up. The FIPSE project (USDE P116B11646) was funded two years ago and will be completed in the fall of 1994.

The components of the two projects attempt in a variety of ways to increase the flow of women enrolling in engineering degree programs. Some elements work to "prime the pump" by introducing the engineering field to students and educators at lower grade levels. Other elements work to ensure that potential future engineers do not "leak out of the pipeline" because of poor preparation or lack of encouragement. For instance, the importance of staying on the math-science curriculum track is emphasized and female role models are utilized to encourage girls to select engineering as their course of study after high school. Some elements work to assure that those women enrolled in engineering stay enrolled by working with both students and faculty at the university level.

If the United States is to remain competitive in world markets, it must utilize all of its resources. The number of white males of college age, who have been the dominant participants in the fields of science and engineering, is predicted to drop significantly in the future. Women and minorities will make up 85 percent of newcomers to the labor force by 2000. [7]

Clearly we must work to increase the number of women in the sciences. The following is a discussion of the efforts directed by the Center for Women in Engineering at UC Davis. These programs, sponsored by NSF and FIPSE, are designed to increase the number of women receiving engineering degrees.

"How Things Work"

NSF provided funds for one of our most innovative efforts: a class unofficially titled "How Things Work". The class, offered on an experimental basis to women only, was designed to give women engineering students the "hardware know-how" they frequently lacked. Students were issued a tool kit and explored machines and common mechanical devices with their hands and their minds. Students examined toilets, doorknobs, electric sanders, compact disks players, bicycles, and cars. They kept journals and gave presentations on what they learned. The written and verbal parts of the class required that the students become comfortable with the engineer's technical language: rack and pinion, solenoid, transducer, etc. In the lab portion of the class, the students learned to use tools in an environment where there were no penalties for breaking something or getting dirty. UC Davis mechanical engineering professor Jerry Henderson, designer and teacher of the women's class, says, "I still can't teach them about every widget and gadget. But I show them that if they can do it once, they can do it again." Students have responded enthusiastically to the class. The UC Davis course is expected to become a model for colleges and universities around the country that are also struggling to attract and retain female students in engineering.

Faculty Sensitizing Workshops

Also funded by NSF are engineering faculty sensitizing workshops. Attended by university engineering, physics and math department faculty, these workshops,

address the issue of the "chilly climate" for women in the classroom. Studies indicate that women face many barriers in the educational system. [8] Examples of gender bias include lower expectations for female students, ridiculing or trivializing women's questions in class, ignoring their attempts to participate, stereotyping women and men's roles in society (women are stewardesses and nurses, men are pilots and doctors), using the pronoun "he" when referencing professionals, etc. In fact, women engineering students can feel isolated and disconnected in today's classroom. Both male and female faculty are invited to the workshops and it is stressed that gender biased teaching is practiced by both sexes.

These workshops typically begin with an introduction to the issue of the chilly climate, citing various studies and case histories. Statistics are presented showing that despite higher GPA's, the university's female engineering students have higher dropout rates and lower levels of self-confidence. An important point demonstrated is that women are academically capable of excelling in engineering and yet do so less frequently. The workshop then opens up to a general discussion where faculty explore their own feelings about the problem.

The workshop demonstrates to the faculty some of the experiences of a female engineering student. In one exercise, drama students perform lighthearted sketches of academic interactions illustrating subtle and not-so-subtle discriminatory behavior in the classroom and during office hours. The workshops also include a panel of women engineering alumnae and students as well as former engineering students who elected to transfer to other majors. The panel members recount their personal experiences during their pursuit of an engineering degree. This tends to be a very powerful portion of the workshop. While this has proven to be an emotional experience for the panel members, it is also the point where the professors take notice and begin to internalize the concept. This activity attempts to move the problem from numbers on paper to real occurrences in the classroom.

NSF funding provided for two workshops, with increased success in the second workshop. The workshops are most successful when they receive support and validation from the university administration. With support from the Alfred P. Sloan Foundation, these workshops will continue and a video tape is being created for more widespread dissemination.

Technology Education and Gender Equity Workshops

These workshops have been developed to work with kindergarten through 12th grade teachers to:

* sensitize teachers to gender biases in the classroom,
* educate teachers about engineering as a viable career for all students,
* increase teachers' comfort level with mechanical devices, and
* provide teachers with ideas they can bring back to their classrooms to increase girls' interest in math and science as well as their understanding of mechanical devices.

These workshops focus on addressing a number of the early barriers that confront girls in the classroom, barriers that make them shy away from science, mathematics, and ultimately engineering. Teachers identify the barriers they see in their own schools that discourage girls from participating or excelling in math and science. They then share their personal solutions to these problems, and learn

specific techniques for producing a gender-equitable classroom.

Many of the participating teachers are women, who are themselves uncomfortable with machines and technology. To help them confront and conquer their inhibitions, the teachers are given the opportunity to explore household technology. The devices range from children's toys and tape recorders to bathroom scales and electric shavers. After disassembling their device, each group of teachers explains to the rest of the participants how their machine works. Then begins the work of putting the devices back together-- all parts included. As they work, the teachers discuss how to recreate these activities in their own classrooms.

Teachers also work with data they collect from their own classrooms regarding their students' career aspirations. Compilation of all the participants data dramatically demonstrates that career choices are sex-segregated from a very early age. Discussions following the exercise eventually evolve to how the participants and their peers selected their own careers. Finally, strategies to advocate engineering as a career option are discussed.

Role Model and Networking Activities

One of the reasons often cited for the lack of women engineering students and the low numbers of girls who even consider engineering is a lack of role models. There are three components in this segment of the project which put girls in touch with female engineers and engineering students.

Day on Campus

The Day on Campus brings students from local schools to the UC Davis campus. The students may be girls from a new chemistry club, or just interested girls with motivated teachers, or in one case, a 6th grade class (both boys and girls) came to campus for the day.

Using the engineering building as a home base, the 'Day' usually begins with a welcome by project staff, followed by a bus tour of campus. This serves to give the students a general impression of the size of the campus as well as all the opportunities the campus has to offer. Students seem impressed with the wide variety of degrees offered as well as the extra-curricular activities: from degrees in biomedical engineering and wine making, to the rock concerts at Freeborn Hall and the weekend kayaking treks.

Students then spend some time in a lecture hall learning a little more about the engineering profession. This is often when the younger students get a chance to meet university female engineering students. The female engineering students talk about why they chose engineering, why they chose UC Davis, and what they like the most and least about their major. Meeting and talking with the older students is a very important part of the experience for the younger students. Lunch is usually an unsupervised affair, where students can mingle with university students and feel the university atmosphere.

Events during the day include participation in an engineering class. When possible, the "How Things Work" class is attended. The students may visit the campus residence halls and the recreation hall. Typically, the engineering labs are toured. The day ends with a discussion with a representative from the Admissions Department. The students learn what high school classes they must take and what their GPA and SAT scores should be. Student comments indicate that the presentation is very effective in communicating the idea that preparation for college begins as early as junior high. The fact that an Admissions officer is making these statements (as opposed to a parent or a teacher) also appears to get the students' attention.

By the end of the day, the students have a feel for life on a college campus. They also

have a better concept of what an engineer does for a living, what kind of classes to take in high school to prepare for an engineering major, and what it is like to attend a university and study engineering.

Luncheons

In this project component, professional engineers from the Society of Women Engineers (SWE) have lunch with a small group of high school girls. The lunch is meant to be an informal meeting where interested girls can explore what it is like to be an engineer. Typically the girls are high school age and have already shown some interest in engineering. The luncheons are kept small so that there is an level of intimacy and sharing that does not occur in the classroom or in larger groups. The professional engineers talk about why they chose engineering and their particular engineering discipline, and what they like about their job and profession, as well as some of the difficulties they have encountered in their careers. Students are given a chance to privately discuss some of their fears and concerns and to get some personal attention. Many engineering disciplines are represented so that students get a deeper understanding of just what these professionals do for a living.

Speakers Bureau

This project element gets women engineers into classrooms as role models by fulfilling requests for speakers in the classroom, at teachers meetings, math/science conferences, career days, etc. Most students and many teachers have never met a woman engineer. Project team members and members of the local sections of SWE act as the speakers/role models.

The Project and the Project Team

The project is implemented by a unique team from the campus and the community. Robby Henes, directs the Center for Women in Engineering, leading the project and taking primary responsibility for the university-level workshops. Dr. Jerry Henderson, professor of mechanical engineering, is the designer and teacher of the 'How Things Work' class. Judi Kusnick, who teaches geology and is a specialist in science education, heads up the technology education and gender equity workshops. Liz Gillis, a professional engineer and vice president of the local SWE section, works on the role model and networking activities. All activities rely heavily on the support of a graduate student position, originally filled by Debby Desrochers and currently by Angie Folson. Meg Bland, a program evaluator with the Center for Women in Engineering, works with the team members to design and incorporate all project evaluations methods, analyze and record data, and make recommendations.

The Center for Women in Engineering considers evaluation of project elements to be an important part of their development and implementation. Ongoing evaluation has provided the project team members with the information they need to both confirm the successful aspects of the project elements and to make necessary changes. A variety of descriptive data is collected from various project participants and then analyzed. Methods such as student and teacher journals, focus groups, interviews, and pre and post questionnaires are used. However, because of the relatively short duration of these model projects, it is not yet evident whether they have yielded the desired long term effects: specifically, whether the project elements result in more girls enrolling in engineering and lower attrition rates for university-level female engineering students.

As the project concludes, it will also be important to evaluate the level of effort and expense required for individual project components weighed against their outcomes. For example, the speakers require relatively little effort or expense as compared to the faculty workshops.

However, the workshops, in working with teachers, ultimately reach many more students, assuming the material is assimilated. Another interesting question is whether the all-female environment of "How Things Work" is critical for its success. Would male students inhibit the learning experiences of their female classmates? According to the student journals, most of the women prefer the all-female format. They are more open to experimentation and begin to build a support network with their female peers.

The Center for Women in Engineering is in the unique position of having support for a wide range of projects, allowing it to work with faculty, administrators, and students from the grade school through the college level. This wide spectrum of activities helps assure that all stages of the engineering pipeline are addressed and that potential students do not 'leak out'. In order to be totally effective, the project components described above need to be continued and replicated on a wider basis. In any event, the work has just begun, and needs to continue and expand if parity is to be achieved for women in engineering.

REFERENCES

[1] "Human talent for competitiveness" (NSF 87-24, National Science Foundation, Washington, DC, 1987).

[2] Bureau of the Census, *Statistical Abstract of the United States: 1984,* Washington, DC: GPO, 1984.

[3] Ibid.

[4] National Center for Education Statistics, in Betty M. Vetter and Eleanor L. Babco, eds., *Professional Women and Minorities, A Manpower Data Resource Service*, Washington, DC: Commission on Professionals in Science and Technology, 1986.

[5] Engineering Manpower Commission, *Engineering and Technology Enrollments*, American Association of Engineering Societies, Inc., Washington, DC, 1990.

[6] Julie Kuhn Ehrhart and Bernice R. Sandler, *Looking for More Than a Few Good Women in Traditionally Male Fields*, 1987, Project for the Status and Education of Women (PSEW), Association of American Colleges.

[7] National Science Board, *Science and Engineering Indicators: 1991*, Tenth Edition, Washington, DC: US Government Printing Office, 1991.

[8] Op. cit.

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HOW THINGS WORK: HELPING GIRLS EXPLORE TECHNOLOGY ENGINEERING EDUCATION FOR ELEMENTARY TEACHERS

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In 1991, the Center for Women in Engineering (WIE) at the University of California at Davis received a three year grant from the U.S. Department of Education's Fund for the Improvement of Post Secondary Education to pilot a program that would help improve the classroom climate for girls in the Sacramento area and could serve as a model for similar programs in other areas. The program consists of two elements: an outreach program directed at students, and a workshop series for K-12 teachers.

While the program was designed and implemented for both elementary and secondary school teachers, this paper focuses on the workshops for K-6 teachers. We anticipated that teachers at each level would have different needs. Specifically, we expected that elementary teachers would be more apprehensive about tools and technology than secondary science teachers,and would be more reluctant to implement a hands-on science program. These expectations were borne out. What we had not expected was a greater openness on the part of the elementary teachers to acknowledge that girls do feel excluded from classroom math and science and to admit the role of teachers in creating a hostile classroom climate. We feel that our program was much more successful in changing attitudes and behavior of the participating elementary teachers than of the secondary teachers, a conclusion that surprised us.

We are still considering what changes in our program could make it more effective for use with secondary science and mathematics teachers. However, we feel that the workshop series for elementary teachers was very successful, and could be replicated elsewhere with equal success. What is presented here is an outline of the project. Interested readers can obtain a complete manual on the project from WIE.

Workshop Goals

The primary goal was to help teachers improve the classroom climate for girls in math and science. While classroom climate is determined by many factors, such as student attitudes and resource availability, the teacher's attitudes and teaching techniques are critical in setting the tone for the classroom. We decided to focus on gender-equitable teaching.

There are two ways of training teachers to teach more equitably: concentrate on what teachers are doing wrong, or concentrate on what they are doing right. The gender equity literature is replete with descriptions of what teachers are doing wrong [1-4]. This literature has inspired some fine training programs such as GESA (Gender Ethnic Student Achievement). These programs make teachers aware of their inequitable teaching techniques, and retrain teachers to avoid these techniques. This sort of training is time-intensive and requires ongoing monitoring and support. Our funding provided only for a two-part workshop series. We could not provide an environment in which teachers would have an opportunity to meet with us on a long-term basis. Under those conditions, concentrating on the negative aspects of what teachers are currently doing would be an ineffective and demoralizing way to try to change teacher behavior. We decided instead to concentrate on the other branch of gender equity research: what teachers do right. These researchers study classrooms where girls have both high achievement and positive attitudes toward math and science. The common elements of these classrooms provide a model for gender-equitable teaching [5, 6]. We identified four teaching strategies from this research: cooperative

learning, pro-active classroom management, hands-on learning, and active classroom career guidance. We designed the workshops to highlight and model these teaching strategies.

A second goal of the workshops was to encourage teachers to use everyday technology in their classrooms. Many women engineering students have little experience with technology such as household devices and automobiles. This inexperience hurts them in the classroom when professors use carburetors or electrical devices as examples of engineering principles. The School of Engineering at UC Davis has recently begun a class for women to teach how various machines work. We set out to adapt the university-level technical activities for K-12 students, and to use exploration of everyday technology as a vehicle for demonstrating gender-equitable teaching.

The final goal of the workshop series was to educate the teachers about engineering. Many people outside the field believe in outdated and inaccurate stereotypes of engineers. Our intent was to have teachers examine their own ideas about engineering and contrast them with a more realistic view gathered from women engineers.

Underlying Philosophy of the Workshops

We believe that for educational reform to occur, it must be embraced by teachers. The best-intentioned outsiders cannot make change happen unless teachers feel some ownership of the proposed reform. The essential ingredient of any program that seeks to change teacher behavior is a regard for teachers as peers in reform.

The underlying philosophy of our workshop series is respect for the participating teachers. We view the project as a collaboration between our staff and the teachers in which we supply some ideas and the opportunity for the teachers to experiment with them. The teachers provide the know-how to implement those ideas. The workshop activities are designed to solicit teacher input and to instill a sense of ownership in the project.

We also believe that teachers construct their own meaning for the concepts they teach. If we want teachers to teach in a more equitable way, they must experience that kind of teaching. If we want them to teach about technology, they must have an opportunity to explore technology. Our workshops were constructed to model principles of equitable teaching, and to give teachers a chance to develop confidence with both the technology they were exploring and the concepts of gender equity themselves.

Workshop Components

Our workshop series consists of three components: an introductory workshop early in the school year in which teachers encounter new activities and teaching strategies; a follow-up workshop near the end of the school year to discuss their progress; and teacher collaboration during the year to help teachers experiment with changing their teaching.

Introductory Workshop

The first workshop of the series is composed of a series of structured activities that highlight each of the goals of the project. Each of these activities is described below in the section entitled Introductory Workshop Activities. This full-day workshop is orchestrated by the project staff, though it is designed to solicit much input from the teacher participants.

Follow-Up Workshop

The purpose of the follow-up workshop is to track the teachers' progress in implementing both gender-equitable teaching strategies and how-things-work activities. We ask participating teachers how they would like to use the workshop time. The first year of the workshops, the teachers chose to discuss their technology activities and explore extensions of the activities across the curriculum. The second year, the teachers chose to do more machine dissections with specific instruction about gears and electric motors. In both cases, we also asked teachers to discuss their progress in implementing a more hospitable classroom climate for girls.

Teacher Collaboration

In our first year of workshops, we did not deliberately include teacher collaboration as an element of the workshop series. However, the school district we were working with sent teams of several teachers from each school who spontaneously collaborated to produce some of our most exciting results. We also noted that the teachers who spontaneously collaborated were the ones who most

diligently completed all of the tasks we set for them. This experience persuaded us that teacher collaboration would help us keep teachers in the program and help them achieve our goals. We decided to schedule our workshops for Saturdays, and use the money set aside for substitute teachers to allow each teacher one day of release time to collaborate on classroom activities. This strategy produced both wonderful results and some unforseen problems, as we describe later on.

Introductory Workshop Activities

Research Assignments

We assign two research projects for teachers to complete before coming to the introductory workshop. Our intention in assigning this research is not to produce rigorous results for our own use, but to give teachers a chance to explore their relationships with their students, and their students' hopes for the future.

In the first assignment (designed by EQUALS), we ask teachers to do some research on their students. The teacher asks students to write an essay (or for young students, draw a picture) illustrating a typical day when the student is thirty years old. The teacher then analyzes the essays, compiling information about what careers are depicted and how students describe family roles. We ask each teacher to bring her compiled results and a three sentence summary to share at the first workshop. During the workshop, teachers compile the results of their research on their students on one large chart. We use this chart to launch a group discussion of the results. Our participants have found this research to be very useful, giving them a much clearer view of how their pupils view themselves and their futures.

For their second assignment, teachers do some research on their teaching. We ask the teachers to have a colleague or a student keep track of who the teacher calls on and who she spends the most time with. The results have been illuminating. Some teachers find that they are very even-handed in calling on their pupils, but most discover some bias. Typically, a few students are using most of the teacher's time and attention. The educational literature says these students are usually boys, but our results were mixed. In some classrooms girls were the dominant students, especially in elementary school. This assignment proved useful to teachers not only in assessing their teaching, but in opening up communication with students about classroom interaction.

Images of Engineers

Many people outside of engineering have stereotyped views of who engineers are and what they do. For example, many people think of engineering as a dirty profession, imagining all engineers spend their time in hard hats on construction sites or manufacturing lines. These are images which, although true of some engineers, may not be attractive to adolescent girls. Girls may also visualize engineers as white men who are very gifted in mathematics, and so have trouble seeing themselves as engineers.

To help broaden the image that teachers and students have of engineering, we designed an activity in which the participant compares her concept of engineering with descriptions given to us by women engineers. The activity begins with teachers thinking and writing about a typical day of an engineer. They share these ideas in groups of three. The teachers then read the descriptions six women engineers gave when asked to describe their typical day. Next the teachers think and write about the skills and talents needed to be an engineer, and again compare their ideas to those of engineers. Finally, the participants reflect on how this experience may have changed their conception of engineering.

We solicited the descriptions of an engineer's typical day through the newsletter of the local chapter of the Society of Women Engineers. We do not claim that our sample is representative of all engineers. Because we sampled only women, we received replies from engineers in the fields where women are more common: civil, environmental, and software engineering. Because of the economics and politics of our region, we received replies largely from women in consulting, educational, or regulatory positions. We made these limitations of our sample clear to the workshop participants. But the descriptions we did get reflected a view of engineering that was new to many of the teachers participating in the workshop. Teachers were surprised at the amount of communicative work described by the engineers: meetings, telephone calls, writing projects. Likewise, teachers were surprised by the emphasis the engineers put on communication skills.

As in the rest of the workshop activities, there are no right answers to the questions asked in this exercise. We encourage teachers to share their personal experience of engineering, and we always

include an engineer on our workshop staff to answer questions and share her own work experiences.

Technical Autobiography
Some teachers are reluctant to do technology-oriented activities with their students because they lack confidence or experience with tools and machines. Before exploring how machines work, teachers individually fill out a Technical Autobiography which consists of questions about their past experiences with and attitudes about tools and machines. Then they discuss their answers with their working group. This activity helps teachers start to overcome inhibitions they have about exploring technology, and helps develop a sense of trust within their group.

How Things Work
In this activity teachers explore how household devices work. We have used a wide variety of common machines for this exploration: bathroom scales, electric mixers, toasters, cameras, tape recorders, mechanical toys. Such exploration into technology can be appropriate for any grade level, depending upon the educational goals of the teacher. With this in mind, we prepared a handout with suggested goals and strategies for carrying out the exercise. For example, teachers of young children may wish to simply introduce children to tools and how to use them. Young children may also take machines apart just to see what is inside. Older children can take machines apart, investigate how they work, and recognize principles from their science curriculum at work. We asked the participating teachers to take apart their device, learn as much as they could about how the machine works, present their findings to the group, and then reassemble the machine. We have discovered a number of strategies that help the activity run smoothly both for us and for the participating teachers in their classrooms. For example, we have workshop participants work inside the cardboard trays that cartons of soda cans come in (we get them from the vendor who fills the soda machines in our building). This way, each group's work space is clearly defined and small parts don't get lost. Other tips and useful strategies are detailed in the project manual available from WIE.

After completing the activity, the teachers discuss how the activity might work in their classroom. Some of the topics we introduce are how technology activities fit into existing curricula; problems the teachers foresee in managing the activity; and gender equity issues introduced by the activity. For example, in every workshop we have done there has been a debate on using single sex groups. In these discussions we act as facilitators, giving the teachers a chance to benefit from the experiences of the other participants.

This activity is the least structured of the day. We let the needs of the participants and the other experiences of the day shape the direction of this activity, just as we hope the participating teachers will let their students dictate the shape of this activity in their classrooms. We do provide a few handouts to offer some guidance on possible directions for the exercise.

Problems and Solutions
Although one of our goals is to inform teachers of teaching strategies that educational researchers have identified as being effective in engaging girls in math and science, we also recognize the teachers participating in our workshops are themselves a resource for gender-equitable teaching strategies. One particular activity, adapted from an EQUALS activity, allows us to tap the experience of all our participants.

Teachers first write about and discuss the obstacles they perceive in their own school that keep girls from persisting in math and science. The teachers then write about and discuss strategies for overcoming the obstacles they have identified. After all the groups have presented their ideas, we present a handout on four gender-equitable teaching strategies: cooperative groups, pro-active classroom management, hands-on learning, and active career guidance in the classroom. We usually find that our participants have already identified all of our proposed teaching strategies as well as providing some other creative methods of interesting girls in math and science.

Outcomes and Lessons Learned

Evaluating the success of a program such as this is complex. While our ultimate goal is to improve the classroom climate for girls in our region, we did not have the resources to directly assess the classroom environments of the participating teachers. Instead, we used a number of methods of

indirect assessment. One way of assessing impact is simply through the number of teachers reached. Over two years, 32 elementary teachers participated in the workshops. Through these teachers, we could potentially affect the education of about 1000 children each year. But this number is meaningful only if we succeeded in changing the attitudes and behaviors of the participating teachers.

To assess changes in attitudes and behavior, we used both qualitative and quantitative methods of evaluation. We used the teachers' responses to some of the activities (Research Results, Images of Engineers, Technical Autobiographies, Problems and Solutions) to understand the teachers' existing belief systems and how they were changing. We used a qualitative, open-ended questionnaire to assess the teachers' reactions to the workshop series. Finally, we administered a quantitative, Likert-scale instrument at the beginning of each of the two workshops in the series to measure self-reported changes in teacher beliefs and behavior. These instruments revealed changes in teachers' attitudes and behaviors with respect to engineering, technology, and gender equity in the classroom.

Teachers' responses to the qualitative instruments indicated changes in their beliefs about engineering. Teachers were surprised to learn that communication skills were so important to engineers, and were also surprised that the women engineers we sampled downplayed superlative mathematical talent as a prerequisite for engineering. On the quantitative instrument, teachers reported they knew significantly more about engineering after completing the workshop series.

The experience of exploring machines helped many of the participating elementary teachers to confront, if not completely overcome, their fear of technology. In their comments, many of the teachers expressed gratitude for the opportunity to do the exploration they were afraid to take on alone. After their experience with exploring technology, the elementary teachers also showed significant changes in their beliefs about the difficulties of doing similar activities in the classroom.

The teachers also expressed a greater awareness of gender issues in the classroom and new understanding of their own biases in teaching girls. As one teacher put it, "My attitude and concept of the needs of female students has been enriched." These attitudinal changes were confirmed by our quantitative evaluation. At the end of the workshop series, the teachers indicated significant increases in their awareness of gender-equitable teaching strategies, and in their acknowledgement of the classroom climate as an impediment to girls in math and science.

Of course, not all of our results were positive. While almost all of the teachers gave the project favorable reviews, one noted that she had expected more ready-made units to take back to her classroom. We lost a few of the teachers through the school year, primarily because of scheduling problems. Because these teachers were not included in the end-of-workshop evaluations, our results may be artificially skewed in a positive direction. On balance, however, we feel the project was extremely successful.

The project hit some unexpected snags along the way. Our proposal called for us to collaborate with a large local school district on the project. Unfortunately, the administrator with whom we had made the collaborative agreement left the school district early in the first year of the workshops. Without an evangelist for our project within the school district, communication and cooperation broke down. We chose to operate the second year of workshops under the sponsorship of a regional science teachers association. Working with this organization gave us access to a well-established community of teachers active in educational reform, a very responsive audience for our message. It also meant that we could influence teachers from a wide geographic area. While this helped in the dissemination of the project, it also made it more difficult to evaluate the impact of the project than if we had chosen to work with a small school district.

One other major administrative snag appeared in the teacher collaboration component of the project. Because we had teachers from many school districts enrolled in the program, setting up contracts to pay for substitute teachers in each district was an administrative nightmare. Once the contracts were set up and teachers began to request substitutes, we discovered that many of the school districts could not supply substitute teachers. To their credit, most of the workshop participants collaborated with their partners, even if it meant doing so on their own time. While we still believe that teacher collaboration is an important aspect of educational reform, we are now rethinking how to achieve collaboration in this administrative environment.

Conclusion

This project offers a model for introducing elementary school teachers to engineering, gender-equitable teaching strategies, and exploration of everyday technology. By influencing teachers of young girls, we begin to change the classroom climate to one that rewards girls for their participation in math and science and that cultivates girls' interest in technology and engineering.

References

1. Becker, J.R. *Journal for Research in Mathematics Education* **12**, 40-53 (1981).
2. Galton, M. in *The Missing Half: Girls and Science Education* (ed. Kelly, A.) 180-191 (Manchester University Press, Manchester, 1981).
3. Kahle, J.B. & Lakes, M.K. *Journal of Research in Science Teaching* **20**, 131-140 (1983).
4. Kelly, A. in *Science for Girls?* (ed. Kelly, A.) 66-77 (Open University Press, Milton Keynes; Philadelphia, 1987).
5. Eccles, J.S. in *Gender and Thought: Psychological Perspectives* (eds. Crawford, M. & Gentry, M.) 36-58 (Springer-Verlag, New York, 1989).
6. Kahle, J.B. & Matyas, M.L. *Equitable science and mathematics education: a discrepancy model* (National Academy Press, Washington, D.C., 1987).

Appendix 6: Information for FIPSE

We want to share the following information with FIPSE:

K-12 WORKSHOP ISSUES

Teachers mentioned a variety of ideas, beliefs and attitudes we wish to pass on to you. We believe the following merit further consideration as others pursue similar research efforts.

1. In the workshops, teachers pointed out several times the need to include parents in efforts towards achieving gender-equitable education. They also stressed that the ever-pervasive, still-biased media also needs to be addressed. Both parents and the media are major influences on student attitudes, and teachers can not overcome these influences in their classrooms.

2. In the first year of the workshops, several of the 7-12th grade math teachers maintained that they had difficulty believing that there arefactors*other than lack of natural ability* keeping girls from pursuing math and science.

3. In general, we observed that secondary teachers felt the power to change the climate of their classrooms lay not within themselves but instead within their administrations. The elementary teachers, on the other hand, felt they did have the power to change the climate of their classrooms.

FIPSE BUDGET DISPERSION

4. We appreciated FIPSE's flexibility in shifting categories for many of our budget items. FIPSE responded to our changing programs in a way that let us give our participants the maximum benefit. For example, shifting money from funding substitute teachers to buying tools for teachers will help ensure that the teachers will continue to do how-things-work activities with their classes.

5. On the other hand, although we understand the limitations of Federal Guidelines in this respect, not being allowed to use any of the funds for food or beverages often made it difficult for us to offer what we felt were quality programs. We weren't comfortable offering day-long programs (such as workshops) without providing at least some minimal refreshments. We felt this was so important in making our programs seem professional that often food items were purchased or made personally by WIE staff.