

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 wrong¹⁻⁴. 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



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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 unforeseen 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.

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