

Women and Girls in Science

Who Are They? Where Are They?

Sundra Flansburg and Gay Gordon

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WEEA Equity Resource Center
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Executive Summary

The WEEA Equity Resource Center's EdEquity Dialogue with the Experts on women and girls in science (November-December 1999), facilitated by Gay Gordon of the Eisenhower National Clearinghouse for Mathematics and Science Education, brought a panel of six experts on issues for women and girls in science to converse on the issues from their different perspectives, as well as to dialogue with practitioners and other interested parties. The result was an intriguing and highly thoughtful exchange on ideas and strategies from the U.S. and around the world on the importance of increasing girls and women's representation and achievement in science, and the range of contributions that women have made and continue to make to science.

Touching both on the current situation for girls and women in science, the conversation identified some of the promising approaches and strategies, including all female programs that plan for moving girls toward cooperative integration and the importance of female role models who are studying and practicing science.

Strategizing around program issues, participants discussed the importance of considering sustainability of projects that are designed to spark and maintain girls' interest. Key elements identified in this aspect of program work include inclusion in school budgets rather than as a supplemental activity, evaluation that shows the effectiveness of the program, for-profit publishers recognition of successful projects, linking of local initiatives, parent and community participation, and a realistic acknowledgement of staff and volunteer time needed to maintain the work.

Another thread of the conversation centered around making visible women's contributions to science. Participants emphasized the need to consider how the practice of science should change to be not only accessible to women but also to interest and support them. Some of these include flexibility in entrance (allowing for women to enter the study of science and science-related careers at any stage of life) and changes to facilitate balancing professional and other demands. In addition, the need to focus the problems science addresses to ones important to the larger society and that benefit a wide range of people was mentioned. Using local knowledge in the teaching and practice of science surfaced as one way to both push this transformative approach and as an educational strategy to interest girls and young women, as well as other currently underrepresented populations.

The linking of theory and ideas with discussion of the daily issues of projects was a goal of this dialogue, and resulted in the identification a variety of resources available, the principal ones of which are listed in the appendix.

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Introduction

Gay Gordon

Recently, I attended the final day of a summer institute for 15 seventh-grade girls at which the girls presented their final projects. The institute was conducted by the Ohio Supercomputer Center for the purpose of interesting girls in science and engineering using a project-based learning framework and an environmental science project. Over 100 girls from all over Ohio applied for the 15 openings. During the week, they learned about point and non-point pollution and water quality; they went to a nearby creek and took water samples and did a macro-invertebrate study; working in teams, the participants chose a river site in Ohio and developed a hypothesis concerning its water quality; they learned how to collect and analyze data that they found on the Internet; they learned the basics of several software packages and how to create a web site; and they created final presentations on their projects, which they gave before a roomful of parents, staff, and faculty.

It was so exciting to watch what the girls had accomplished during the week that it gave me chills. It also made me pause and wonder how many of the talented girls I was watching would stay the course and become scientists or engineers. These girls were clearly interested in, even excited about what they were doing, but as we know from statistics gathered by NSF (National Science Foundation), it is likely that only a few of them will pursue an advanced degree. When do girls change their minds about mathematics, science, and engineering? Why do they change their minds? Where are their mentors? Is the science profession to blame? What can we do to encourage more girls to take the courses they need throughout their years of education in order to pursue such careers?

The participants in the WEEA Equity Resource Center's EDEQUITY Dialogue with the Experts in December 1999 discussed answers to these questions as they explored the topic of women in science. The panelists for the discussion, including myself, were the following:

- Gay Gordon, Associate Director for Publishing, Eisenhower National Clearinghouse for Mathematics and Science Education (Facilitator)
- Sophia Huyer, Executive Director, Women in Global Science and Technology (WIGSAT)
- Jasna Javanovic, Assistant Professor, Human and Community Development Department and the Women's Studies Program, University of Illinois—Urbana
- Mary Susan Lindee, Acting Graduate Chair, Department of History and Sociology of Science, University of Pennsylvania
- Jayshree Mehta, President, Once and Future Action Network
- Londa Schiebinger, Author, *Has Feminism Changed Science?*
- Mary Thompson, Author, *Scientist Within You*

The panelists pursued several discussion strands, which are reflected in this summary document. One strand examined education issues, particularly why most girls do not pursue advanced mathematics and science courses and what can be done to encourage them. A number of participants in the discussion described programs for girls with which they are involved. Another strand examined how women currently contribute to science and how they might change science by bringing a different perspective to scientific research. Panelists and participants offered various solutions to the problems raised during the course of the discussion, not the least of which was to raise awareness that a problem exists.

As I watched the girls at the summer institute, I reflected on this online discussion and wondered whether they will “opt in” or “opt out” of math, science, or engineering courses. Perhaps they will encounter some of the cultural biases mentioned by the panelists—a guidance counselor who says that girls don’t need to take physics or a relative who thinks science isn’t feminine—or perhaps their experience at the institute will be just what they need to spur their interest in science as a career. I think that most of the people who participated in the discussion believe that girls have more options today than they had before, but there is still much to be done.

The discussion identified a number of ideas and possible directions for that work, and we encourage you to join this ongoing conversation, and support and help promote some of the exciting initiatives currently happening. What follows is a summary of the online discussion, which also links many of the points raised to the global exchange that occurring around this issue. Though we have tried to convey the diversity and richness of this conversation, a summary is a summary, and we have been unable to depict all of the opinions and comments that formed a part of this exchange. We welcome comments and follow-up on this document, and strongly encourage you to subscribe to the EdEquity listserv (for instructions on how to do so, see the Conclusion) and become an active participant in exchanges around a series of gender equity issues.

Women and Girls in Science

Who Are They? Where Are They?

Girls' representation and performance in science education and careers has been a significant concern of the Women's Educational Equity Act (WEEA) Program from its early years, as well as an ongoing area of work for the educational equity and science communities at large. Why it should be important that girls be equally represented in elective science courses and in science-"dependent" careers has already been well established and agreed upon by a range of fields and societal sectors. Example of these reasons include the need to maintain open options for postsecondary education and for interesting and well-paying jobs. It is important that more women be active contributors to the fields of science and engineering, but it is also important to recognize that more and more nonscience professions and jobs require basic math and science skills. Fortunately, girls and women have made progress while boys and men continue to maintain a relatively strong showing. But much more can be done, and while we recognize advances we must also pay attention to areas for improvement, especially in terms of how gender differences and similarities play out across the diversities of race, ethnicity, socioeconomic class, disability, geographic location, and so on. It is when we begin to examine these dimensions of the problem that not only do we see boys' and girls', women's and men's strengths and weaknesses, but also how certain groups of girls and boys are "opting out" of science, often with unforeseen but nevertheless serious consequences.

In late November and early December 1999, the WEEA Equity Resource Center, in collaboration with the Eisenhower National Clearinghouse for Mathematics and Science Education, hosted an online discussion on the issue of women in science, with the goal of looking specifically at why girls and women are underrepresented in science education courses and, subsequently, in science-based careers. The interest in and timeliness of this conversation is evident in the fact that approximately 700 people subscribed to EdEquity specifically to participate in this discussion.

This compilation is designed to capture some of the important issues raised in this discussion, and to provide a basis for further exchange and strategizing on this topic. We will look both at some U.S.-specific concerns and programs and at some of the international frameworks and discussions that were mentioned, trying to illustrate some of the areas that were raised for exchange among regions, countries, and programs.

The Current Setting

Advances for girls and women have been achieved over the last three decades. For instance, as Facilitator Gay Gordon pointed out, in the United States

women are now enrolled in as many math and science classes in high school as men (with the exception of physics), the numbers of doctorates in science and engineering awarded

to women over a ten-year period are up by 69 percent, and the proportion of women receiving doctorates is also up. The AAUW finds that young women are majoring in math and science in college at a higher rate and that women earn equivalent or higher grades than males at all points in their academic careers.

But there is also continuing cause for concern. Panelists Sophia Huyer, executive director of Women in Global Science and Technology, and Jayshree Mehta, chair of the International Gender & Science & Technology Association, outlined some of the issues for girls and women internationally. Huyer quoted from a report issued by the gender panel at the World Conference on Science (Budapest, June-July 1999):

- In many countries, especially in Africa, there are fewer girls than boys that have access to primary education, and of those children that do have access, fewer girls than boys learn about science.
- In many countries fewer girls than boys study scientific and technological subjects in either secondary or tertiary education.
- In many countries fewer women than men pursue scientific or technological careers, and far fewer reach the top professional, managerial, or policy making positions. (UNESCO, 1999)

While some issues are different between countries, especially among poor, middle-, and high-income countries, or culturally according to gender roles and other factors, some concerns are relatively consistent, such as those raised at the World Conference on Science.

Identification of the reasons why students and workers opt in or opt out of science is one of the key focuses of much current research and discussion, a necessary grounding for establishing effective action plans and programs. In keeping with this, a major strand of the EdEquity discussion centered on education and the current problems associated with keeping girls interested in science beyond elementary school. When we look at specific fields and aspects of the problem, great gender disparities still exist. Overall, women hold only 31 percent of all Ph.D.'s awarded in the U.S. in science. Men hold more doctorates than women in all scientific fields except psychology. Clearly, something happens to discourage women from pursuing degrees in mathematics and science and conversely to encourage some groups of men to do so.

Researchers have investigated various aspects of this issue, and some of these findings were mentioned in the panelists' opening statements. According to Mehta, causes of some of this gender disparity globally include a lack of family and peer support, few or no female role models, teachers who are insensitive to gender issues, poor organization of science and technology curricula and content, inappropriate or uninteresting teaching methods, and lack of connection of material to girls' daily lives.

Gordon referred to a U.S.-based study by Iris Weiss (1993) indicating that many elementary and middle school teachers, who are mostly women, have negative personal histories and issues around science and math and may be passing them along to their students. Since many feel they are not adequately prepared to teach science, they lack

confidence in their ability to do so and, thus, may not be good role models in terms of modeling scientific interest for girls (or boys) who could benefit from this. In addition, Gordon noted, other studies show that boys and girls are treated differently in the classroom, with boys being called on more than girls, girls' contributions being overlooked, and so on.

Gordon also noted that middle school is the time during which girls are most likely to opt out of math and science for several reasons: they don't see science as feminine; they underestimate their abilities, and they lack self-confidence, role models, and encouragement to pursue a math or science career. Perhaps worst of all, there is no perception in most schools and communities that a problem exists. In case studies done in the U.S. following the Third International Mathematics and Science Study (TIMSS), researchers saw a clear gender gap in science and math in the high schools they studied, but the teachers, students, and parents in those schools did not (NCES, 2000).

Cultural Bias

Many problem areas concerning science education for girls and women are directly related to cultural biases, and participants in the discussion pointed out how culture around the world, including the U.S., makes it difficult for a woman to pursue a career in science.

Certain groups of women have been raised with the idea that they will marry and stay home to raise a family. In the U.S. and some other industrialized countries this was especially true among middle- and upper-class women over 40. Since there was no need to go to college other than to look for a suitable husband, university degrees were considered irrelevant. Certain jobs were acceptable for women, such as nurse, secretary, or teacher, but it was unacceptable for women to take jobs that men needed in order to support their families, such as doctor, lawyer, engineer, or scientist. This attitude is still seen around the world to a greater or lesser degree in certain social classes and cultures, making some question even the need for schooling of any kind for girls and women, much less science and math. Some of the participants in the dialogue mentioned continuing evidence of this type of barrier. For instance,

- Discouragement from family members who don't believe that science is a viable career for a woman
- The negative attitude toward women in engineering, as workers, as managers, and as supervisors
- The negative attitude of girls toward science
- Teachers' lack of comfort with science at the elementary level and the notion that science is messy
- Teachers' lack of sensitivity to gender issues and irrelevant and uninteresting teaching methods
- Lack of recognition by parents, teachers, students, and counselors that a problem exists

- The perception that girls have a lower aptitude for math and science, are incapable of rational thought, and are confused by emotionality and desire, and that they have no place in the field
- Lack of access in some parts of the world to basic education for girls and lack of access to science courses for the few that do go to school
- Technological changes that target tasks men perform, rather than tasks women perform, especially in the developing world
- Lack of connection of science to women's daily lives
- Sexual harassment in science and engineering education and careers

Solving the Problem: What We Know

Many possibilities for increasing girls' interest and achievement in science were mentioned, taken both from research and practice. For example, we already know some ways that teachers can make math and science class more interesting to females. Gordon provided the following list quoted from Sue V. Rosser (1997):

- Provide hands-on experience and practical applications
- Be sensitive to the applications and methods of experiments
- Use both qualitative and quantitative data
- Use an interdisciplinary approach
- De-emphasize competition
- Provide a broad, holistic scope of study
- Create collaborative groups or study groups
- Use female examples
- Include more history of science
- Create communities of learners

But while most of these techniques would create a better learning atmosphere for all students and would promote improved math and science learning overall, Gordon noted, that improved math and science teaching cannot make up for all the cultural pressures that girls face, including problems dubbed "the yuck factor" and "learned helplessness."

Critical Decision Points

There is evidence that middle school is a critical decision point in terms of whether girls go on to take optional math and science courses, keeping the doors open for a variety of postsecondary study and careers. Participants Bill Lamb and Ina Morgensen questioned this assumption, however, believing that the decision to opt out of science may develop over a period of time. Morgensen suggested that things would be different if girls had to take things apart and reassemble them and engage in more inquiry activities. Another participant, Marty Henry, seconds this based upon her experience with an early childhood magnet school in St. Louis where girls in grades pre-K–2 show enthusiasm and interest in math/science and problem solving by engaging in such activities. She believes that it may be necessary to target very young girls to retain their interest in math and science.

Panelist Mary Thompson observed that girls become more conscious of peer attitudes in fifth grade, which, based on current socialization, can be disastrous to retaining their interest in science. Based on her experience with the Partners in Science Program* she suggests that programs to interest girls in science should begin in elementary school and should contain several important elements, including the following:

- separation by sex with a move to cooperative integration while being mindful of interests and learning styles
- role models of both sexes from a variety of occupations
- involvement of community members
- partnering with institutions, agencies, and organizations
- involvement of parents
- training facilitators to achieve a student-centered climate
- begin by third grade, but no later than fourth grade, and create a positive and supportive environment
- encourage establishment of and participation in programs such as Girls, Inc., or Girl Scouts
- form partnerships between schools and community colleges with the objective of establishing mentoring programs, conferences, and other experiences

Participant Cerise Roth-Vinson, director of CyberSisters, a middle school mentoring program for girls, shared their work to involve all the people who influence girls' daily lives in their program. This includes parents, teachers, mentors, peers, and protégé(e)s. For instance, parents learn "not to justify their daughter's negative attitudes through statements such as 'That's okay if you're not doing well in math, I never did either.'" Girls face choices about their education in middle school and high school that are not present in elementary school. They have to decide to take advanced math and science classes, instead of doing what "everyone else" is. If, as Lamb posits, their elementary experience in math and science has not been good, and if, as Roth-Vinson suggests, their parents, peers, or others are supporting negative attitudes, then girls may opt out. And, Gordon added, once they have made such a decision, it is much less likely that they will undertake advanced math and science in college.

Single-Sex Classes

Participant Rosa Hemphill asked whether single-sex classes helped encourage young women to pursue careers in science. Hemphill pointed out that she has had chemistry classes that were predominantly female and found that there was greater camaraderie and sharing in the group activities than when the classes were more evenly split. She also noted that the all female class did not score as well on tests as the class that was predominantly young men, the latter of which she characterized as more competitive and more focused. In a U.S.-based study, the AAUW concluded that the value of single-sex education is disputed and "there is no evidence *in general* that single-sex education works or is better for girls than coeducation" (AAUW, 1998). Indeed, while some single-sex programs do seem to produce positive results for girls, this could easily be due to

* Please refer to the Appendix for additional information on the resources mentioned in this summary.

high-quality teaching and interesting approaches, which could have positive results in coeducational settings as well.

Role Models

If single-sex classes are not the answer to the dilemma of recruiting and retaining girls in science, what about role models? Many programs cited by participants had a role-model component, including Partners in Science and other programs in which Mary Thompson is involved; the CyberSisters program discussed by Roth-Vinson; the web site for the Women's College Coalition at Mt. Holyoke College described by Hemphill; and the Coalition for Women in Science, Mathematics, & Engineering at North Carolina State University described by Kristina Fowler. Lamb agreed that these kinds of programs can be very important, and a recent study by the National Academy of Engineering supports how crucial role models may be. The study, mentioned by Hemphill, found that lack of role models is one of the principal factors that discourage women from pursuing/remaining in engineering at the pre-college, college, and professional stages (Wasserman, 2000).

The Women in Science website (<http://library.thinkquest.org/20117/>) also promotes the idea that role models are important to inviting and sustaining girls' interest in science. Several interviews with women scientists note the lack of women role models in study and careers, as well as the women's strong belief that having had them would have helped them face some of the challenges. For instance, Meg Urry points out in her interview that

the hardest part of getting to where I am in my career today has been developing the confidence that there IS a role for me, for women, in science, and in overcoming the insidious training I have, as does any girl in our society, to be a quintessentially female: to be self-effacing, to avoid "bragging," to support others even at the expense of taking appropriate credit of oneself—all wonderful, polite things, but very much at odds with the dominant scientific culture today, at least in the U.S. Reading about successful women, especially in fields where they had to fight to establish their right to be there, was a great morale boost and a great support. Finding a few women ahead of me and more in my peer group and even more coming up behind, has been critical to me staying in astronomy.

Concretely, an activity suggested by one of the participants, Judith Abrahami-Einat, advisor on gender equity to the Israeli Ministry of Education, is to encourage young women to see themselves as potential scientists and ask UNESCO and UNIFEM to "prepare a series of posters with international representation of female scientists, with photos, names of professional interests, contributions, etc., so girls and women of all nations and races have a rich variety of role models and actually see images of women who have done it."

Among the energizing and encouraging aspects of the online discussion was the variety of ideas generated by participants on raising the level of awareness regarding women in

science. Huyer had numerous suggestions beginning with connecting the networks that exist and launching a campaign to highlight international role models. As a first step she suggests that a central listing of international women in science and technology organizations be included on the web as a resource for everyone concerned with this issue. Huyer noted that the World Conference on Science included a high percentage of the recommendations of the Gender Advisory Board in its Conference Framework and Declaration (UNESCO, 1999), including a recommendation for a global campaign in cooperation with UNESCO and UNIFEM to raise awareness of the contribution of women to science and technology.

Long-Term Progress and Sustainability of Programs

Many participants outlined programs that spark the interest of girls and maintain the interest of women in science. Lamb posed a critical question about such programs: “How can we keep them going for a sufficiently long period of time to effect the generational change that’s needed to evolve . . . society to the point where they are no longer needed?”

In the context of the U.S., both Gordon and Mary Thompson raised the importance of schools considering these programs (and appropriate curricula and other materials) as an integral part of their science programs. This could be shown, for example, by including these programs as a part of the school budget rather than expecting teacher stipends to cover them as “supplemental” materials. Gordon posited that “schools involved in reform efforts are the best place to look for long-term support for such programs. Why shouldn’t a mothers and daughters science club be a regular school program, like other enrichment programs.”

Thompson also believes that a critical source of support for innovative programs is publishers, “Innovative science and math grant-driven programs will start being implemented throughout the nation when they are packaged, marketed, and promoted by the major educational for-profit publishers.” She agreed that schools should support programs as a regular part of the curriculum and not as a supplemental or enrichment activity, and adds that publishers could help make this happen.

An important aid in sustainability is the linking together of local initiatives and programs. Along these lines, enthusiasm was shown for the creation of a comprehensive list of current programs at the international level. Roth-Vinson stated the importance of this even within the U.S.: “When I look for models, or I need to refer a girl who is moving to a new state to a program in her area, where do I look? One of the best things we can do here is to document these sources of information.”

Several other participants mentioned critical components of programs that are frequently missing and that could help with their sustainability. Meredith Thompson pointed out, and Fowler seconded, that programs often do not budget for an evaluation of their impact and effectiveness. Without this, it is difficult to demonstrate positive change and, thus, to win wide support for continuation.

An important issue surrounding sustainability is the “person” time needed to maintain efforts. Carol Muller noted that many “programs that help inspire girls and young women [do not] account fully for the time (=human resources=staff+volunteers) required.” Failing to account for the time required to make a program successful may give a false impression of the investment needed to sustain the program. This was seconded by Barbara Tavares who said that her groups always look at how time is accounted for in grant review meetings. Tavares noted that “education regard[s] a teacher’s day to be similar to a bottomless cup of coffee (you can keep pouring stuff in for no extra money), but I agree that [this] is why any demonstration project slowly comes to a halt after the funds end.”

One solution to the sustainability problem, described by Mary Thompson, comes from the Partners in Science Program. This program trains community members over the course of three years to work with students. They begin with a teacher, but eventually conduct the program on their own with the help of other community members. Partners in Science includes a range of science careers from flower arranging to nursery operator to botanist, and does not assume that all students will pursue one or more college degrees.

By providing information and contacts on-line, programs enlarge their reach and make them easier and more affordable to maintain. Along these lines, several of the participants mentioned Internet resources and programs. One is an online course for teachers designed to raise their level of awareness of gender issues in math and science provided by the WEEA Equity Resource Center and another is the CyberSister telementoring program. Information on the online course is available through the WEEA web site (<http://www.edc.org/WomensEquity>). The CyberSisters program provides for long-term communication between mentors and their protégées.

Additional Resources for Programs

Huyer shared some additional recommendations contained in the Gender Advisory Board’s World Conference on Science Framework and Declaration, including the following:

- Promote within the education system the access of girls and women to scientific education at all levels
- Improve conditions for recruitment, retention, and advancement in all fields of research
- Undertake research, supported by collection and analysis of gender disaggregated data, documenting constraints and progress in expanding the role of women in science and technology
- Monitor the implementation and document best practices and lessons learned through impact assessment and evaluations
- Continue to document the contributions of women in science technology (UNESCO, 1999)

Roth-Vinson noted that universities can provide a wealth of support for programs, but not necessarily of a monetary nature. She advocates for universities to collaborate in the following ways:

- Support role models through faculty recruitment of women in computers, science, math and engineering
- Provide free venues for meetings
- Provide free use of equipment such as computer labs
- Publicize campus tours led by college women (let girls see what a professor's office looks like, where a scientist might work, where a computer lab is located, and what an engineer's dorm room is like)
- Speak at mentor training workshops
- Sponsor girls in summer science camps

She encouraged people to ask universities for their numbers on entering vs. graduating women in these fields.

Fowler, at North Carolina State, described the group her campus has started, entitled the Coalition for Women in Mathematics, Science, and Engineering. According to Fowler, this coalition is a multidisciplinary team of advisors, administrators, faculty, staff, and students committed to “creating and sustaining through programmatic initiatives an environment of encouragement and success for women of all ages in science, mathematics, engineering, and related fields.”

Participant Joseph Bellina told of his involvement in organizing Teacher Science Institutes, summer workshops for elementary teachers, who often feel uncomfortable with science materials. These workshops help teachers learn to use the guided inquiry mode of instruction supported by state and national standards and convey to their students that science is something they can do.

Meredith Thompson, a researcher involved in a large-scale investigation of why women choose to stay in or leave engineering at the undergraduate level, suggested several outreach activities, including Girl Scout Badge days run by women engineering students through the Society of Women Engineers, summer camps for girls that bring girls into research labs, and various activities like straw bridge building that make engineering more accessible to all students.

In her contributions, Thompson also addressed recruitment and retention, two additional concerns. She suggested that engineering students come to college fairs or to high schools and talk to students, and that there be orientation programs in these areas for incoming college students. She also suggested that current students call prospective students to talk about their classes. To retain students, Thompson promoted the idea of learning centers or dorms that house engineers together, e-mail mentoring that pairs students with engineers in industry, mentoring of new college students by more advanced ones, special courses, and participation in engineering societies.

Challenges in Improving Outcomes for Girls and Women in Science

In both the international and U.S. arenas there are a range of challenges ahead regarding the participation and achievement of girls and women in science education and careers. On the one hand, the issue of unequal access is still a large issue. On the other is girls' and women's interest and motivation, and science's ability to open up to different experiences, perspectives, and agendas. In other words, it is not just about opening doors, but also looking at what is behind them—examining and changing the way that science is carried out and taught, even conceived.

Some of these transformative approaches to the issue were posed as challenges by panelists Mehta and Huyer. Mehta posed the following questions as challenges in the international arena:

- How do we make science, mathematics, and technology (SMT) education interesting to girls and relevant to their needs?
- How do we sensitize large numbers of teachers at the primary, secondary, and undergraduate levels?
- How do we include indigenous knowledge systems in the classrooms of which women are the custodians?
- What kind of SMT training modules can be developed that can be used in nonformal education that reaches women in rural areas. How can we create a basic SMT literacy?

Huyer added the following as specific challenges:

- How do we get to a critical mass of women engineers and scientists in developing countries to avoid “marginalization,” given the scarcity of resources and the poverty which push families to have their girls marry quickly or shorten their education?
- What are useful strategies for supporting women scientists and technologists in developing countries?
- What kinds of networking would best support women scientists in developing countries, and around which issues or goals? How can e-mail and other forms of networking be used?
- What activities can we suggest to support UNESCO's and UNIFEM's mandate from the World Conference on Science to launch national, regional, and global campaigns to raise awareness of the contribution of women to science and technology and to overcome existing gender stereotypes among scientists, policymakers, and the community at large?

Participant Christine Min Wotipka, a doctoral candidate at Stanford University's School of Education, asked “What are the possibilities for future action at the global level to include such transformative approaches to women in science that go beyond simply calling for women's equal access to what is essentially a man's science? I am certain that if any change is to occur, that it would be NGO [nongovernmental organization]-

inspired.” Her contribution underscores the need for many sectors to work collaboratively, highlighting the greater flexibility in many countries of private (often nonprofit) organizations.

A Transformative Approach

One way of seeing equal participation of women in science as benefiting science as a whole, and not just women, is to examine women’s actual and potential contributions to the field of science. As Huyer noted, the issue is now part of UNESCO’s and UNIFEM’s mandate. It has been raised by feminists and others engaged in equity work within this area, and involves efforts to increase the visibility of women who are in scientific fields, as well as identification of the ways that women’s contributions may be different to men’s and, thus, transformative. Within feminist critiques of science, issues such as the following have been raised: the objectivity-subjectivity dichotomy versus continuum; the myth of the autonomous “knower”; the ideology of science versus the practice of science; and so on. An important look has also been taken at who does science and how this affects science’s current structures and approaches. In addition to recognizing, as we have traditionally, that scientists are “well-educated,” we see that historically science has been practiced and, importantly, created by a small group of privileged males.

This issue was addressed during the on-line forum by several participants. For instance, Londa Schiebinger stated that “I think it is important to reverse our thinking and not ask how we can encourage the science profession to accept women, etc., but to ask what do women have to offer?” This perspective was echoed and further developed by Huyer, who recounted some of the discussion that was carried out within the UN Commission on Science and Technology for Development’s 1993 Gender Working Group:

There was a considerable amount of debate as to whether having more women in science would bring about a “different” science—which many of the advisors believed—or whether it was important to bring more women into science for equity reasons alone. In the end, the group as a whole officially accepted ... that having more women scientists in decision-making positions would lead to different research priorities and the development of different sorts of technology.

Even in this limited way, the group’s recommendations represent some important conceptual shifts. As Schiebinger states, “If the recommendations of the Gender working group on S & T for development were ever substantially implemented by national governments, the results would certainly be transformative!”

This transformative approach builds on the diverse experiences and perspectives that women (and especially women of color and others who have not traditionally participated in the definition and practice of science) bring to this field rather than working to erase or minimize these differences. And women, including those with feminist critiques of science, have already brought much. As scholar Sandra Harding has noted, “The destabilization of thought has often advanced understanding more effectively than

restabilization, and the feminist criticisms of science are a particularly fruitful example of an arena in which the categories of Western thought need destabilization” (1986, p. 245).

Contributions to the “Logistics” of Science

The ways mentioned in which women contribute to the field included both the logistical and theoretical. As an example of the former, Gordon asks “Should women change to meet the current demands of the science profession or should science change to help women solve the ‘three clock problem’ (balancing career, home, and partner’s career)?” Schiebinger makes the important point that this problem “is not a mother’s problem any more than it is a father’s problem. The problem is one for professionals and working parents more generally.” This issue, first raised in relation to women’s concerns, has a more general applicability. Much as experience has shown that, for instance, improving math and science instruction for girls has collaterally improved the instruction (and outcomes) for boys, addressing some of the issues now being raised as women’s issues would serve to make the profession more accessible to all kinds of scientists.

Gordon raised another point regarding the practice of science that could also have repercussions for other groups of people: “One of the assumptions that we too frequently make is that we’ve lost women to science (or any profession) if they don’t do it while they are young. As Londa [Schiebinger] asks, why not make . . . it possible for them to contribute in their own time frame.” Gordon suggested that women have the support to return to school and become scientists (or at least improve their science literacy) at any time. The model of scientist going straight through the educational system and taking a position immediately afterward appears to be a more typically white, middle-class, male pattern of entry. This is one way of navigating the process, but certainly not the only one. This question arises particularly with respect to women, since some women choose to devote themselves to family issues early in their adult life, and later continue their education.

But women are not the only ones who would benefit by welcoming people with different entry patterns. Rethinking this assumption also admits the more flexible education process required by those working class or lower middle class students who can attend university only part-time or who must alternate working full time with university in order to pay for their studies. Some students with physical disabilities may also need more flexible timeframes in order to deal with health issues simultaneously. In many cases, this would only mean scheduling evening classes to make it possible for people to work and go to school at the same time. Seeing the individuals who require this as less serious or talented than those who follow the more traditional route is unnecessarily limiting the pool of good, potential scientists.

Contextualizing the Field

There has historically been an ideology surrounding science, at least “pure” science, that has painted it as objective, timeless, and apolitical. What some women (as well as some men), especially those from the nonindustrialized countries, have been contributing to

discussions on science is the perspective that this field is historically, culturally, and socially situated. Those people who have traditionally participated in the field have perhaps not recognized this in part because they are part of this culture and share its perspective (or have learned to), and in part because of the “ideal” that is held up of what science is.

In addition, there has traditionally been an artificial division between “pure” scientific research and whatever its application might be in the real world. Many scientists have felt little responsibility for the possible uses to which the knowledge they produced was put. Having served for centuries mainly as “objects” of scientific investigations and applications, however, some women have brought a different perspective to scientific research, and parts of the women’s global movements, for instance around health, have pushed for an ethical science that is focused on human needs and situations and that serves the people who most need it. They argue that real world outcomes should be directly linked to decisions around what is studied and which questions are asked and have highlighted how military and profit priorities currently drive the areas in which supposedly apolitical science is focused. As Mariamne Whatley has commented,

Part of the problem is that science teachers don’t usually raise the issue that even ‘good’ science reflects the values of the scientist [and that] the very question asked in a research study can have political implications. It is essential to remind students that science, no matter how well it is done, can have political implications and that scientists have to take responsibility for what is done with this work. (1986, p. 188)

Though concerns like this have been raised by many as part of an ongoing re-examination of what science is and the ethical implications of science knowledge, women have played a large role in initiating and framing this discussion.

Participants in the online discussion raised several of these more theoretical contributions that women have and can make at various points throughout the forum. For instance, Mary Susan Lindee asked “if a model of science as a profession utterly outside the realm of normal life (for women) is a productive one?” This question is related to what feminist critics say is science’s often lack of concern with major societal problems, and its narrow and restrictive definition of who can produce knowledge. As Lindee adds, “One of the critical activities of science as a knowledge production system has been the exclusion of persons who, for whatever reason, were not interpreted as reliable witnesses to nature’s ways. . . . Women have long practiced science under conditions that mitigated and limited their ability to contribute visibly to the central activity of science, the creation of new knowledge for which individual credit could be claimed.”

Local Knowledge and Sustainable Human Development

One way of opening up the circle of “knowers” is to examine the whole issue of the role of local, or indigenous knowledge. This prompted an interesting exchange on the implications of considering local knowledge in scientific endeavors. The report issued by

the gender panel at the World Conference on Science noted that “technological change, especially that designed to improve the quality of life in rural areas in developing countries, has been more directed to the tasks that men perform than to the tasks women perform, both in and outside the household. Development programmes frequently have not taken this gender dimension into account.” On this issues, Lindee opined,

I personally think that focusing on women’s (and men’s) indigenous knowledge is potentially revolutionary: that is, requiring science to acknowledge, test, and refine (where necessary) indigenous approaches to agriculture, natural resources management, and health could substantially change the way science research is framed and implemented. To make it . . . more people oriented.

But simply focusing on local knowledge will not in and of itself bring about a people-centered science. As participants noted, women and men hold different kinds of local knowledge, and programs in the past have tended to focus on men’s local knowledge, or as María Fernández has observed, “Women, who are often visible in their own cultures and production systems, are becoming less and less visible as disconnected ‘bits’ of local—indigenous—knowledge are made known to the outside world. There is little or no reference to the differentiated role of men and women in the generation, transmission and use of knowledge” (1994).

There have been efforts recently to both include women’s local knowledge and to make it visible as gendered knowledge. Important international calls for this, as several participants mentioned, including Min Wotipka, were the “Declaration on Science and the Use of Scientific Knowledge” and the “Science Agenda, Framework for Action” developed from the World Conference on Science. Both of these documents explicitly state the need for inclusion of women’s local knowledge in scientific endeavors.

On an action note related to this topic, Mehta posed the challenge of “how to include indigenous knowledge systems in the classrooms of which women are the custodians.” Though time did not allow detailed strategizing around this challenge, a similar call has been raised in a general way in other forums. For instance, Kroma (1995) sees the incorporation of local knowledge in Third World science education as a way to make education relevant to students’ lives and therefor better interest them, and to begin composing a science education model that works for regions like Africa and does not simply reproduce imported models.

The incorporation of local knowledge obviously brings with it many responsibilities in terms of respect for these knowers and credit due participants in this process, as well as recognition that “scientific” knowing is not the only way of knowing nor inherently better in all situations. In relation to this, Sandra Harding observes,

All versions of the scientific world take science to be a totalizing theory; it has been assumed that anything and everything worth understanding can be explained or interpreted within the assumptions of modern science. Yet there is another world hidden from the consciousness of science . . . within which we all live most

of our waking and dreaming hours under constant threat of its increasing infusion by scientific rationality. Part of the project of feminism is to reveal the relationship between these two worlds—how each shapes and forms the other. (1986, p. 245)

Finally, Huyer noted that discussions on science reform at the international level are currently framed primarily in terms of sustainable human development. She posited that transformation of the current model might best be achieved by showing concrete examples of international problems (e.g., environmental degradation) that occur or worsen due to science's disregard of women's knowledge and practice, and by "demonstrating how women's approaches to science can contribute to sustainable development."

Conclusions

Sundra Flansburg

The Women and Girls in Science electronic dialogue clearly shows the eagerness with which teachers, parents, researchers, and activists share ideas, resources, and learning when given the opportunity. So many issues and questions were raised during this discussion that the WEEA Equity Resource Center and Eisenhower Clearinghouse decided to prepare this document as a way to capture some of the themes and to follow-up both in terms of further discussions and in sharing and acting on some of the specific recommendations.

Rather than collect the main themes here (see the Executive Summary for this), I would like to reflect on some of my reactions to the issues raised in this conversation and to the event in general. One of my first thoughts comes from having returned to the U.S. after living abroad for over six years, and observing again the curiously polemic way that conversations on gender are presented in this country. The media approach here, though there are a few important exceptions, poses gender issues as “wars” or “debates,” especially those related to gender. This is not to say that equity advocates do not run up against many hurdles elsewhere. They do, and continue to move forward in the face of extremely limited access to resources and strong opposition. Rather, what became clear to me during the course of this discussion, is that the vast majority of us care about all humans, male and female, and are hungry to exchange resources and learning to improve what is clearly an area in which girls and women still face limited possibilities and more burdens than boys and men, affecting outcomes by gender, as well as the continued development of science in its many forms. I can’t help thinking that the openness and eagerness shown during this dialogue was due not only to the high caliber of the panelists, but also to the number of practitioners and activists who were involved, and the emphasis on exchange of concrete and practical strategies in addition to ideas.

Science is also at what many conceive as a transition point, in which many aspects of the traditional way of envisioning and doing things are being questioned from within and without, including science’s role in knowledge production and recognition, its responsibility in addressing relevant societal and global problems, the current highly differentiated access people and whole societies have to the benefits of science, and so on. The 1999 World Conference on Science clearly demonstrated both the new issues being raised internationally and the exciting possibilities there are at this moment. Clearly, the field needs the participation and contributions of a wide range of people to face these challenges and move toward a more socially responsible field that recognizes and benefits the majority of the world’s inhabitants and honors and cares for the environment. The fact that more and more jobs require math and science skills, and entire nations’ economic futures depend on their ability to access, participate in, and contribute to scientific activities is important, but just one part of the picture.

It is also curious to me that many in my country tend to see the international arena of improving science education in terms of competition rather than collaboration. What was

invigorating about this electronic dialogue was the enthusiasm panelists and participants, U.S. and from other countries, showed to learn from each other's experiences, to share resources, and to explore questions that arose from these exchanges.

It is clear that the international arena is not just another business opportunity. It is a complex and challenging area in which we can learn from variety of experiences and perspectives, question our assumptions, and unite to address a problem that most countries and regions agree needs everyone's input. There is so much happening and being learned that opportunities to reflect and share with each other are increasingly important, and possible. As panelist Sopia Huyer said so well, "All of this goes to show that we have a lot to learn from each others' experience, in my view, and could all equally benefit from exchange of experiences, strategy and research between North and South."

The online discussion that is the focus of this summary was hosted by the WEEA Equity Resource Center, part of the Center for Education, Employment and Community, at Education Development Center, Inc., as part of the Educational Equity Discussion List (EdEquity). EdEquity is an international electronic discussion focusing on promoting educational equity in a multicultural context. To subscribe to this listserv, send the message "subscribe edequity" (no quotation marks and no subject line) to Majordomo@mail.edc.org. You can unsubscribe at any time.

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Appendix

Programs Described By Participants

American Association of University Women Educational Foundation

Grants are available to support gender equitable math/science/technology programs through the Community Action Grants and the Eleanor Roosevelt Teacher Fellowships.

American Association of University Women Educational Foundation

1111 Sixteenth Street, NW

Washington, DC 20036

Phone: (800) 326-AAUW

E-mail: foundation@aauw.org

<http://www.aauw.org/3000/felgrawa.html>

Coalition for Women in Mathematics, Science, and Engineering

The coalition is a multidisciplinary team of advisors, administrators, faculty, staff, and students at North Carolina State University committed to creating and sustaining an environment of encouragement and success for women of all ages in mathematics, science, engineering, and related fields.

Coalition for Women in Mathematics, Science, and Engineering

North Carolina State University

ADDRESS

Phone: (919) 515-5510

E-mail: kris_fowler@ncsu.edu

CyberSisters Mentor Program

CyberSisters is an educational telementoring program in science, math, and technology for middle school girls that pairs them one-on-one with college women mentors. The telementoring component provides a long-term form of communication between mentors and protégées and allows the program to reach rural and urban locations nationwide.

WESTIC CyberSisters Mentor Program

P.O. Box 1518

2300 Leo Harris Parkway

Eugene, OR 97440

Phone: (541) 346-3256

Fax: (541) 484-9027

E-mail: cybersisters@wistec.org

<http://www.cyber-sisters.org>

Eisenhower National Clearinghouse for Mathematics and Science Education (ENC)

A contract with the U.S. Department of Education, ENC identifies effective curriculum resources, creates high-quality professional development materials, and disseminates useful information and products to improve K-12 mathematics and science teaching and learning. An electronic catalog describing ENC's comprehensive collection of math and science resources is available online, as are its print and CD-ROM products. To search for materials in the collection on gender equity, including a number of items mentioned in the discussion, go to the search section and enter keywords gender and equity.

Eisenhower National Clearinghouse
Ohio State University
1929 Kenny Road
Columbus, OH 43210-1079
Phone: (800) 621-5785
Fax: (614) 292-2066
E-mail: web@enc.org
<http://www.enc.org>

Expanding Your Horizons in Science, Mathematics, and Engineering Conference

Expanding Your Horizon is a conference to encourage seventh grade girls to consider careers in science, mathematics or engineering. Over 500 girls, 70 teachers and 50 women scientists gather to learn about and do science.

Expanding Your Horizons Conference Coordinator
The Science House
NC State University
Box 8211
Raleigh, NC 27695-8211
Phone: (919) 515-6118
Fax: (919) 515-7545
E-mail: science_house@ncsu.edu
http://www.ncsu.edu:80/science_house/EYH_2000.html

Girlstart (formerly SmartGrrls)

Girlstart is a nonprofit organization dedicated to encouraging young women to reach their full potential. Girlstart offers hands-on programming in math, science and technology and is the founder of the first and Girls' Technology Center in Texas.

Girlstart
608 West 22nd St.
Austin, TX 78705
Phone: (512) 916-4775
Fax: (512) 916-4776
<http://www.girlstart.org/>

Oregon Youth Enrichment and TAG Programs

Youth Enrichment and Talented and Gifted Programs provides a wide variety of educational opportunities for students, parents, and educators including enrichment classes during the school year, summer day-camps, a two-week residential summer program, mentorships for girls interested in the sciences, special conferences designed to address issues of gender equity and more.

University of Oregon Youth Enrichment/TAG
Youth Enrichment and TAG Programs
College of Education
5259 University of Oregon
Eugene, OR 97403-5259
Phone: (541) 346-3084
Fax: (541) 346-3594
E-mail: tag@oregon.uoregon.edu
<http://interact.uoregon.edu/tag/index.html>

Partners in Science

A collaborative model that partners third- through eighth-grade students in hands-on science, mathematics, and engineering activities. The middle-school students serve as role models to the younger students. The programs brings girls together with a female teacher/facilitator in order to encourage them to stay in the math and science classes.

Dr. Margorie DeBuse
Youth Enrichment/TAG Programs
College of Education
5259 University of Oregon
Eugene, OR 97403
Phone: (541) 346-3084
E-mail: mdebuse@oregon.uoregon.edu

Teaching SMART

Teaching SMART, a program of Girls Incorporated® of Rapid City, South Dakota, is an equity-based, comprehensive three-year teacher professional development program designed to produce systemic change in the classroom by improving science education at the elementary school level. The mission of Teaching SMART is to encourage the performance and persistence of all students, particularly girls and minority youth, in elementary science. To achieve this end, Teaching SMART provides instruction and hands-on training for third through fifth grade teachers, which increase their awareness of and comfort level in using equitable, hands-on, inquiry, and exploration based approaches to teaching science.

Teaching SMART
1920 Plaza Boulevard
P.O. Box 2813
Rapid City, SD 57709

Phone: (800) 529-1400

Fax: (605) 342-0693

<http://www.teachingsmart.com/welcome.html>

WEEA Equity Resource Center

A national project funded through the U.S. Department of Education, the WEEA Equity Resource Center was established 1976. Currently, the WEEA Center has published over 300 titles on a range of gender equity issues and provides technical assistance the K-16 education community on such educational equity issues as sexual harassment, Title IX, accessing resources, and effective classroom practices.

WEEA Equity Resource Center
Education Development Center, Inc.
55 Chapel Street

Newton, MA 02458-1060

Phone: (617) 969-7100 / (800) 225-3088

Fax: 617-332-4318

E-mail: WEEActr@edc.org

<http://www.edc.org/WomensEquity/>

Women in Engineering Programs and Advocates Network (WEPAN)

WEPAN was established to effect a positive change in the engineering infrastructure conducive to the academic and professional development of women and men.

WEPAN Member Services
1284 CIVL Building, Room G167
West Lafayette, IN 47907-1284

Phone: (765) 494-5387

Fax: (765) 494-9152

E-mail: wiep@ecn.purdue.edu

<http://www.wepan.org/>

Women in Science

This is a highly awarded website with a number of resources useful for female scientists, teachers, and students. Includes an international registry for women in science, virtual field trips through science-related laboratories, a mentoring area a which you can contact a female scientist and ask questions about her work, transcriptions of interviews with women in science, and lesson plans for teachers.

<http://library.thinkquest.org/20117>

Women in Technology Project

The Women in Technology Project is a series of five-day summer technology camps for primarily middle school girls. Girls work with professional women in technical fields. They also have Girl Scout Computer Badge Days and serve rural areas with a telementoring project.

Women in Technology Project
Vermont Technical College
Randolph Center, VT 05061-0500
Phone: (802) 728-1510
E-mail: Cbrown@vtc.vsc.edu
<http://www.vtc.vsc.edu/wit>