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Advancing Women In Leadership

Gender Equity Models in Science Teaching and Learning Mirrored Structures, and Designs for Change Doris Ash, Ph.D.

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A video is presented by an educational researcher from UC Berkeley, and a large group of predominantly female teachers watches a series of vignettes featuring a variety of configurations of girls and boys doing small group math problem solving. They watch as one quiet young Asian girl in a mixed-gender group attempts to voice her opinion. She is continually swamped by opinions of louder and larger boys.

They watch as, later, other girls voice their uncertainties by saying things like: "I feel stupid". Throughout the showing of the vignettes there are frequent sighs by the teachers indicating their empathetic feelings. When the researcher states that one of her findings is that 'all female' groups spend more time collaborating and that females in general tend to express their uncertainty more, the teachers give a knowing laugh, as though they already know this and that, indeed, they have lived this particular experience.

Introduction

Over the past ten years research on gender equity in mathematics and science (Linn 1992, Klein, & Ortman, 1994, Kahle & Meece, 1994) indicates that although the gender gap is closing there is still much work to be done at many different levels. According to the September 2000 Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development's Land of Plenty Report: Diversity as America's Competitive Edge in Science, Engineering and Technology:

Despite the growing proportion of women in the workforce, the relative proportion of women in such fields as engineering, computer science, and physics lags far behind that of men.

Currently only 19% of the SET workforce is female despite significant improvement among girls in mathematics and science achievement and course taking over the

last 20 years. There are now only small differences between girls' and boys' science and mathematics scores on the National Assessment of Educational Progress (NAEP) tests, and girls are now taking the upper level mathematics and science courses required to enter SET college majors at the same rate as boys.

Although the ability and basic academic background needed to continue in SET careers exist for many girls, their interest in these careers is not maintained. Among SAT-takers, over three-fourths of students wishing to major in engineering and computer science are boys. The only science field attracting more girls than boys is the biological sciences.

By eighth grade, twice as many boys as girls (independent of race/ethnicity) show an interest in SET careers. (p. 26)

In this paper I develop a 'mirrored structures' model that applies to three NSF-funded gender and science projects aimed at improving girls' understanding, attitudes, and abilities in science, mathematics, and technology. All are concerned with the under-representation of women in science, math, and technology. All three facilitate girls' success at critical educational junctures particularly the middle/junior high transition where girls are lost to science. The three projects have developed rich and varied programs aimed at increasing understanding, confidence, and ability in the science, math, and technology for girls, and for their teachers, their parents, and administrators. The projects are different but share some common underlying elements and in many ways are typical of the multi-tiered gender equity programs across the country. Together the three programs offer powerful evidence for understanding systemic change within diverse geographies. All three programs share similar philosophies³—there are many different ways to achieve equity goals but it is essential that participants at all levels capitalize on existing strengths, their particular "ways of knowing". I argue that the 'mirrored structures' model cuts across all levels of participation within all three projects.

The projects, are: FIRST (Female Involvement in Real Science and Technology) in Oakland, California; The Voices project: Rural and Urban Images: Voices of Girls in Science Mathematics and Technology in rural Appalachia, West Virginia; and Girls Inc. of Lynn, Massachusetts's Operation SMART (Science Math and Relevant Technology). While the model offered in this paper was based originally on the FIRST project, it is applied to the Voices and Operation SMART programs.

Together they provide exemplars for examining systemic change because the programs emphasize not only the changes within the target audience, elementary and middle school girls, but also an expanded group of teachers, parents, and administrators within school districts that serve diverse student populations. By systemic change, I mean change at multiple levels of participation which can interact in both positive and negative ways. Change can be better understood by analysis of these relationships and by maximizing the positive interactions as leverage points.

Background on the three programs

FIRST

The model was originally developed within the FIRST project, a cost-effective design experiment for museum-led, school-based, inter-community agency collaboration¹. It provided a forum and a local urban laboratory in the form of a design experiment (Brown, 1992) that simultaneously introduced a series of innovations and studies their effects. The project provided a model for systemic change, working with elementary and middle school girls, their teachers, and administrators within the Oakland Unified School District (OUSD) a large urban district that serves a diverse student population.

The project included these major design features: 1) a program specifically aimed at reaching girls at the juncture between elementary and middle schools; 2) a discipline that has long attracted the largest proportion of women scientists³ biology³ using an environmental studies emphasis; 3) a project-based/inquiry format for all grade levels; 4) a community building component that emphasizes discourse and communication skills; and 5) multiple entry points for advancement of understanding for teachers, administrators, business and research mentors. Programmatic structural elements include classroom activities² for both boys and girls, after-school science clubs for girls, and specific leadership skills training for girls. FIRST also collaborated with local industry and business in order to link female scientist/mentors with Science Club and Leadership girls.

VOICES

The Voices Project³ focuses on the middle school juncture as a critical time to intervene so that girls do not become sorted out of mathematical and science tracks. The program focuses on the rural/urban split, particularly issues faced by rural girls living in poverty. The Voices progra was designed to look at "the ways rural and urban places can support and hinder girls' SM T education without taking the networks and experiences of advantaged girls as the norm" (Carter, Keys, & Kusimo, 1999, p. 4).

Voices tested a series of interventions to help girls do well and feel confident in science, mathematics, and technology. Designed to promote middle school girls' interest and achievement in science, mathematics, and technology, they had two project's two sites³ one rural and one urban. Programs included activities in science, math, and technology, mentoring, academic assistance, and an advocate network for families. They did not assume that girls raised in Appalachian cultures, whether rural or urban, are deficient either developmentally or with respect to SMT learning. Instead, they look to what these girls, their families, and communities can teach about girls' development and possibilities.

GIRLS Inc.

The Girls Incorporated of Lynn⁴, Massachusetts's Operation SMART program encouraged girls to persist in math and science and addressed issues of power, equity with students, parents, and their teachers. Operation SMART's programming provided girls with hands-on experiences and introduced them to careers in

science, math, and technology. It also provided training and support, curriculum guides and materials for teachers, and advanced professional development both in and out of the classroom. Girls. Inc. mission is to build girls' capacity for responsible and confident adulthood, economic independence, and personal fulfillment.

Major program goals include: working with girls on hands-on science with activities that are open-ended and risk free; allowing girls and their teachers to understand and change their stereotypes about science; helping girls, parents, and teachers understand that they can enjoy science; and that science is everywhere, in the lab, in the kitchen, and outdoors; and it is accessible to all, equally. These elements are combined in a variety of programs for a wide audience including schools, clubs, and other social organizations.

One unique feature of SMART programming is its inter-mixing of core program elements that, while focussing on inquiry in science, examine other aspects of gender identification, for example, using activities such as role playing and stereotype reflections. These subtle aspects of professionalism, when brought to the surface, help make conscious personal views about science. These activities helped sensitize teachers and promote an attitude shift that decreased fear of science for female teachers and helped male teachers to understand gender differences.

The proposed model

All three projects share common features, for example: they make efficient use of already available and tested materials, a variety of geographic locations, participant structures and personnel; they encourage all participants to test, to adapt, and to share ideas that fit within their philosophical and practical guidelines; they work with many different levels of expertise simultaneously; and they combine real life with science seamlessly. When examined from the perspective of levels of participation and the way in which participants were guided to increase their professionalism some underlying systemic patterns emerged.

The model outlined in Figure 1 captures these levels of participation and layers of professionalism. The model, designed first for the FIRST project, identifies three levels of participation—students, teachers/parent, and researchers and three layers of expertise—foundational, scaffolded, and leadership. The three layers of expertise reflect increasing ability to take on more sophisticated content and responsibility. They include:

Foundational—Provides the basic elements for examining science as part of the individual's life, as well as one's relationship to doing science, and thinking about it. This can include hands-on science activities, direct modeling of teaching techniques, and other direct communication techniques. Examples include modeling hands-on activities for students and teachers, talks by women scientists and architects, and trips to laboratories, colleges, or nature sites.

Scaffolded—Refers to the increasing abilities of learners as they are guided to

improve their mastery with experience. The scaffolding process begins with the 'learning leader' at first doing most of the cognitive work. This phase is followed by one in which the teacher and learner share responsibility. "Finally, the learner is able to perform independently." (Campione, Brown, Ferrara, & Bryant, 1984, p. 8). The 'scaffolding' is gradual, as the teacher maintains the interaction within the learner's zone of understanding. Examples across the programs include ongoing work with women mentors, including professionals such as architects, scientists, or the teachers themselves. As the mentor/student relationship continued over time, the students become more confident and independent in pursuing long-term goals, such as independent investigations, preparing for standardized tests, or simply increasing competence in activities not considered typical for girls.

Leadership ³Characterized by increasing ability of individuals at all levels advance toward novel situations with success and, having learned the principles of project, to mentor others and to reach wider audiences. Examples include classroom teachers becoming lead teachers in other schools and other districts, girls preparing to take pre-algebra in a hostile environment, and girls science club expanding to include school wide activities such as recycling.

Theoretical underpinnings

Vygotsky (1978) and the notion of the zone of proximal development (zpd), as well as the work of Newman, Griffin, and Cole (1989) provides the theory that informs this work. "A zone of proximal development is the region of activity that learners can navigate with aid from a supporting context, including but not limited to people. It defines the distance between current levels of comprehension and levels that can be accomplished in collaboration with people or powerful artifacts. The zone of proximal development embodies a concept of readiness to learn that emphasizes upper levels of competence" (Vygotsky, 1978; Brown et al., 1993). I argue that a reciprocal interaction occurs between the «teacher and learner» as they work together in the zpd so that so each is changed at all three levels of interaction. In short, both the «teacher» and the «learner» inform each other in substantive ways, so that the role teacher and the role learner become interchangeable. Working within the zpd, each acts as both teacher and learner in a mutual dance of appropriation of ideas and actions (Brown, Ash, Nakagawa, Gordon, Rutherford, & Campione, 1993).

Levels: Girls, teachers, and researchers

Level 1: The girls

"Math, math, math is cool. It makes us want to stay in school" chant the voices of a group of bright-eyed, smiling sixth graders. --Voices girls

It is well documented that, at about the junior high level (Orenstein, 1994), girls lose confidence in their abilities, even if they have heretofore displayed competence. Research on classroom experiences for girls has been extensive³in short summary, girls say less, do less, get less attention and are encouraged less frequently to speak up, to analyze or to think deeply³when they get older they

are less confident about their work, they spend more time checking it for accuracy, and they are more modest in speaking about their expertise (Linn, 1992; Sadker & Sadker, 1994).

Thus, the target audience is elementary/middle high girls who typically become lost to science and math before high school. The intent is to: encourage and model an early and successful interest in science, its tools and ways of thinking; to keep this interest alive and lively within the transition from elementary to middle school; and to help mentor girls in the transition to high school.

FIRST worked with girls grade 3 through 8 across elementary and middle schools within the same large urban district. Although originally intended for grade 5 and up, teachers in younger graders also insisted on being part of the program, suggesting that starting at younger grades might give a longer time to develop confidence and abilities.

The Voices project began with sixth grade girls of all interests and levels who came from two diverse environments, urban and rural. The comparison study did not take the urban experience as the 'standard', instead sought to identify the essential elements for success for rural girls. The girls were faced with distinct disadvantages that arose from a variety of sources including teachers, school policy (especially in relation to preparation for algebra), and general social conditions that afford success.

SMART worked with girls across a variety of ages in elementary through middle school and with a variety of formats. The emphasis was on working with students and their teachers simultaneously so that professionals can learn new teaching pedagogies by seeing them modeled by others, practice them and then reflect on that practice. The reflective environment with ongoing coaching fostered a collaborative community of teachers, students and parents.

Level 2: Their teachers and parents

"I feel like I should have been an engineer" "I wasn't encouraged to explore a variety of career areas, at home boys cut the grass, girls washed the dishes" "I was always interested in math and science and I wanted to be a scientist...I was encouraged to take liberal arts...I was told that's what females do..." -- FIRST teachers

Historically women have been perceived to play a minor role in the history of science. FIRST's elementary school teachers, more than 90% women, had interest in science but typically have little formal training. Many had been left out of the science and math track in their own educations and wished to: become part of the process of doing science; to learn along side the girls; and to foster and share their sense of excitement in making discoveries. In doing so these teachers illustrate (self-selected) professional development in science. Significantly, they also act as role models in the process of acquiring the skills and concepts and especially the confidence that comes with doing science successfully.

Girls in the US are behind boys on a variety of measures in science and this is

partially related to the differential teacher-student discourse in the classroom. Teachers have been described as more likely to encourage boys than girls to ask questions, make integrative comments, and to explain (Crowley, Callanan, Tenenbaum, & Allen, in press). Because research indicates that even teachers sensitized to gender issues typically favor white boys in the classroom (Sadker & Sadker, 1994) gender equity concerning discourse is a parallel professional development goal. Teachers often lack time and practice for reflection on their own practice, a necessary component for their pivotal role in counteracting the effects of gender bias with their students. Classroom practice is slow to change even in cases where this is an explicit goal—³even teachers who wish to make changes sometimes need help. Because gender and its relationship to science and math careers is not a major part of elementary school teacher training, FIRST's and SMART's professional development included—³in-depth examination of gender equity issues including summaries of current research studies, model classroom and club materials, activities and curricula, as well as work with science content and pedagogy.

The same can be said for the Voices project. All three programs simultaneously work with attitudes and long held feelings about what science is (only for white males, who have test tubes and are absent-minded) and who can be allowed to do it. This sensitivity training comes side by side with the day to day logistics of doing hands-on science. As one Smart director says: "The first hurdle you need to achieve is attitude shifts about who can do science, then participants can be concerned about the logistics of doing the actual activities" (J. Martin, personal communication, April, 2001).

The Voices program had a larger challenge in trying to engineer attitude shifts at school-wide and district levels, by working to change existing views of what girls can do, for example, take complex math. They needed to pave the way for advanced courses to be offered, as well as to encourage the girls to want to take them. The teachers were pivotal in this change, as they themselves were changed by the program. The parents were an integral part of all three projects but were especially so in Voices, where a vital component was advocating for family networks. In the rural mountain location, as a result of their work, the Voices program led to reinstatement of pre-algebra and algebra courses and increased enrollment in pre-algebra.

Primarily women in the FIRST and SMART projects, the administrators came from the ranks of teachers and share the desire for more science but view the problem of equity more globally. Their charge is to create a systemic view of equity science (and other subjects) and to disseminate this view throughout their school and their district. They look for efficient means for doing this while maximizing the structures that are already in place. They have also been the recipients of inequities in their own careers and seek to mentor teachers and students in their science efforts.

Level 3: The researchers

I felt that I was —too stupid to do math—³girls don't do that—[®] Ruth Cossey, Mathematics Educator, Mills College --Conversation with FIRST teachers

Because gender equity has not become a reality in spite of years of research and implementation efforts; because new and systemic programmatic efforts are necessary; because those planning for future equity require models that address these needs, in this paper the mirrored structures model help identify research agendas matched to these needs. Towards this end, FIRST's, Voices, and SMART's design efforts are directed at deep understanding of inequity patterns, then feeding that research directly back to the practice of equity education.

All women, the researchers for these projects, view their programs as models for creating and sustaining change. For example, research suggests that females (at many ages levels) express more uncertainty with their ability to do science even when their ability tests high. This is a dynamic that cuts across all educational levels—students, their teachers, administrators, and researchers. Such systemic undercurrents must be dealt with at many levels simultaneously. Thus while students gain confidence in their ability to learn science, teachers gain confidence in their ability to learn and teach science, administrators gain confidence in their ability to understand, and foster good science teaching for girls and researchers attempt to capture these cumulative and singular changes as they occur.

Similarly, it is important to understand more deeply the interconnected nature of changing attitudes about science and resultant change in practice. If stereotyping is unmasked and if past views are adjusted, does actual teaching practice change, or does it go deeper than that? These are the kinds of questions these researchers in the three programs grapple with daily.

The layers : Foundational, scaffolded, and leadership

The vertical dimension in [Figure 1](#) is the degree of advancement available for each level, the layers are foundational, scaffolded, and leadership. The foundational level includes the basic experiences, understandings, and ways of knowing that each level brings to the setting. For girls, their teachers and researchers the foundational level occurred during the classroom and field activities. Girls are an integral part of a complex classroom social learning environment replete with activities and structures. Teachers manage these complex environments, assess their students understandings and design complex classroom activities, and grow as professionals. Researchers watch the complex interaction between them. The classroom experience is the stepping stone for increased opportunities for advancement and leadership.

Scaffolded experiences allow participants entry into expanded opportunities to work with peers, teachers, parents, mentors, administrators, and researchers, all of whom act as scaffolding for increased expertise and engagement. This includes girls science clubs, field trips, camping, coaching, tutoring, summer camps, and many other forms of participation that are self selected, guided, female only, and open-ended. These activities give opportunity to practice scientific processes in a safe, comfortable environment. In clubs and science camps, girls encounter a variety of scientific concepts, processes, and ways of reasoning (along with their leaders), and importantly they witness modeling by successful women in science, with science mentors, and their own teachers leading the way. They have a chance to practice

using the thinking tools of science—the processes, such as predicting and hypothesizing as well as the physical tools, such as hammers and screwdrivers. Girls science club/camp/field activities help level the playing field for the girls using teachers, mentors, and administrators as well as materials, activities, camaraderie, and time as leverage agents.

For teachers, scaffolding occurred chiefly in peer settings, primarily in professional development sessions where science mentors and experts, new materials, and curricula, and most importantly, opportunities for self-reflection, provide multiple opportunities for growth. It is also important to tie professional development opportunities directly to classroom practice. SMART and FIRST programming for example typically asked teachers to reflect immediately after trying activities with children. In these sessions teachers were able to examine what just happened with a SMART/FIRST mentor to guide their examination. Over time these reflections led to changed practice.

The Leadership level allows seasoned participants to move to newer areas, to touch new audiences, and to disseminate their work. For the girls, the leadership experience occurs in mixed-age groups in summer training at local colleges, science jobs, field sites, or working with women professionals such as architecture. In the summer mixed-school, mixed-aged, and leadership training sessions, girls gain advanced skills in presentation, in athletics, and in ways of doing science, as well as career information. For teachers this entails working with larger audiences, other schools, national audiences—in short, opportunities to grow and to disseminate without the support of the peer group as offered in scaffolded settings.

The model in action

I argue that the three layers and the three levels—a 3 by 3 matrix that includes nine cells, each of which has distinctive characteristics—are inter-connected, much like a biological ecosystem. To some extent each feeds and retrieves information from the others in reciprocal fashion. For example, assessing girls' attitudes or learning at one level, the classroom or club for example, allows their teachers (administrators and researchers) to make parallel, related but personalized changes in their own work at their level of understanding. Teachers become more sensitive to gender issues and more able to reflect on their own practice, and with administrator support, practice changes slowly. Researchers find ever more interesting areas to explore within the design experiment as these changes occur.

For these reasons the model is described as mirrored because movement, both vertically and horizontally, is mirrored by the levels and layers. Below are three examples of interactions that begin to demonstrate these interconnections. One describes the interconnections between classroom activities and professional development, the second and third involve activities that cut across all levels of participation.

Examples of the model in action:

Example 1: FIRST—The classroom and professional development. Why women

can't be president!

At one urban elementary school site, 6th grade boys and girls spent a great deal of time creating a women's history dinner plate project, one that highlighted the role of women in history, especially women scientists, medical doctors, and mathematicians. In preparation for the dinner plate project the class had already had extensive discussions of what their life would be like if they happened to be born the opposite sex. Narrowly defined gender roles dominated these discussions and students' opinions were highly charged. The teachers who led the plate project were surprised and informed by these comments. These activities acted as a formative assessment of students' attitudes and in turn directly affected teacher practice. Teachers designed the plate project, in part, to change views of women's abilities over time.

As a result of these discussions, the dinner plate project was designed so that each student became an expert on one woman's career and subsequently explained that particular woman's role in history, artistically, in written form and orally to an assembled audience of parents, other students, and friends at a specially planned evening event. Later, the teacher who organized this event used this as the focus for one of FIRST's professional development sessions. The idea spread to another school, this time using the "if I were born a--opposite sex" for third and fourth grades. Third graders confirmed the same views of gender stereotyping observed in the first school and both teachers in the second school, in turn, were informed and surprised. In the third grade, students were convinced that a woman could not become president because there never had been one before. They argued: "if women could be president why hadn't there been one already?"³ there was no existence proof. Needless to say these discussion at younger grade levels also eventuated with their teachers designing a series of follow-up activities, similar to those of the sixth grade students, designed to highlight the role of women in the sciences. These activities are now following into a second year for younger and older students in both schools.

Example 2: FIRST & SMART³ Clubs, leadership, and professional development leveling the playing field

In FIRST and SMART, both the science clubs and the summer leadership training involve a mixed age group of girls. Throughout the clubs⁵ and camps the girls, their teachers, and aides, sometimes their parents, their mentors and science buddies, together, explored a wide variety of science areas, some working towards a long-term, school-based, environmental project. During summer leadership training mixed age groups from many schools along with their school site liaison person (a parent, teacher, or aide), enjoyed in-depth training in the life sciences, athletics, career explorations, and presentation skills.

In both clubs, camps, and leadership settings, girls learned new skills and gained confidence in their ability to do science, but so too do their mentors, aides, teachers, administrators, and parents. For example, in FIRST's summer leadership cadre, while girls dissected and identified the reproductive parts of a flower, their supporting adults (parents, aunts, or teachers aides, etc.) did the same thing and

in the process, they too felt the thrill of science as a "way of knowing". Adults and children gained in expertise simultaneously so that accomplishment passes between and across ages reciprocally. All the attending females, to some extent, gained ground while undertaking the same activity and while using the same materials, for example, a microscope. Adults re-captured what had been left out in their science training and gained confidence in the role of life-long learner while, simultaneously acting as support for the girls. The women of many ages, all of whom entered the summer training with different backgrounds and expectations, advanced according to their particular need.

Among Operation SMART's goals are to guide participants to be more reflective about themselves as learners, to be learners of science in a different way; and for teachers to apply this information to their work with kids. Parallel (for teachers and for students simultaneously) changes along these lines were evident as part of SMART summer camp training. After modeling lessons with the students, teachers and SMART trainers spent time reflecting on the experience. These reflections revealed profound changes by the teachers and students. For example a fifth grade student had been heard to say: "I'm going to do that experiment next week for the whole class", while a teacher discussed ways to pass on the information to other teachers by swapping classrooms temporarily. One teacher said: "I really liked the role modeling component of the Operation SMART training. I'm a visual learner, so I learn and retain things much better by watching them than by reading. Also, I probably wouldn't have believed that these activities would work with kids if I hadn't seen them in action."

Similarly the Director of the school program said: "At the head teachers meeting J. was full of ideas and enthusiasm about the things that she's been doing during the week that you've been here. We were discussing various methods for passing on the information to the other teachers. We will probably have some of the teachers, that you've trained swap classes for a day, every so often, so the other kids can benefit from Operation SMART. We may also try different combinations of team teaching. We'd also like to have an Operation SMART day some time during the summer so that other staff and kids can become as excited as the three who have been trained this week."

It seems that activities of this nature 'level or flatten the playing field' for female science learners. Each level of participant grew in learning, but on a different trajectory—³the students as first-time to science participant, the teacher and parent as long left out of science participant.

I consider this professional development⁶ according to adapted needs. These insights lead researchers to explore further how leadership can be developed and encouraged for all levels of participants in a variety of ways because:

—³science ability and materials are scarce for all women

—³certain activities act as gatekeepers to further science for females

—³across-age experiences can be powerful motivators for advancement

Example 3: Changing voices³ Changing expectations: Equal access to mathematics

The Voices program had far reaching impact across the rural community over its three years, especially regarding changing societal norms about expectations for their girls. Voice had more success in the rural mountain setting than in the urban river setting. Within the Mountain community there had been a general malaise of mind regarding what the girls might be able to do. The assumption was: 'We can't expect too much of our students, given their background and lives at home', as a result children 'get by' because "low expectations permeate the system³—they structure educational opportunity without being overt enough to challenge" Carter et al., 1999, p. 11).

Voices did make substantive changes in the way math is seen as a gatekeeper to high school. Because of their ongoing support at many different levels, the Voices girls were able to take pre-algebra, to take the test that had limited their entry, and most importantly change the structure of the school that heretofore had not seen this as a necessity. To do so they needed to gather support at many levels. The girls needed to "want to take algebra" i.e. to see themselves as successful. The teachers had to see the importance and to help change the status quo. As part of this process of change, it seems that teacher mentors learned as much as the girls. Voices " may have had more powerful impacts on the mentors than on the girls they mentored. Because so many of them (mentors) were teachers and not science and math specialists, they had to seek ways to increase the girls' awareness of science and technology in nearby workplaces. In the process the mentors themselves learned a lot about the use of science and mathematics in jobs not usually scientific³—lessons that many took back to their classrooms to share with their students" (Carter et al., 1999, p. 20).

Most importantly, the families had to learn how to be better advocates for their daughters "Voices families got access to information about college, financial aid programs, scholarships and other opportunities...they also learned ways that they can make their voices heard in schools and (to) question sexist and economically elitist policies and procedures. One mother got her GED so that she could better support her daughter. ³— A number of families invested in computers for their girls and themselves" (Carter et al., 1999, p. 17)

Discussion

I have proposed a design model for studying systemic change in relation to gender equity in science for elementary and middle schools girls. This model posits important interconnections across levels of participation (girls, teachers, administrators, and researchers) as well as between the layers of expertise³ foundational, scaffolded, and leadership. Although only a beginning analysis, the model has allowed re-definition of several important components of systemic change in three NSF funded programs across the United States. Specifically, first, it encourages focussing on the interactions between student attitude and expertise in science with similar components of teacher professional development; and second, it identifies the equalizing effect across age and science knowledge for females while taking

part in gender/science activities.

By assessing their own and their children's existing ideas about gender roles, teachers, parents, mentors, and researchers became more sensitive, more informed, more concerned and more able to design future activities for their students and for research that might begin to ameliorate gender biases. Partially as a result of these projects, girls, teachers, parents and administrators began to take charge of their own inquiry into gender matters, to grow and to learn, to teach each other and to "step up" into gender/equity issues as models for their own schools and communities.

And as teachers indicate, gender work spills over and becomes part of the rest of the curriculum and the entire school day. Instead of being a part of one day, equity becomes part of every day³ "a way of life", in one teacher's words. Thus there appears to be linked and interconnected change between student attitude and learning and teacher professional development in relation to science content, pedagogy, and equity sensitivity.

Last, there is need for re-definition of the meaning for the phrase professional development, since the experience of these three projects has shown us that this may occur at many levels simultaneously from students to researchers. Working professional women, students administrators, university researchers, mother volunteers, as well as teaching professionals grow in awareness and ability to act upon equity issues and science within their own contexts. This is not a 'one size fits all' model, instead it a 'design your own' professional development model. The implication is that we need to look across groups, not just at teachers³ but to look at teachers and students in relation to each other and in relation to administrators and researchers, in a more systematic way.

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Footnotes

1FIRST is a museum-district collaboration overseen by the Chabot Observatory and Science Center in Oakland, with Mills College, the University of California, Berkeley, the East Bay Association of Women in Science, and the Oakland Museum.

2Classroom design features are meant to enhance all learners opportunities- specifically by emphasizing FCL (Fostering a Community of Learners; Brown & Campione, 1994; 1995) principles.

3The Voices Project is conducted by the Appalchia Educational Laboratory in West Virginia.

4A local affiliate of the national organization, Girls Incorporated, formerly Girls Club

of America, has been operating programs for girls since 1942.

5 Activities range from electronic appliance or owl pellet dissection to visits to local science centers such as the Exploratorium for behind the scenes tours, to visits by local female scientists and engineers

6 Professional development is defined more broadly for the multiple levels of participants including students, teachers, administrators, parents, and researchers.

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Figure 1. Mirrored Structures

	Levels		
Layers	Girls	Teachers/Parents	Reasearchers
Foundational	Classroom Field Activities	Classroom Teaching Ongoing Reflection	Classroom Design Ongoing Reflection
Scaffolded	Science Clubs Field Activities	Professor Development Clubs, Classrooms	Professor Development Design
Leadership	Summer Camps Mixed-ages Mixed-school	Across Schools Dissemination	Dissimination Across States (Ash 2001)

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