Science, Gender, and Afterschool

A RESEARCH-ACTION AGENDA

EEC
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Educational Equity Concepts, Inc. (EEC) is a national nonprofit organization, founded in 1982, which develops innovative programs and materials to provide equality of opportunity in schools and afterschool settings, starting in early childhood. EEC understands gender, race, ethnicity, disability, and poverty to be interrelated aspects of bias that limit the potential of all children. By working proactively with educators, parents, and the general public, EEC addresses equity in the broadest possible terms. EEC conducts research, creates programs and materials, and offers workshops and leadership institutes to challenge current attitudes and practices. Most recently, EEC developed *After-School Science PLUS: Hands-on Activities for Every Student*; *Playtime is Science: An Equity-Based Parent/Child Science Program*; and *Quit it! A Teacher's Guide on Teasing and Bullying for Use with Students in Grades K-3*. In 2000, EEC joined the New York office of AED to form the Educational Equity Center at AED. For more information about EEC, go to *www.edequity.org*.

The **Academy for Educational Development, Inc.** (AED) is an independent, nonprofit organization committed to addressing human development needs in the United States and throughout the world. The AED Center for School and Community Services uses multidisciplinary approaches to address critical issues in education, health, and youth development. The center provides technical assistance to strengthen schools, school districts, and community-based organizations. It conducts evaluations of school and community programs while striving to provide the skills and impetus for practitioners to undertake ongoing assessment and improvement. The center also manages large-scale initiatives to strengthen practitioner networks and accelerate systems change. AED is headquartered in Washington, DC and has offices in 167 countries and cities around the world and throughout the United States. The Center for School and Community Services is located in AED's office in New York City. For more information about the center, go to *www.aed.org/scs*.

Acknowledgments

The Science, Gender, and Afterschool (SGA) conference was a true collaborative effort, and we wish to thank the many people who contributed their ideas, expertise, and resources to the process.

We first want to thank the National Science Foundation for its support of the conference and this report. In particular, we are grateful to Dr. Ruta Sevo who, in a conversation over lunch, encouraged us to pursue our idea for a conference to bring together the issues of science, gender, and afterschool. And we extend our deepest appreciation to our program officer, Dr. Margrete (Gretchen) Klein, for her support and encouragement throughout the planning stage and for her attendance and input during the conference.

SGA was an invitational, working conference and we are grateful to the advisory committee for its extraordinary participation throughout every phase of the planning and development. Advisory committee members lent their expertise to the preconference summary, *What We Know about Girls, STEM*, and *Afterschool Programs*, helped develop the conference agenda, and commented extensively on this report (see appendices for list of committee members). We also thank conference invitees who contributed their thoughts before, during, and after the conference. Even those who could not attend took time to lend their expertise to conference documents.

The SGA conference was greatly enhanced by the collaboration of the American Association for the Advancement of Science (AAAS). Dr. Shirley Malcom, director, and Dr. Yolanda S. George, deputy director and program director, Directorate of Education and Human Resources, provided names of potential participants, served on the advisory committee, and made major contributions to the program. In addition, AAAS provided space for planning meetings and co-hosted the conference at its headquarters in Washington, DC. We also want to express our appreciation to Senayt Assefa for her able assistance in facilitating logistics during the planning meetings and the conference.

We extend a special thank you to Eliana Orellana, EEC administrative assistant, for her excellent work in conference coordination. Because of her careful attention to detail, the SGA conference went smoothly from start to finish.

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Introduction

This report presents a research-action agenda to enhance the role of afterschool education in increasing girls' participation in science, technology, engineering, and mathematics (STEM) courses, majors, and careers. The agenda arose from discussions during the Science, Gender, and Afterschool Conference, which took place in Washington, D.C. in September 2002. The conference was funded by the National Science Foundation's Program for Gender Equity and sponsored by Educational Equity Concepts (EEC), the American Association for the Advancement of Science (AAAS), and the Academy for Educational Development (AED). Thirty-nine individuals with expertise in science, gender equity, and afterschool education attended the conference, an invitational working meeting held at AAAS headquarters.

In preparation for the conference, Cheri Fancsali, AED program officer, developed a summary of the literature, *What We Know about Girls, STEM, and Afterschool Programs*. An advisory committee of practitioners, policymakers, and researchers in the field commented on this summary and participated in planning the one- and one-half day agenda. (See appendices for a list of advisory committee members, conference participants, and an agenda.)

The conference's goal was to determine research areas and questions, the findings of which could help advance girls' STEM participation and achievement.

Four key afterschool issues were addressed:

* **Access, recruitment, and persistence**
* **Program content, approaches, and strategies**
* **Professional development and retention of staff**
* **Connecting school and afterschool**

The conference opened with a dialogue between Jane Quinn, assistant executive director for community schools, Children's Aid Society, and Yolanda George, deputy director, Directorate for Education and Human Resources, AAAS. They addressed two key questions: "What do we know from research and experience about what constitutes high-quality afterschool programming?" and "What is the quality of the research base regarding girls' interest and participation in STEM?"

A panel discussion followed the dialogue, with Donna Walker James, senior program associate, American Youth Policy Forum; Eric Jolly, senior scientist and vice president, Educational Development Center; Phyllis Katz, director of research and special projects, Hands On Science Outreach; Alejandra León-Castella, executive director, Fundación CIENTRIC; and Heather Johnston Nicholson, director of research, Girls Incorporated. Panelists addressed a key research question: "How can we use available research to inform program development?"

On the second day, after a plenary session in which DeAnna Banks Beane, director of Partnerships for Learning, Association of Science-Technology Centers, and Ellen Wahl, director of youth and family programs and community outreach, American Museum of Natural History, summarized the opening sessions, participants met in small groups for guided discussions on each of the four major issues. A draft research-action agenda was reported out in the final plenary session.

Overview of Major Issues

The major topics covered in the opening dialogue and panel discussion included the challenges of evaluating afterschool programs; the increased focus on afterschool; the importance of enrichment; the "fit" between science and afterschool; capacity building in the field; what we know from the research; the need to change perceptions of science and "how science is done"; and labor market issues. The discussion in this overview has been enriched by written comments contributed by participants and others who were invited to the conference but were unable to attend.

The Challenges of Evaluating Afterschool Programs

The challenges of evaluating afterschool programs involve both the voluntary nature of afterschool on the part of participants and the enormous variety of afterschool programming. Cheri Fancsali summarized four major afterschool evaluation challenges in her remarks during the panel discussion:

* Keeping track of participants for a long enough time to evaluate
* Developing instruments sensitive enough to measure program outcomes and determine if changes in youth attitudes, behaviors, and knowledge result from exposure to the program or other factors such as school and home environments
* Establishing an appropriate comparison group
* Finding resources for evaluation [Crane et al. (1994); Fashola (1998)]

Yolanda George elaborated on the great variety of afterschool programs as a central challenge to research in the field. This diversity can include location, sponsorship, schedule, and, most important, goals, philosophy, and content. Afterschool programs may be linked to schools, museums, or youth development and community-based organizations; they may be clubs or affiliates of national youth-serving organizations like the Girl Scouts, Girls Incorporated, the YM/WCAs, or the Boys and Girls Clubs, to name a few. Programs may be chiefly recreational or have a specific program focus or be somewhere along the spectrum between "informal" and "formal" in terms of content and scheduling. Nor does "afterschool" education take place only at the end of the school day: the broader field of informal education includes Saturday and summer programs, community service and service-learning programs, precollege and pipeline programs, and religious and cultural education programs, among many others.

The Increasing Focus on Afterschool

Jane Quinn emphasized the growing awareness by both policymakers and the public of the crucial importance of afterschool programs:

> *More and more afterschool is seen as a unique opportunity to get the developmental supports needed to reduce young people's risk-taking behavior and provide academic enrichment and support.*

Such awareness is in stark contrast to attitudes 10 years ago when the Carnegie Council on Adolescent Development published *A Matter of Time: Risk and Opportunity in the Non-school Hours*. At that time, according to Quinn, there was "little understanding of the issues among the public and policymakers alike," and it was a challenge "to get that set of issues on the policy radar screen."

Expanding research on afterschool has played an important role in increasing public awareness of its importance. Quinn cited both new research in the field, including studies by Milbrey McLaughlin and Jacquelynne Eccles, as well as research of those who have done "excellent work in these vineyards for years," such as Patricia B. Campbell, Beatriz Chu Clewell, and Deborah Vandell.

Quinn also cited significant evaluations of afterschool programs, including the National Research Council's study of youth development programs (Eccles & Gootman, 2002); the Policy Study Associates' evaluation of the first three years of afterschool programming supported by TASC (The After-School Corporation) in New York City (2003); Mathematica Policy Research's evaluation of the 21st Century Community Learning Center's learning programs (Dynarski et al., 2003); AED's evaluations of the New York City Beacons Initiative (Warren et al., 2002) and the New Jersey School-Based Youth Services Program (Warren & Fancsali, 2000); evaluations conducted by Public/Private Ventures (P/PV) and Manpower Development Research Corporation of afterschool programs for the Wallace-Readers Digest Fund (Grossman et al., 2002); and P/PV's evaluation of the San Francisco Beacons (Walker & Arbreton, 2001).

The Importance of Enrichment

Beginning in the opening dialogue and continuing throughout the conference, participants discussed the nature and importance of enrichment. Jane Quinn described three qualities of true enrichment: exposure to new ideas, hands-on experience, and motivation:

> *We know from all the evaluations of afterschool programs and of STEM afterschool programs that there is no substitute for hands-on experience . . . and we know that motivation makes a huge difference. So, if we have those ingredients, I think we're doing something totally different from remediation.*

Not that there is no need for remediation, Quinn noted. Some youth clearly need remediation, but "all youth need enrichment." Phyllis Katz agreed that some children do need remediation:

> *I would love to be idealistic about enrichment . . . but some children need more time for practicing school skills, or for obtaining help—or even remediation. If some programs fill those needs, I don't want to dismiss them out of hand. Perhaps our research will show how we can enrich and make up skills deficits.*

Many participants agreed with Ellen Wahl that much of the afterschool time spent on reading and mathematics remediation could be spent on informal science and math enrichment that "introduces kids to big ideas, concepts, methods, inquiries."

The Fit between Science and Afterschool

The characteristics of afterschool programs make them promising sites for addressing girls' STEM participation. According to Phyllis Katz, recent research in play theory leads directly to the conclusion that "science and afterschool (especially if we mean the more general 'informal learning') are well-matched." That is, the experiential/hands-on, informal learning and "play" epitomizing the best of science teaching both engage young people and foster a constructivist approach to knowledge and life-long learning; these characteristics make STEM activities ideal for the afterschool setting. Conversely, the informal setting and schedule of many afterschool programs, the freedom from prescribed curricula and tests, the close ties between staff and young people, and the fact that many afterschool programs are embedded in the community make them ideal for STEM projects and activities. Alejandra León-Castella maintained:

> *We know the importance of out-of-school opportunities to try out science, outside of the usual pressure from peer and school expectations. Growing girls, and many boys too, need to "thicken their skin" and try out different options.*

Further, given increasing evidence that "once in, girls persist" at science and mathematics on the K-12 level, a major challenge for the field is to determine what afterschool STEM programs can do to foster better articulation and STEM access for girls and young women on the postsecondary level to help girls choose STEM majors in college and see themselves as people who can "do science." As Beatriz Chu Clewell, principal research associate, Education Policy Center, the Urban Institute, stated:

> *The schools are doing a much better job of getting girls to take higher level math and science courses and performing well in these subjects. But they are not doing a good job of sustaining girls' interest in STEM careers at the postsecondary level where a lot of the drop-off occurs. Afterschool programs have the potential to keep interest going. Additionally, early afterschool programs have the potential to awaken the interest of very young girls in the physical sciences.*

Capacity Building in the Field

Yolanda George cited major issues in building the capacity of afterschool programs to deliver high-quality programming: curricula, staffing, and professional development. Specifically, given the difficulty of recruiting and retaining high-quality staff because of poor working conditions and low compensation, the development, dissemination, and use of high-quality curricula for afterschool programs are vital. George described herself as becoming a proponent of curricula "through the school of hard knocks":

> *I am not going to wait for the millennium when we really have a well-paid workforce. I'm working on it but I don't see it happening in the near future. If we're working with people who love kids, and who care about kids. I think we have to support them with excellent program content.*

Another way to build afterschool capacity in STEM areas is to link schools and community-based organizations (CBOs) with science-rich institutions.

In terms of staffing and professional development, Cecily Selby, independent scholar, maintained that the key issue is staff attitudes—that staff must understand both that girls can do science and that diversity is important to STEM fields:

> *As a scientist and science educator, I find that the primary quality that STEM staff need is attitudinal. The STEM fields serve society best if different perspectives (girls and boys, all races, etc.) are involved. The message to infuse in professional development is that differences add value to science.*

The Importance of Outcomes: What We Know from the Research

In the opening dialogue, Jane Quinn summarized what we have learned from 20 years of research on what constitutes high quality in afterschool programs and the components that foster girls' interest and build confidence in science.[1] She specifically cited the research of Deborah Vandell (1999) and Vandell and Pierce (in press) on elementary school students who participated in high-quality afterschool programs, which identified four sets of outcomes: improved work habits, social relations, emotional adjustment, and academic achievement by a variety of measures. Quinn also mentioned the work of Milbrey McLaughlin (2000), who studied teenagers' participation in community-based, out-of-school, youth development programs and determined that young people who participated regularly in these programs, regardless of their content—whether focused primarily on sports, community service, or the arts—had stronger education and career aspirations and a stronger sense of social responsibility than youth who did not.

Quinn also described outcomes from recent studies of afterschool and youth development, which included improved student preparation for school, improved attendance and attitudes about school, and improved rates of school completion. Programs have also been shown to increase young people's prosocial behavior and literacy, enhance their knowledge of career options, and teach them how to get help from adults, as well as reduce negative student behaviors and conflict at home (found in the evaluation of LA's Best because the students were getting help with their homework).[2]

Research has also documented the role of afterschool in fostering improved attitudes and enthusiasm among girls (and boys) about STEM. These include greater confidence in scientific ability, improved performance in scientific subjects, persistence in the scientific pipeline, increased knowledge of and interest in STEM careers, changes in course-taking behavior, improved problem-solving skills, and changes in perceptions of who can do science.[3] Important work by Beane (1988) and Sells (1981) in the eighties made clear that mathematics and science are "critical filters" for girls and minorities in terms of their taking courses in these areas and pursuing STEM careers. We also know, as Yolanda George pointed out, that "dosage—frequency and duration of participation in afterschool programs—makes a difference."

However, as Cheri Fancsali and others noted, research on girls and STEM in particular is limited. Some data relevant to gender and STEM are broken down by race and some by gender but rarely by both. Even less frequently are data differentiated by important subgroups such as race/ethnicity or by disability, immigrant, socioeconomic, and first-language status. Further, we also know from the literature that research conducted on one group of girls is not generalizable to girls of other backgrounds or subgroups. In short, Fancsali concluded, "The research tells us a great deal about effective afterschool programming but not which components are good for which subgroups."

Several panelists agreed. Citing the paucity of studies on gender, afterschool, and STEM as a whole, Donna Walker James maintained that gender equity is often an "afterthought" even in excellent programs with a youth development perspective, and that, while there may be a focus on access and equity in some programs, "gender is often not part of the conversation."

Yolanda George expressed some concern about the current call for outcomes in afterschool education and the growing expectation that afterschool should enhance students' academic achievement:

> *The exponential growth [of afterschool] sounds like good news, but a lot of it is a repetition of the kind of school that is not working during the school day and a lot is remedial, whether or not the kids need remediation, so I think there is an undertow pulling afterschool programs in the wrong direction.*

In addition, as one participant pointed out, the call for outcomes in the afterschool field could be seen as running counter to the growing field of "free-choice learning," as described by the Center for Learning Innovation—"self-directed, voluntary, and guided by an individual's needs and interests" (Falk and Dierking, 2002). This "outside-of-school" learning, the most common type of learning, is typified by the best of afterschool programming. On the other hand, George concluded that the standards movement does represent an "opportunity to improve afterschool programs and youth worker practice" if practitioners take the "enrichment approach" suggested above.[4]

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1 The preconference paper, *What We Know about Girls, STEM, and Afterschool Programs*, by Cheri Fancsali (AED, 2002) summarizes much of this research (see appendices). See also "Taking Stock: Where We've Been, Where We Are, Where We're Going" by Beatrice Chu Clewell and Patricia B. Campbell (2002) in the *Journal of Women and Minorities in Science and Engineering*; the article, and the entire journal, published after the conference, provides an excellent overview of the field.

2 See Fashola, O., 1998; Holloway, J.H., 1999; Huang, D. et al., 2000; Afterschool Alliance, 2001.

3 See Clewell, P.B. & Darke, K., 2000; Crane, V. et al., 1994; Fashola, O., 1998; Nicholson, H.J. et al., 1994.

4 Much of this research can be found on the Harvard Family Research Project's out-of-school time evaluation database (www.gse.harvard.edu/hfrp/projects/afterschool/evaldatabase.html).

Need to Change Perceptions of Science

Despite improvements in girls' STEM participation and engagement in K-12 education, a major topic of discussion at the conference was the need to change STEM fields—both how they are perceived and how they are practiced—to address the continued underrepresentation of women in the STEM labor force. This would entail making STEM fields more attractive and welcoming to girls and young women and changing the prevalent notions of "how science is done." Cecily Selby maintained that this latter involved changing outmoded notions of the objective scientific method to a more realistic view of science practice:

> *Promoting science as a human inquiry, involving the hands and the heart as well as the brain, one's personal interests and tastes—rather than an anonymous application of a universal method—is a message that could help eliminate sex discrimination at all levels in science. These misperceptions, among many others, tend to attract boys rather than girls and promote alienation and attrition from science.*

Several participants suggested, as Clewell and Campbell (2002) point out, that, although efforts have been successful in "getting girls to the point at which they have the requisite academic skills" to pursue a STEM career, "these efforts have not been sufficient to get girls to want to be scientists or engineers." They suggest that young women "may have considered their future in these fields and not liked what they have seen." Many conference participants maintained, as Dietz, Anderson, and Katzenmeyer (2002) suggest, that the focus of research and advocacy must shift from "preparing women to fit into the science and engineering system" to "reshaping the system itself so that it becomes more relevant to women."

Jacquelynne Eccles noted that the way STEM activities are taught and introduced is critical:

> *Some work has shown that the particular examples used to illustrate principles in physics matter a lot—using the heart to illustrate the principles of a pump will interest girls much more than an oil rig will. So STEM afterschool programs need to put effort into making sure the way the material is presented reflects girls' interests in human service occupations, human needs, and biological systems.*

Many participants attested to the importance of diversity to science as a field. Heather Johnston Nicholson asked "What if race, ethnicity, culture, and class were not predictors of STEM achievement?" and maintained that girls would have an "easier time seeing themselves as STEM insiders" if there were "no clash between being a scientist and being a 'people' or a family person":

> *There would be more role models of many backgrounds, fields, and interests that would say to young people "science is normal for people like me." We might have more computer games with win-win scenarios and we might have people who can demonstrate that you can actually do science and also have a family and work in a community.*

Luz Claudio, associate professor, Mount Sinai School of Medicine, agreed:

> *Nothing turns girls off more to a career in science than the stereotypes of scientists as "nerds," science as incompatible with beauty or fashion, and the image that women cannot be scientists and have a family life—the image of women scientists as frantic, unhappy women.*

Labor Market Issues

Eric Jolly presented the labor market argument for dramatically increasing the numbers of girls, minorities, and students with disabilities who pursue STEM careers. Quite simply, given that minorities are projected to comprise 40 percent of workforce entrants by 2008, there is a great need for STEM fields to be more diverse from both a labor market and an equity perspective to ensure an adequate supply of workers in these fields. This argument is presented in detail in *Upping the Numbers*, a report commissioned by the GE Fund and co-authored by Jolly and Campbell and others (2002). As documented in the report, the challenges to diversifying the STEM workforce include the realities that:

* **Students as young as nine years old see physical science and technology-related courses as appropriate subjects for boys to study; life sciences are seen as appropriate for girls (Farenga and Joyce, 1999).**
* **By eighth grade, independent of racial/ethnic group, twice as many boys as girls are interested in quantitative disciplines and science careers (Catsambis, 1994).**
* **Relatively few African American, Hispanic, and American Indian students graduate from high school with the skills and knowledge necessary in quantitative fields (Campbell and Hoey, 1999).**

Jolly maintained, that, as the nature of the U.S. population continues to change, we need to develop STEM programs to attract this changing population—to determine "what works for whom and in what circumstances":

> *If women, men, minorities, and people with disabilities were represented in the sciences to the degree they are in the general population—we would add over one million employees in the quantitative disciplines, instantly.*

Research Not Evaluation

Eric Jolly also pointed out that much of what is considered STEM research is in fact evaluation, "telling us why an individual program works or what it must do to improve" but not "advancing the field about what works in general and for whom." Such evaluation, Jolly maintained, is often conducted "retrospectively" to determine whether a program was effective and how, rather than "prospectively" to test a "theory of change" about how a program works. In fact, Jolly maintained, there is almost no "hypothesis-driven research" testing what works in afterschool programming to increase girls' STEM participation, engagement, and persistence.

Jolly recommended that we turn some of our "intuition" about what works and what outcomes are reasonable to expect, into a "theory-driven program" and "test out whether the theory holds up." The findings from such research about science, gender, and afterschool education would contribute to a growing body of knowledge about effective practices, environments, and policies for girls in general and for girls in specific subgroups. They would also help program staff plan and carry out effective programs to foster girls' STEM interest and participation.

Jolly described some of the work that led to the report, *Upping the Numbers*, including a review of 20 colleges or college programs that help develop pathways for girls and minorities through college science. This work led to the development of three primary categories—engagement, capacity, and continuity—to describe characteristics supporting girls' STEM participation. From this, the authors developed a "matrix" for categorizing different aspects of the programs/institutions studied that dealt with engagement, capacity, and continuity broken down by factors such as race, gender, age, and disability. Such a matrix, Jolly maintained, could advance the knowledge-base on STEM, gender, and afterschool by providing identified characteristics "that we were going to track and ask afterschool programs to follow, with a clear set of identified outcome measures to compare."

Research-Action Agenda

A research-action agenda was developed for three of the areas addressed at the conference: access, recruitment, and persistence; program content, approaches, and strategies; and staff and professional development. (Questions discussed under the fourth area, "connecting school and afterschool," are included under program content and approaches.) Many issues highly relevant to the debate about afterschool and increasing the participation of girls, minorities, and students with disabilities—and to other fields such as youth development, education reform, service-learning, and character education—were discussed at the conference. The research-action agenda focuses on issues specifically relevant to afterschool, STEM, and girls, including girls of color and girls with disabilities.

> **"ULTIMATELY, THE FIELD NEEDS TO DEVELOP A THEORY OF CHANGE for what we hope will happen if the mechanisms are in place to engage STEM effectively. I think that should be an articulated research goal. If we do research in the action areas, will we be able to develop a theory of change for STEM? Or, do we need to develop a theory of change first and then conduct research in these areas to test/adjust our model?"**
>
> —Priscilla Little, project director, Harvard Family Research Project

Research to determine answers to questions raised in the agenda should include both quantitative and qualitative studies, including interviews, surveys, retrospective studies, and case studies of girls and young women pursuing STEM majors and careers; meta-analysis of the STEM participation of subgroups of girls; case studies of STEM youth workers; and large-scale studies of outcomes for girls in STEM afterschool programs.

Participants suggested several overarching research areas for the field as a whole. These include:

* **An assessment to determine gaps in existing research**
* **Theory development about what content and approaches lead to improved STEM participation and persistence on the part of girls**
* **Studies of the role of afterschool in girls' STEM persistence at the postsecondary level**
* **Longitudinal studies of STEM afterschool participants**
* **A compilation of reasonable outcomes to expect of afterschool STEM programs**

Although participants felt that long-range quantitative outcomes studies would be desirable, many also noted the benefits of qualitative research in this area, agreeing with Beatriz Chu Clewell and Carol J. Burger (2002) in their introductory essay in the *Journal of Women and Minorities in Science and Engineering*:

> *Among several suggestions for future research, the authors call for an intensive, qualitative look at the decision-making process girls engage in when considering their career paths. Quantitative data can only take us so far; it will be the words of the young women themselves that will inform our future programs and projects to make science and technology careers more welcoming for women.*

The following presents research questions and action areas identified by conference participants as needing to be addressed to advance the field, as well as examples of research studies that could be undertaken.

I. Access, Recruitment, and Persistence

A. What specific access and recruitment barriers are related to the participation of girls in STEM afterschool programs?

B. What are the critical program characteristics that foster access and recruitment of girls into STEM afterschool programs and their persistence in those programs and activities?

These questions address particular barriers and issues that all girls—girls of different races, ethnicities, socioeconomic status (SES), and abilities—face in accessing STEM afterschool activities and programs, as well as the characteristics of STEM afterschool programs that do successfully recruit girls and help them persist. Given the evidence that "once in, girls persist," access and barriers to access are clearly crucial in terms of girls' STEM participation.

Discussion at the conference centered on general barriers as well as those specific to girls and STEM. Transportation is often an access issue for many girls, and often for girls more than boys. This includes girls in rural areas where physical distance may be the major barrier, as well as girls in urban areas, where concerns about safety may limit parents' willingness to let their daughters participate in afterschool activities if it means going home after dark or using public transportation rather than school buses. Transportation is also a huge issue for girls with disabilities. Financial considerations can also be general barriers, especially for older teens (both boys and girls) from low-income families who may need to earn money after school.

> **"I SUSPECT THAT MANY GIRLS ARE NOT ATTRACTED TO SCIENCE because it is perceived as demanding and unattractive in terms of family life. How do some employers foster women's contributions and others not? Theirs are not lives in a vacuum—how do their husbands recognize their career capacities and work in partnership? Providing their stories might go a long way in the 'yes you can' realm."**
>
> —Phyllis Katz, director of research and special projects, Hands on Science Outreach (HOSO)

> **"[FOSTERING A SENSE OF COHESION] CAN BE DONE VIA PEER MENTORING, activities that incorporate elements of the girls' culture, activities that contribute to the girls' community, and an environment in which a group of girls can create their own culture."**
>
> —Beatriz Chu Clewell, principal research associate, Urban Institute

Further, girls typically have more afterschool responsibilities at home than boys do, which may hinder their afterschool participation. Other gender-specific access issues include expectations—on the part of staff, families, and girls themselves—about who can do science and about the importance of girls participating in STEM programs and activities. Psychological barriers, gender expectations, and what one participant called "coolness" factors (e.g., the view of STEM activities as "nerdy") can act as barriers to the STEM participation of girls (and many boys).

Given these expectations and the fact that afterschool participation is voluntary and self-selected, outreach to girls and families is clearly crucial. Is a STEM afterschool program's outreach appropriate for the population targeted? Is the program publicized in a way to persuade girls and their families of its importance? Characteristics specific to recruitment include a program's connections to the community, its cultural relevance, and characteristics of staff (race/ethnicity, economic background, disability, and training). Several participants also mentioned recruiting a "critical mass" of girls from underrepresented groups to foster a sense of group cohesion and provide peer support.

Examples of Research: Access, Recruitment, and Persistence

CASE STUDIES/SURVEYS of girls and young women in STEM afterschool programs about how they became/stayed involved and the major barriers, if any, they faced in accessing/choosing/persisting in a STEM afterschool program

RESEARCH into how STEM majors and careers are marketed to girls in comparison with how more traditional career options are presented

RETROSPECTIVE CASE STUDIES/SURVEYS of young women pursuing STEM careers, asking what factors fostered or discouraged their STEM interest, participation, and persistence at all levels of education (and of young men, asking what helped them persist)

COMPILATION OF KNOWLEDGE from different disciplines, such as youth development, STEM, and gender education, to determine effective strategies for fostering girls' STEM interest, participation, and persistence

II. Program Content, Approaches, and Strategies

A. What skills do girls need to succeed and persist in STEM courses and careers?

B. What are the best STEM curricula, approaches, and strategies in terms of fostering girls' STEM interest, skills, and persistence?

1. **What approaches and strategies help build and sustain girls' interest and persistence in STEM courses and careers? What approaches and strategies act as barriers?**
2. **In what ways is cultural relevance of curricula or approaches a critical factor in the STEM engagement and persistence of girls from diverse backgrounds?**

C. What are the characteristics of successful STEM collaborations between schools and afterschool programs?

D. How do we merge the best of youth development and STEM content and approaches to increase girls' STEM interest, participation, and persistence?

E. What are the STEM and non-STEM outcomes we should expect from girls' participation in STEM afterschool programs and how do we measure them?

1. **Does girls' participation in afterschool STEM activities and programs affect their in-school participation and outcomes? If so, how?**

Before considering the best curricula and approaches for fostering girls' interest, skills, and persistence, conference participants stressed the importance of considering the essential skills girls need to flourish in STEM programs—such as confidence in asking questions, competence in seeking answers, and the ability, as one participant put it, to "survive as a minority in a hostile environment."

Conference participants also agreed that curricula were critical, especially in afterschool, where many staff may not have a specialty in STEM content. Many participants also noted the challenge, in terms of program content, of teaching STEM subjects to girls without making it "girls' science." While most participants did not think that content was "gender specific," many felt that cultural relevance could be a factor in determining appropriate approaches for teaching STEM content in a particular program, as well as in staff's ability to act as role models or mentors.

"THE MOST IMPORTANT SKILL THAT GIRLS (and boys) need is confidence in asking questions and competence in seeking scientific evidence for answers. These skills can be optimally taught in STEM settings—freed from inappropriate curricular demands and testing."

—Cecily Selby, independent scholar

A review of the research on cultural relevance or a case study of an existing program or new research with subgroups, including minority girls and girls with disabilities, could help determine which program characteristics and/or approaches are most important with which subgroups. Answers to this question would help educators present science from, in the words of one participant, "outside the dominant culture's understanding of what science is, and connect science with practices in everyday life."

In addition, studying what factors encourage/discourage girls and young women from thinking of STEM careers as possible and from pursuing and persisting in STEM courses and careers at the postsecondary level could help clarify what strategies work to keep girls of different ages and at different levels of schooling connected as STEM "insiders." Do these approaches vary for girls of specific races/ethnicities/cultures/SES, and disabilities? This research could help afterschool staff develop strategies for helping girls make the transition to postsecondary STEM courses, majors, and careers. Beatriz Chu Clewell pointed out that particular attention could be paid to curricula and approaches that introduce girls to the physical sciences and other areas in science where women are underrepresented, especially since research has shown that girls, as early as the third grade, shy away from engaging in these types of activities.

In terms of what fosters the STEM interest and persistence of girls of particular ages, race/ethnicities, disabilities, and SES status, we know from extensive research that these program characteristics include mentoring, hands-on activities, parent and community support, personal issues such as self-efficacy and self-confidence, and knowledge about careers. They can also include particular teaching strategies; a program's connections to the community; program longevity or continuity; and characteristics of staff (race/ethnicity, economic background, disability, and training). Other important factors could be non-STEM-specific—for example, characteristics of good youth development programs in general, including opportunities for young people to share in program decision making, develop and work toward articulated goals, build competencies, and form healthy bonds with other participants and staff.

In terms of outcomes, the field of afterschool has grappled with the question of what outcomes—particularly academic outcomes—are reasonable to expect from programs and how they can be measured.

"CULTURAL BACKGROUND (and gender) may be a factor in terms of the kinds of questions that the inquirer, female or male, poses—in other words, young people from particular backgrounds may need more support in taking the inquiry stance so essential for effective participation in STEM activities and courses."

—Ellen Wahl, director of youth, family, and community programs, American Museum of Natural History

Obviously, for a particular program, expected outcomes should reflect the program goals and objectives. If, for example, the goals are to increase academic skills, then these outcomes should be measured. Other outcomes suggested by participants included a continuing interest in science, general understanding of STEM issues, and taking science courses/majors in school and college. Research could also seek to determine how girls' participation in STEM activities and afterschool programs contributes to their in-school interest, participation, and persistence in STEM courses, programs, and activities.

Examples of Research: Program Content, Approaches, and Strategies

AN OVERVIEW AND CRITIQUE of existing STEM afterschool curricula and programs

IDENTIFICATION OF KEY FEATURES of effective STEM curricula and approaches

INTERVIEWS WITH WOMEN who are successful and comfortable with their roles as scientists/science educators and mothers about how they "create their lives"

REVIEW OF THE RESEARCH on cultural relevance or new research with subgroups

CASE STUDY of an exemplary STEM program to determine reasonable outcomes

REVIEW OF EVALUATIONS of afterschool/informal programs

REVIEW OF RESEARCH on existing STEM school-afterschool collaborations

CASE STUDY of an existing collaboration between a school and an afterschool program

LONGITUDINAL EVALUATION of participants in STEM school-afterschool collaborations

III. Staffing and Professional Development

A. How do staff influence girls' interest and persistence in STEM activities, courses, and careers?

B. In terms of professional development, how do we merge the best of youth development and STEM to increase girls' STEM interest, participation, and persistence?

C. How does gender equity get infused and sustained in professional development?

Questions about staffing and professional development are closely related to questions about access, recruitment, and persistence. However, conference participants deemed it important to consider separately the impact of afterschool teachers, mentors, coaches, and counselors on girls in terms of their STEM interest, participation, and persistence, and how this impact might differ by girls' race, ethnicity, age, disability, and SES status. Participants discussed whether a correlation between the race/ethnicity and culture of staff and students made a positive difference in STEM for girls. Drawing from the extensive research on mentoring and role models, research could also seek to determine whether the nature, quality, and stability of youth/youth worker relationships have an impact on girls' motivation and persistence in STEM areas.

> **"THE ISSUE OF CONTENT VERSUS STRATEGIES and approaches seems to me to be one of the most important research questions. In terms of current practice and in terms of programs that might be developed to train staff, which works better: training current youth workers in STEM, or training current STEM workers in youth development? Is there a sufficient source of the latter to make it a worthwhile investment?"**
>
> —Jean Taylor, professor, Rutgers University

The question about merging the best of youth development and STEM in professional development for youth workers raises the issue of how professional development can help a staff person with limited STEM education or training become an effective STEM teacher. As several participants maintained, both STEM knowledge and youth development approaches are important, which raises the question of whether, given limited resources, it is better to train current youth workers in STEM or train current STEM workers in youth development.

It also is important to determine best practices in infusing gender-equity issues into ongoing professional development. This is based on what participants thought was a valid assumption: that good professional development is ongoing and can have a positive impact on practice. This is underscored by a key finding from the 2002 AED report, *BEST Strengthens Youth Worker Practice*, which found that high-quality professional development activities increased youth workers' use of youth development practices.

> **"WHILE WE MAY BE A WAY OFF from being able to measure the direct impact of training and education on young people, at least there is documentation of a change in practice. Therefore, if the promotion of STEM activities were included in current youth development professional development activities, there might be a positive change in the practice of youth workers—i.e., encouraging more girls to participate in STEM."**
>
> —Jennifer Gajdosik, program officer, National Training Institute for Community Youth Work, AED

Examples of Research: Staffing and Professional Development

STUDY OF THE IMPACT/INFLUENCE of STEM afterschool staff on girls' STEM access, interest, persistence, and outcomes

STUDY OF EXISTING STEM afterschool programs with a youth development focus

CASE STUDY of model gender-equity professional development

IMPACT STUDY of professional development in STEM content and pedagogy on staff's practices and outcomes for girls

IMPACT STUDY of professional development in youth development on staff's practices and outcomes for girls

CASE STUDIES AND SURVEYS exploring the impact of staff background in youth development and outcomes for girls

* * *

This STEM research-action agenda is a work in progress. In effect, the agenda questions provide a starting point for continued work in the fields of afterschool education, girls' education, and STEM. They serve as a guide to researchers, funders, and policymakers by identifying the areas and issues identified by experts in the field as gaps in our current knowledge about STEM, gender, and afterschool education.

As stated throughout the conference, research on afterschool education presents numerous challenges. However, conference participants agreed that the current focus on afterschool and the urgent need to increase the STEM participation of girls, minorities, and people with disabilities, from both labor market and equity perspectives, present a real opportunity for researchers, educators, and policymakers to help shape and advance the afterschool field.

Research-Action Agenda Summary

I. Access, Recruitment, and Persistence

A. What specific access and recruitment barriers are related to the participation of girls in STEM afterschool programs?

B. What are the critical program characteristics that foster access and recruitment of girls into STEM afterschool programs and their persistence in those programs and activities?

II. Program Content, Approaches, and Strategies

A. What skills do girls need to succeed and persist in STEM courses and careers?

B. What are the best STEM curricula, approaches, and strategies in terms of fostering girls' STEM interest, skills, and persistence?

1. What approaches and strategies help build and sustain girls' interest and persistence in STEM courses and careers? What approaches and strategies act as barriers?
2. In what ways is cultural relevance of curricula or approaches a critical factor in the STEM engagement and persistence of girls from diverse backgrounds?

C. What are the characteristics of successful STEM collaborations between schools and afterschool programs?

D. How do we merge the best of youth development and STEM content and approaches to increase girls' STEM interest, participation, and persistence?

E. What are the STEM and non-STEM outcomes we should expect from girls' participation in STEM afterschool programs and how do we measure them?

1. Does girls' participation in afterschool STEM activities and programs affect their in-school participation and outcomes? If so, how?

III. Staffing and Professional Development

A. How do staff influence girls' interest and persistence in STEM activities, courses, and careers?

B. In terms of professional development, how do we merge the best of youth development and STEM to increase girls' STEM interest, participation, and persistence?

C. How does gender equity get infused and sustained in professional development?

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Appendices

Conference Agenda

Conference Advisory Committee

Conference Participants

Preconference Report: What We Know About Girls, STEM, and Afterschool Programs: A Summary

About the Authors

Conference Agenda

Science, Gender, and Afterschool

Creating a Research-Action Agenda

Co-sponsored by Educational Equity Concepts, Inc.
American Association for the Advancement of Science
Academy for Educational Development

Funded by the National Science Foundation/Program for Gender Equity

September 23-24, 2002
Washington, DC

Agenda

DAY ONE: SEPTEMBER 23, 2002

1:00 **Lunch**
Welcome & Introductions

Merle Froschl and Barbara Sprung
Co-Directors
Educational Equity Concepts, Inc.

Margrete S. Klein
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2:00-2:45 **Summary of Issues**

Cheri Fancsali
Senior Program Officer
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Opening Dialogue

Jane Quinn
Assistant Executive Director for Community Schools
Children's Aid Society

Yolanda S. George
Deputy Director
Directorate for Education and Human Resources
American Association for the Advancement of Science

2:45-3:00 **Break**

3:00-4:30 **Panel: How to Use Available Research to Inform Program Development**

Panelists

Heather Johnston Nicholson
Director of Research
Girls Incorporated

Phyllis Katz
Director of Research and Special Projects
Hands On Science Outreach

Donna Walker James
Senior Program Associate
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Eric J. Jolly
Senior Scientist and Vice President
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Alejandra León-Castellá
Executive Director
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4:30 **Questions/Feedback**

5:30-6:30 **Reception**

DAY TWO: SEPTEMBER 24, 2002

8:15 **Breakfast**

9:00 **Summary and Charge to Working Groups**

DeAnna Banks Beane
Director
Partnerships for Learning
Association of Science-Technology Centers

Ellen Wahl
Director Youth, Family, and Community Outreach Programs
American Museum of Natural History

10:00-2:30 **Working Groups** (through lunch)

Groups each discuss two key issues and make recommendations for research/action agenda

2:30–3:00 **Break**

3:00–4:00 **Large Group Report Back and Summary**

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Preconference Report

What We Know About Girls, STEM, and Afterschool Programs

A Summary

Prepared by
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2002

Introduction

Trend data show that girls and women have made substantial gains in the last three decades in terms of educational equity (NCES, 2000). They are doing as well or better than their male peers on many indicators of educational achievement and attainment. However, they still lag behind their male peers in aspects of mathematics and science achievement and advancement towards, and attainment of, careers in science, technology, engineering, and mathematics (STEM).

For example, girls and boys perform at similar levels in mathematics and science in elementary school, but girls show less positive attitudes toward science (Weinburg, 1995). Girls have fewer out-of-school science experiences than boys (Farenga, 1995; Kahle, et al., 1993), which Farenga (1995) found to be related to girls' reduced participation in school science courses. While girls comprised a small majority (54%) of the advanced placement test-takers in 2001, they were underrepresented in the areas of mathematics and science (College Board, 2001). Further, although the gap has decreased in the last decade, males still outperform females on high-stakes tests such as the SAT and ACT (Sadker, 1999). Girls are also much less likely to major in science-related fields in college and less likely to complete undergraduate and graduate STEM degrees (Clewell, Thorpe and Anderson, 1992; Davis, et al, 1996; NSF, 2000). They comprise a disproportionately low percentage of the STEM workforce, earn less, and are less likely to hold high-level positions in STEM careers (Long, 2001; NSF, 2000). (See attachment for summary of key status indicators related to girls and STEM, broken down by race where available.)

This paper summarizes key research and literature related to what we know about girls' participation in science, technology, engineering, and mathematics education at the primary, secondary, and postsecondary levels, as well as their participation in afterschool programs with a gender-equity focus and in STEM careers. The summary is organized around five areas:

- **learning styles, teaching strategies, and educational environments promoting girls' STEM participation and achievement;**
- **characteristics of effective STEM and afterschool programs;**
- **afterschool program access issues for girls;**
- **STEM afterschool program outcomes that have been measured; and**
- **examples of STEM programs with evidence of success.**

This summary, while not an exhaustive review of the literature and research, provides a basis for discussions related to the Science, Gender, and Afterschool working conference funded by the National Science Foundation's Program for Gender Equity. As a field, afterschool education is growing rapidly and plays a significant role in the development of young people in terms of providing opportunities and promoting positive behavior to foster their academic, vocational and social success. The conference will address two critical issues in terms of how afterschool programs can engage and support all girls' interest in STEM: 1) how to use available research and evaluation to inform program development: and 2) how to ensure the high quality of current and future programs.

Learning Styles, Teaching Strategies, and Educational Environments Promoting Girls' STEM Participation and Achievement

Research indicates that gender differences in performance are related to "common, ordinary differences" in the mathematics and science education of girls and boys (e.g., sex-role stereotyping about mathematics and science skills)—differences that contribute to "different interests, attitudes, achievements, and enrollments during junior and senior high school" (Kahle, 1996, p. 86). These differences can have serious ramifications for girls in terms of their postsecondary education and career choices. High school course-taking, for example, has been shown to have a substantial effect on a student's postsecondary education. According to Clifford Adelman, of all precollege courses, taking high-level mathematics courses in high school has the strongest impact on a student's postsecondary education: "Finishing a course beyond the level of Algebra II more than doubles the odds that a student who enters postsecondary education will complete a bachelor's degree" (Adelman, 1999, executive summary). The Campbell et al. review of the research also showed that a strong high school background, particularly in math, is "key to overall success in college" (Campbell, Jolly, Hoey and Perlman, 2002).

Research also points to several practices that promote an equitable learning environment for girls and have a positive impact on their continuation in quantitative disciplines and science. They include collaborative learning, hands-on experiences, an emphasis on practical applications, and the teaching of science in a more holistic and social context (Campbell et al, 2002; Davis and Rosser, 1996; Hansen et al., 1995; Koch, 2002; Lee, 1997; Wenglinsky, 2000). Many researchers also agree that mentors, role models, and networks are important from the early grades and throughout a woman's career in the sciences (Astin and Sax, 1996; Clewell and Darke, 2000; Hansen et al., 1995; Thom, 2001). Programs for girls combining hands-on activities, role models, mentoring, internships, and career exploration have improved girls' self-confidence and interest in STEM courses and careers and helped reduce sexist attitudes about STEM (Campbell and Steinbrueck, 1996; Ferreira, 2001).

Lastly, in addition to collaborative learning, mentors and role models, Hansen, Walker, and Flom (1995), authors of *Growing Smart: What's Working for Girls in Schools*, found evidence that girls are more likely to thrive in a learning environment that provides:

* **opportunities for leadership and exploration of new ideas;**
* **active, intelligent engagement with concerned adults and other students;**
* **consciousness-raising about gender, race, and class issues; and**
* **single-sex grouping to provide a more supportive context for learning.**

These issues and issues of diversity are discussed below.

LEARNING STYLES

Different learning styles based on gender have been suggested as factors related to the STEM participation and achievement of girls and students of color. For example, locus of control has been cited as a factor related to mathematics and science achievement. Some studies have shown that men are more likely than women to attribute success in mathematics to their own ability, while women are more likely to attribute success in mathematics to effort or luck. However, other studies have not found a sex difference in **locus-of-control** orientation, making the evidence unclear (Clewell and Anderson, 1991). **Cognitive style,** or the way men and women process knowledge, has also been shown to be related to achievement. Some research suggests that students of color tend to be more "field dependent" (i.e., they process information in a more global than analytic fashion) in their cognitive style than their white peers. A field-dependent cognitive style may inhibit students' interest and performance in mathematics (Clewell and Anderson, 1991).

Spatial visualization, although more a skill than a learning style or characteristic, is often cited as a factor related to different outcomes in mathematics by gender (Leder and Fennema, 1990). Fennema found that low spatial skills seemed to have a different impact on the achievement of males and females. In one study, males with low spatial skills but high verbal skills had the highest performance on a mathematics achievement test while females with low spatial skills and high verbal skills had the lowest performance. Again, the research is unclear as to whether there are sex differences in spatial visualization ability (Clewell and Anderson, 1991).

In terms of technology, researchers have documented **different interactions and attitudes to technology and computers** among girls and boys (AAUW, 2000; Kaiser Family Foundation, 1999; Margolis and Fisher, 2002; see also Volman and van Eck, 2001). For example, in a 2000 study conducted by the American Association of University Women (AAUW), girls reported a preference for interacting with people to working on a computer. They were more likely to view the computer as a tool, while boys were more likely to see it as a toy. Girls are more engaged by software that provides opportunities for collaboration, strategizing and critical thinking, and creativity (AAUW, 2000; Kafai, 1998; see also Volman and van Eck, 2001). In contrast, Kafai found that, in designing games, boys were more likely to create adventure games organized around fantasy places. The games boys designed were also more likely to involve violence than those designed by girls (1998). These differences led Davis, et al. to suggest that girls need help seeing the "people benefits" of computer science (and of science and engineering in general) as well as the creative aspects of programming (1996).

Research has also shown that knowledge of computer programming is related to the computing gap between boys and girls. Girls' level of programming skills is a strong predictor of their sense of self-efficacy in computing and of college success in computer science (see Sanders, 2002). Other researchers have found that differences in computer knowledge and skills are closely related to differences in computer experience, again favoring boys (Volman and van Eck, 2001). And, on the question of how to increase girls' participation in computer science, one study found that improving teachers' use of gender-equity strategies did not increase girls' enrollment in advanced placement computer science courses (Sanders, 2002).

TEACHING STRATEGIES

Studies suggest that certain teaching strategies may foster the STEM participation and achievement of girls and students of color. For example, some studies have found that **cooperative learning groups and active learning** motivate young women to study mathematics and science (Bartsch et al., 1998; Ferreira, 2001). Girls' performance in scientific subjects is also enhanced by field trips, labs, and career counseling, which help students see the relevance of science and mathematics in the broader context of work and life (Kahle, 1996). A study of Project Discovery found that participation in classes where teachers were trained in authentic assessment, cooperative learning, grade-appropriate inquiry curricula, and the national standards in mathematics and science significantly decreased the number of boys and girls who thought that "science was for boys" (Kahle and Rogg, 1996).

However, there is also evidence suggesting that cooperative learning may not always increase girls' participation and achievement. Some research has documented situations where girls were less likely than boys to receive help from boys in cooperative groups, and, if there is only one girl in a group, the boys usually ignore her (Lee, 1997). Jovanovic and King found in their study that boys were more likely to "hog" resources in small, coed settings, while girls were more often passive participants (1998). Volman and van Eck's review of research on information technology also found evidence that boys tend to dominate computer-related activities (2001). Another study found no achievement gains for boys or girls associated with increased cooperative group work in high school biology classes (Kahle, 1996, cited in Boone and Kahle, 1998).

In their review of literature, Hansen, Walker, and Flom found that **hands-on experiences** such as handling tools and equipment may boost girls' interest in mathematics and science (Hansen, et al, 1995). Another study found that hands-on engineering activities made girls six times more likely to consider engineering as a career (Campbell and Shackford, 1990). However, contrary to their expectation, Jovonovic and Dreves found that hands-on science classrooms did not reduce the gap between boys' and girls' science attitudes (1998). They concluded that "boys and girls experience hands-on science classrooms differently." Similar to the findings on cooperative learning, both Hansen et al. (1995) and Jovonovic and Dreves (1998) found that boys tend to dominate science-oriented activities, especially those involving special equipment.

There is some evidence that using scientific equipment and hands-on activities are related to higher science and mathematics achievement. The Campbell, et al. (2002) report, *Upping the Numbers*, points to several studies providing such evidence, including the following:

* **National Assessment of Educational Progress (NAEP) science achievement scores were higher for nine-year-olds who used equipment like meter sticks, scales, and compasses in class (Campbell, Hombo, Shackford and Mazzeo, 2000).**
* **NAEP mathematics scores were higher for eighth graders who participated in hands-on learning activities than for those who did not. They were also higher for 17-year-olds with access to computers to learn mathematics and solve mathematical problems (Wenglinsky, 2000).**
* **Participating in physical science laboratory activities improved girls' achievement, while not affecting that of boys (Burkham, Lee and Smerdon, 1997; Lee, 1997).**

LEARNING ENVIRONMENTS

Closely related to teaching strategies, certain educational environments may help increase the STEM participation and achievement of girls and students of color.

Related to the findings about the impact of mentors and role models, studies have found that **support from adults** can play a key role in encouraging girls. One Girls Incorporated study, *The Explorer's Pass*, showed that girls in mathematics and science classes and programs benefited from adult encouragement and modeling to overcome "a reluctance to get dirty and a tendency to ask for adult rescue when a task seemed difficult or boring" (Girls Incorporated, 1991, p. viii). The study also found that girls needed a supportive environment to pursue interests, take (reasonable) risks, not fear making mistakes, and use "mistake making" as a method of learning. Another AAUW report, *Girls in the Middle: Working to Succeed in School*, showed the importance of adults fostering an atmosphere of respect for girls' voices and approaches to learning, whether or not they conform to the dominant culture of the school (Cohen et al., 1996).

Although several scholars support **single-sex grouping** as a way to provide a supportive learning environment for girls, the research around the long-term effects of single-sex education are inconclusive (Davis et al., 1996; Phillips, 1998). AAUW's review of research on this issue determined that single-sex learning environments in primary and secondary schools do not necessarily eliminate sexism or lead to increases in achievement for girls (1998). In fact, some research has shown single-sex environments to be more sexist than coeducational environments (Lee, 1997). Research to date has also not supported long-term gender segregation in mathematics and science classes as strengthening girls' interest, achievement, and persistence in STEM fields (Leder, 1990, cited in Davis, 1996). Many researchers and educational reformers fear that single-sex learning environments are too simplistic a way to address the complex issues related to providing equitable and supportive learning environments for girls and may detract from efforts to make coed schools more equitable (Bailey, 1996; Campbell and Wahl, 1998a; Campbell and Wahl, 1998b).

ISSUES OF DIVERSITY

Women of color in the sciences face the double barriers of racism and sexism. However, little research has explored the relationship of gender and ethnicity in terms of girls' STEM achievement. Very limited data are available disaggregated by sex and racial/ethnic group (Coley, 2001; Kahle, 1996); more often, data are presented by either sex or race/ethnicity. One exception is a recent Educational Testing Service report, which provides some data, including NAEP, SAT, high school course-taking, advanced placement, educational attainment, and employment data by gender and race/ethnicity (Coley, 2001). Coley found that across these indicators, gender differences did not vary much by race and ethnicity. Females outperformed males on some indicators while males outperformed females on others. He concluded that the "nature of gender inequality in education is a complex phenomenon," and noted that both gender and race/ethnicity are "crucial factors" that must be attended to (see attachment for a summary of achievement data results by gender and race/ethnicity).

Clewell and Ginorio found in their review that research on Caucasian women and girls is not generalizable to women and girls of color. Neither is research on women and girls of one race/ethnicity or social class generalizable to other race/ethnicities or social classes (Clewell and Ginorio, 1996). The majority of research on girls and women of color has been conducted with African-American girls and women, followed by Latinas. Three studies found that at the time of school entry, race, social class, and gender differences in mathematics readiness were small. One study found that in the early grades, the link between parental and child expectations (e.g., that boys will perform better in mathematics) was weaker in schools with students from low-income families than in schools with middle-class students (Clewell and Ginorio, 1996).

While research has shown that some learning styles influence different achievement in mathematics and science for women and people of color, there is no research on the learning styles of girls of color and the ways in which sex and race or ethnicity interact to influence learning (Clewell and Ginorio, 1996). NAEP data showed that girls' experiences in mathematics and science differed by race/ethnicity. White students had more science experiences than African-American students, and the difference increased with age. It also showed that African-American girls at ages nine and 13 have conducted the fewest science experiments of all racial/ethnic groups (Clewell and Ginorio, 1996).

In terms of persons with disabilities, data are even more limited (Bauer, 2001; National Science Foundation, 2000). Available data indicate that girls with disabilities are among those least likely to have mathematics and science experiences (Wahl, 2001). Students with disabilities of either gender are unlikely to take advanced course work in mathematics and science, and few disabled students pursue higher education. Further, there are substantial differences between disability groups, which necessitates the disaggregation of data by type of disability. For example, achievement outcomes are very different for students with visual impairments compared with those with physical or mental disabilities (Wahl, 2001).

Characteristics of Effective STEM and Afterschool Programs

An estimated three to four million (20% to 25%) low- and moderate-income urban children participate in afterschool programs, and the number appears to be growing (Halpern, 2002). Attention to afterschool hours has increased substantially in the last decade as policymakers, child development professionals, and parents see this time period as "one of unusual risk and opportunity" (Hofferth, 1995, cited in Halpern, 2002). The risks range from boredom to self-destructive behavior and crime on the part of young people, while the opportunities for youth include developing caring relationships with peers and adults and taking part in academic enrichment and support (Halpern, 2002). Halpern suggests that, after home and school, afterschool programs are becoming a "third critical developmental setting for low- and moderate-income children."

One nationally representative study of afterschool programs indicated that in 1991, 1.7 million kindergarten through eighth-grade children were enrolled in approximately 50,000 programs (Seppanen et al., 1993). This study found tremendous variability in program characteristics such as sponsorship and location. It is not clear how many children and youth are enrolled in afterschool programs that focus on science, technology, engineering, and mathematics. However, as noted earlier, studies have documented that girls have fewer computer and science-related experiences outside of school than boys (Farenga, 1995; Kahle et al., 1993; see also Volman and van Eck, 2001).

Studies have also shown that afterschool participation contributes to reduced drug use and juvenile crime, and lower dropout and teen pregnancy rates among youth, as well as higher standardized test scores and college attendance rates, better handling of conflicts, more cooperative relationships, better social skills, and improved self-confidence (Fashola, 1998; Holloway, 1999; Huang, 2000; Afterschool Alliance, 2001). Specifically, Fashola concluded, based on an extensive review of programs, that the following qualities were related to increased student academic achievement: greater programmatic structure (e.g., scheduled activities, planned curriculum); a strong link to the school-day curriculum; well-qualified and well-trained staff; and opportunities for one-to-one tutoring (Fashola, 1998). The U.S. Departments of Education and Justice (2000) found that characteristics of high-quality afterschool programs of any type (not just those intended to increase academic achievement) include clear program goals, strong leadership and effective managers, skilled and qualified staff, ongoing professional development, and low adult-to-child ratios (U.S. Departments of Education and of Justice, 2000).

A YOUTH-DEVELOPMENT FRAMEWORK

Several researchers note that effective afterschool programs are not simply replications of the regular school-day curricula. Children who are not successful in school are not likely to be any more successful in an afterschool program that provides "more of the same" (Scarf and Woodlief, 2000). Recent research suggests that programs adhering to a youth-development framework are more likely to promote positive youth outcomes (James and Jurich, 1999; McLaughlin, 2000; National Research Council and Institute of Medicine, 2002; Roth and Brooks-Gunn, 1998). Research related to effective youth-development programs are summarized below.

In a review of research related to community-based programs, Eccles and Gootman found that characteristics linked to promoting positive development and outcomes in adolescents include safety and security, a structure that recognizes adolescents' increasing social maturity, and strong links between families, schools, and community resources. Characteristics of effective programming and a youth-development framework also included opportunities for youth to:

* **experience supportive relationships and receive emotional and moral support;**
* **feel a sense of belonging;**
* **be exposed to positive morals, values, and positive social norms;**
* **be efficacious, to do things that make a real difference, and play an active role in the program; and**
* **develop academic and social skills, including learning how to form close relationships with peers that support and reinforce healthy behaviors, as well as acquire the skills necessary for school success and a successful transition to adulthood (National Research Council and Institute of Medicine, 2002, p. 117).**

In four compendia of evaluations of effective youth programs, the American Youth Policy Forum (AYPF) presented summaries of 199 youth program evaluations. The analysis of these programs yielded a list of characteristics similar to that of Eccles and Gootman. Specifically, the forum listed the following characteristics as contributing to program effectiveness:

* **high quality implementation;**
* **high standards and expectations of youth;**
* **parent/guardian participation and community involvement;**
* **viewing youth as resources;**
* **provision of long-term services, supports and follow-up;**
* **caring, knowledgeable adults; and**
* **community service, service-learning, work-based learning (American Youth Policy Forum, 1997, 1999, 2000, 2001).**

McLaughlin's research on community-based organizations (CBOs) also supports these qualities as relevant in terms of program effectiveness. Specifically, organizations that are youth, learning, and assessment-focused had a significant impact on the skills, attitudes, and experiences of the at-risk youth they served (McLaughlin, 2000). For example, youth who participated in CBOs characterized by these qualities had higher academic aspirations, greater self-confidence and optimism, and stronger feelings of civic responsibility compared with American youth generally.

Roth and Brooks-Gunn (1998) found that high-quality outcome evaluations of youth-development programs are scarce, but a review of the literature showed that programs incorporating more elements of youth-development approaches showed more positive results. They also found that longer-term programs engaging youth throughout adolescence appeared most effective. However, Roth and Brooks-Gunn noted that, while there was some evidence of the effectiveness of the youth-development framework, many questions remained. For example, it was not clear what mix of youth-development program characteristics produced what outcomes and for whom.

GENDER ISSUES AND AFTERSCHOOL PROGRAMS

Scarf and Woodlief (2000) reported that much of the literature on afterschool programs deals with diversity issues on a very general level, typically relating to issues of cultural sensitivity. Very little is written about specific gender issues in youth-development and afterschool programs, and there are few guidelines and recommendations for practice and implementation of gender-equitable programs other than to avoid stereotyping activities by gender. In fact, even in teacher education texts, gender is barely mentioned. Zittleman and Sadker (2002) found in their content analysis of methods texts that, on average, only slightly more than one percent of content dealt with gender issues. Even more limited are guidelines and recommendations for afterschool programs serving girls with disabilities (Froschl, Rousso, and Rubin, 2001).

A 1992 working paper for the Carnegie Council on Adolescent Development's Task Force on Youth Development and Community Programs by Heather Johnston Nicholson does deal with gender issues in youth development. Her review of the research and literature around gender issues led her to conclude that since more boys than girls associate science and mathematics with males, youth-development programs may need to extend special efforts to encourage girls (and minority boys) to choose and persist in mathematics and science activities. In addition, since boys typically have more experience in mathematics and science outside school, Nicholson advised youth workers to avoid gender stereotypes (e.g., girls are less skilled or interested in math, science, and technology) and be sensitive to "differences in interest and style that may correspond to gender" in planning nonsexist programs involving computers and similar equipment (p. 38). Nicholson also described the large number of adults in out-of-school programs who are unprepared or uncomfortable offering mathematics and science programs as a major challenge in fostering girls' STEM participation and achievement. Other challenges include providing:

* **coed programs that are not predominately male;**
* **exciting opportunities that include girls and take into account different skills and levels of confidence in mathematics and science; and**
* **nonsexist programs that assume everyone is and needs to be good at mathematics, science, and technology.**

In *The Explorer's Pass*, a study of three communities, Girls Incorporated found that, while sexism was often not overt among parents and adults working with youth, there were frequently subtle but pervasive messages of "under-expectation" of girls in terms of mathematics and science; overprotection and "rescue" of girls from making mistakes and assessing risks; and lack of understanding of the important role adults play in encouraging girls' interest in mathematics and science (Weiss, 2001).

Afterschool STEM Program Access Issues for Girls

Scarf and Woodlief's (2000) review of the literature on equity and access in afterschool programs revealed the following "tangible" enrollment barriers that can limit equitable access to such programs:

* **program tuition and fees, lack of financial assistance and scholarships, and the stigma associated with tuition waivers;**
* **minimal or inaccessible transportation to program location;**
* **program location in or near unsafe areas; and**
* **programs inaccessible for young people with disabilities (in terms of accessible facilities and transportation).**

Less tangible access barriers include racism, gender stereotyping, or linguistic homogeneity. Although few have analyzed these access issues as they relate to girls, a few authors identified issues of concern. Quinn found that girls' accessibility can be affected by whether the program has a "welcoming" atmosphere. Similarly, Camino found that programs must be responsive to diverse cultural backgrounds and experiences in terms of staffing, relationships, and activities; and Nicholson found that a staff's "gender-related expectations" can either invite or exclude girls' participation (Scarf and Woodlief, 2000).

In terms of technology, AAUW's Commission on Technology, Gender and Teacher Education recommends creating school-home-community links and partnerships to increase computer access for girls; developing intergenerational learning activities; reconfiguring informal spaces for computers so that all students (not just white males) feel welcome; infusing computing into a range of clubs and activities; offering single-sex programs for girls to socialize and work on computer-related projects together; and starting early (most programs tend to reach out to high school students) (AAUW, 2000).

Measured Outcomes of STEM Afterschool Programs

Historically, the number of studies of afterschool programs in general, and informal science education specifically, have been few (Falk, 2001; Fashola, 1998; Nicholson, Weiss and Campbell, 1994). More recently, there has been a surge of support and funding for afterschool programs (Halpern, 2002; National Research Council and Institute of Medicine, 2002), and research and evaluation efforts on afterschool programs are growing (see Department of Education, University of California at Irvine, 2001; Huang et al., 2000; Policy Study Associates, 2001; Schinke et al., 2000; Warren et al., 1999). Recently, the Harvard Family Research Project embarked on an effort to support and disseminate information related to the afterschool field through its Out-of-School Time Learning and Development Project. As part of this effort, the project has established a publicly accessible database of profiles of out-of-school-time evaluations (Harvard Family Research Project website, *http://www.gse.harvard.edu/~hfrp*, accessed May 2002). Nonetheless, attention to afterschool programs with STEM-related activities and objectives and gender-related outcomes remains limited.

Afterschool programs face numerous challenges in evaluating program effectiveness and outcomes. First, participants are difficult to keep track of long enough to evaluate. It is also difficult to develop instruments sensitive enough to measure program outcomes and determine if changes in youth attitudes, behaviors, and knowledge are a result of exposure to the program or other factors such as school and home environments. Further, most studies of afterschool program effects suffer from selection bias and have difficulty establishing an appropriate comparison group. Evaluation can also be burdensome on participants and program staff, and resources for evaluation are often scarce (Crane et al., 1994; Fashola, 1998).

Of the programs that have been studied, measured outcomes included the following:

* **extent to which participants have practical, hands-on experience with scientific materials and concepts;**
* **youth attitudes and enthusiasm about, and interest in, mathematics and science;**
* **confidence in scientific ability;**
* **performance in scientific subjects (both in terms of process and content);**
* **persistence in the scientific pipeline; and**
* **increased participation of underrepresented groups in the scientific field (see Clewell, 2000; Crane, 1994; Fashola, 1998; Nicholson, Weiss and Campbell, 1994).**

Examples of STEM Programs with Evidence of Success

The following section provides brief summaries of afterschool programs, extended-day, or enrichment activities with a focus on STEM subjects. The programs profiled below were selected because research and evaluation has shown some evidence of success in terms of achieving desired program outcomes. However, the reader is cautioned that this list is not exhaustive, and findings were summarized from the programs' publications and reports or other publications (e.g., American Youth Policy Forum's study of successful youth programs). We did not assess the appropriateness of methods used or validity of the resulting conclusions. Programs are presented in alphabetical order.

AFTER-SCHOOL SCIENCE PLUS

After-School Science PLUS (AS+) is a hands-on, equity-based program for youth ages 5 to 14 in afterschool settings. Based on the Playtime is Science[1] in-school curriculum for grades K-3, AS+ uses "fun, hands-on, developmentally appropriate science activities to bring science to a broader range of students and parents" (Campbell, Acerbo and Hoey, 1999). The inquiry-based physical science activities support the national standards for science and literacy and focus on equity issues, role models, careers in science, and literacy connections. An evaluation using a pre-post design showed that after participating in AS+, student attitudes about science became more positive and less stereotyped: they were more likely to say "Everyone does science" and more accurately responded to the question, "What is science?" Evaluators found that staff who participated in training to implement AS+ were more effective than those who had not (Campbell, Acerbo, and Hoey, 1999).

AUSTIN YOUTH RIVER WATCH PROGRAM

The Austin Youth River Watch Program (AYRWP) has three major goals: to improve water quality of the Colorado River; reduce student dropout rates through positive role-model interaction; and increase the participation of minority students in environmental issues and science and mathematics careers (Turner, 2001). At-risk middle and high school students in this afterschool program learn about mathematics, science, and English through hands-on activities, such as conducting water-quality tests, writing reports to the Lower Colorado River Authority, and making presentations on their data. In addition, older students mentor and tutor younger participants in mathematics and science. Students are paid for conducting water-quality tests and conducting tutoring sessions. Evaluation findings showed that AYRWP participants:

* **believed they knew more about water pollution issues, environmental issues, and science because of their participation;**
* **reported that the program helped them become more interested in environmental issues and more aware of and interested in careers in science;**
* **had more regular school attendance than a comparison group of students;**

[1] Playtime is Science was identified by the U.S. Department of Education as a "promising program" promoting gender equity in education in 2001.

* **stayed in school despite being identified as "severely at risk for dropping out of school"; and**
* **had comparable or higher grade-point averages than students districtwide.**

The 2000-01 evaluation, conducted by the Austin Independent School District's Office of Research and Evaluation, concluded that the positive outcomes of AYRWP provided evidence that student mentoring "within authentic, situated-learning activities" is an effective model for addressing the needs of at-risk youth (Turner, 2001).

EUREKA!

EUREKA!, a component of Girls Incorporated's Operation Smart, is a summer and school-year program that uses sports and the opportunity to be on a college campus as "hooks" to attract girls in the middle grades to the sciences. It targets girls of color and those from low-income families. (Campbell, Storo, and Acerbo, 1995). Key components of the model include a college campus location, individual and group sports, career-related field trips, hands-on mathematics, science and computer experiences, and health and sexuality education. An evaluation of EUREKA! showed that girls who participated in some sites increased the number of mathematics and science courses they planned to take and were more interested in careers in science compared with a control group. In addition, EUREKA! participants were more likely to see themselves as assertive (e.g., less likely to describe themselves as "not a leader" and more likely to speak up and challenge teachers) than the control group (Campbell, Storo, and Acerbo, 1995). Another evaluation showed that EUREKA! participants were more likely than comparable national samples to take four years of high school mathematics and science, enroll in college, and participate in sports (Clewell, 1992, cited in Nicholson et al., 1994). Campbell, Storo and Acerbo (1995) found that programs where the classes were less school-like, involving more hands-on and group work, and where the girls identified with their instructors appeared to have the most impact.

FIFTH DIMENSION

The Fifth Dimension (5D) is a computer-based, afterschool program for elementary school children. In an informal environment, participants progress through a "maze" of tasks, including computer games and educational activities. Participants decide on goals for their journey through the maze and make decisions, such as where to begin, which activities to participate in, and how long to participate. A key component of the program is a "wizard" (an undergraduate student) with whom students communicate using a word processor. Activities often require collaborative groups. Several studies of the program compared regular participants in 5D clubs (more than 10 visits) with similar students who were not regular participants on computer literacy, comprehension, and problem-solving skills, and improvement in standardized test scores over the course of an academic year. In every case, regular participants outperformed their peers. The authors of the study concluded that participation in an "educational computing environment results in learning that goes beyond simple retention of specific computer facts and procedures and that "experience with educational technology (in informal, collaborative learning environments) can promote important cognitive changes in children" including improved problem-solving and language comprehension skills (Mayer, Schustack and Blanton, undated).

GATEWAY TO HIGHER EDUCATION PROGRAM

Gateway, a program for minority high school students, offers an extended-day and school-year program; a rigorous academic curriculum with separate mathematics and science classes; information and support for college applications and internships; and enrichment experiences in the sciences and arts (Campbell et al., 1998). An evaluation of the program showed that participants had higher high school graduation rates; greater completion of academic high school science and mathematics courses; better SAT scores; and greater college attendance rates than a control group of similar students who were not in the program (Campbell et al., 1998). Factors cited as contributing to these positive results included:

* **carefully selected, qualified staff;**
* **a focus on strategies likely to produce immediate results;**
* **developing a sense of connection between students, teachers and directors; and**
* **high expectations, a peer culture supportive of achievement, appropriate equipment in laboratories, and access to information about colleges (Jurich and Estes, 2000).**

HANDS ON SCIENCE OUTREACH

Hands on Science Outreach (HOSO), a once-a-week afterschool program for students in pre-kindergarten through grade 6, provides youth with recreational hands-on activities, collaborative learning opportunities, and materials and activities for use at home with parents. The program is designed to stimulate students' awareness of "science in [their] life" (Goodman and Rylander, 1993). A 1993 outcome study[2] of HOSO found that children participating in the program made statistically significant gains in their understanding of what science involves and improved their perceptions of who can do science compared with a comparison group of children. Evaluators also reported that HOSO participants said they enjoyed the program and would recommend it to their friends. However, neither the HOSO participants nor the comparison group made gains on a problem-solving task or showed improvement in their understanding of what is needed to do science. No gender differences were seen in these outcomes. The study's authors found that quality of staff ("well prepared for activity"; "feels comfortable in what she/he is doing"; "allows children to explore and come to their own conclusions rather than directing children to answers") had a positive impact on participants' experience.

MATHEMATICS, ENGINEERING, SCIENCE ACHIEVEMENT

Mathematics, Engineering, Science Achievement (MESA) offers academic and financial counseling, student-centered classes, and enrichment activities for middle and high school students. Evaluation findings showed that MESA students were much more likely to complete advanced high school mathematics, chemistry, and physics courses than all California high school students—and Black and Latino students in particular—were to even enroll in those courses (California Postsecondary Education Commission, 1996). It also showed that while half of MESA participants reported that their grades had not improved because of the program, they continued to take advanced mathematics and science courses. The study authors suggest that MESA activities and support led to increased confidence and perseverance in these courses.

SAY YES TO FAMILY MATH/SCIENCE

The National Action Council for Minorities in Engineering's (NACME) SAY YES to Family Math/Science program is an afterschool program for elementary school-aged students and their families in New York City. The goal of the program is to motivate young children and parents to explore and experience mathematics and science in a fun environment. The afterschool sessions include hands-on family involvement activities and emphasize cultural heritage and career connections. In a two-year study of the program, evaluators reported that students said they enjoyed Family Math/Science much more than their science and mathematics classes in school because they were able to "make projects and did not have to just read text books." Further, students reported that their parents helped them more at home with their school work and other learning activities after having attended Family Math/Science. Parents confirmed this, reporting that they more

[2] A new research report will be available in summer 2002.

frequently worked on school assignments with their children and incorporated learning experiences into their daily interactions with them. Further, almost all participating parents noted that Family Math/Science helped them improve their own skills, making it easier for them to help their children. Finally, parents reported that their children's grades and test scores in mathematics and science, as well as their attitudes towards those subjects and school in general, had improved (Academy for Educational Development, 1996). Weisbaum's study of a similar Family Math project developed by the Lawrence Hall of Science in Berkeley California also showed positive effects on parents' and students' attitudes about mathematics (Nicholson et al., 1994).

VOYAGER

The Voyager program has been implemented as a before- and after-school program as well as summer and intersession program. The hands-on, "adventure-based learning experiences" curriculum is organized around themes; it includes many STEM subject areas, such as mathematics, business, biology, astronomy, physics, archaeology, anthropology and health, as well as reading and history. Characteristics of the program include increased learning time, use of high-quality teachers, small classrooms, collaborative learning approaches, and a learner-centered curriculum and instruction. Teachers who implemented the summer program participated in 12 hours of training and received a step-by-step curriculum guide. An evaluation of the summer program implemented in New York City, Washington D.C., and Houston, Texas showed statistically significant improvement in participants' basic reading and mathematics skills (Roberts, 2000). Specifically, students who attended at least 90 percent of classes made the equivalent of a six- to nine-month academic gain over the course of the 23-day program.

Summary

Women and girls are now doing as well or better than their male peers in many areas of educational achievement and attainment. However, they still lag behind males in some aspects of mathematics and science achievement and in terms of advancing through the scientific educational "pipeline," entering STEM careers, and advancing within these careers. Further, there is a paucity of research conducted with girls of different backgrounds (e.g., girls of diverse racial/ethnic or language backgrounds), as well as girls with disabilities.

The research does point to several effective approaches to teaching girls STEM subjects, such as hands-on activities, emphasis on practical applications, use of role models and mentors, and career exploration. The long-term impact of these practices on girls' continuation in advanced degree programs and STEM careers is less clear. Research on differences in learning and cognitive styles for boys and girls is also unclear.

Further, research on afterschool programs is fairly limited—but growing—and faced with daunting methodological challenges. What we do know about afterschool programs is that those with a youth-development focus (e.g., viewing youth as "resources" and providing youth-centered activities and leadership roles for young people) have been effective in improving a range of outcomes for youth. Further, several afterschool programs that specifically address STEM subjects have been effective in improving students' attitudes about and understanding of science, as well as improving youth outcomes such as completion of mathematics and science courses; reducing dropout and retention rates; improving reading and mathematics test scores; and increasing college attendance. Characteristics common to several of these effective programs include exposure to hands-on, collaborative activities; a connection between the program and home; high-quality and trained staff; and environments that are less school-like and where students receive support from and develop meaningful connections to adults.

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Attachment

KEY STATISTICS ON THE STATUS OF GIRLS AND STEM

The following provides a summary of key statistics related to the status of girls and STEM. They are organized around five issues:

- **The current state of girls' achievements in STEM**
- **Gender gaps in STEM achievement**
- **Gender gaps in participation in STEM academic programs**
- **Gender gaps in participation in STEM careers**
- **Earning gaps for women in STEM careers**

CURRENT STATE OF GIRLS' ACHIEVEMENTS IN STEM

Most girls' mathematics and science skills are not at proficient levels. The percentage of girls scoring at or above proficient levels on the National Assessment of Educational Progress (NAEP) mathematics and science exams decreases substantially by 12th grade.

Science

- **26% of 4th grade girls, 27% of 8th grade girls, and 16% of 12th grade girls scored at or above proficient on the NAEP science exam in 2000.**

Mathematics

- **24% of 4th grade girls, 25% of 8th grade girls, and 14% of 12th grade girls scored at or above proficient on the NAEP mathematics exam in 2000.[2]**

GENDER GAPS IN STEM ACHIEVEMENT

Girls continue to lag behind boys in science in grades 4 and 8, and in mathematics in grades 8 and 12.[3]

Science

- **In 2000, males outscored females on the NAEP science exam in grades 4 and 8; the difference at grade 12 was not statistically significant. The gap was largest for grade 8: 27% of females and 36% of males scored at or above the proficient level in this grade.[4]**
- **In 2000, Asian/Pacific Islander and white students had higher scores, on average, than Black or Hispanic* students.[5]**

Mathematics

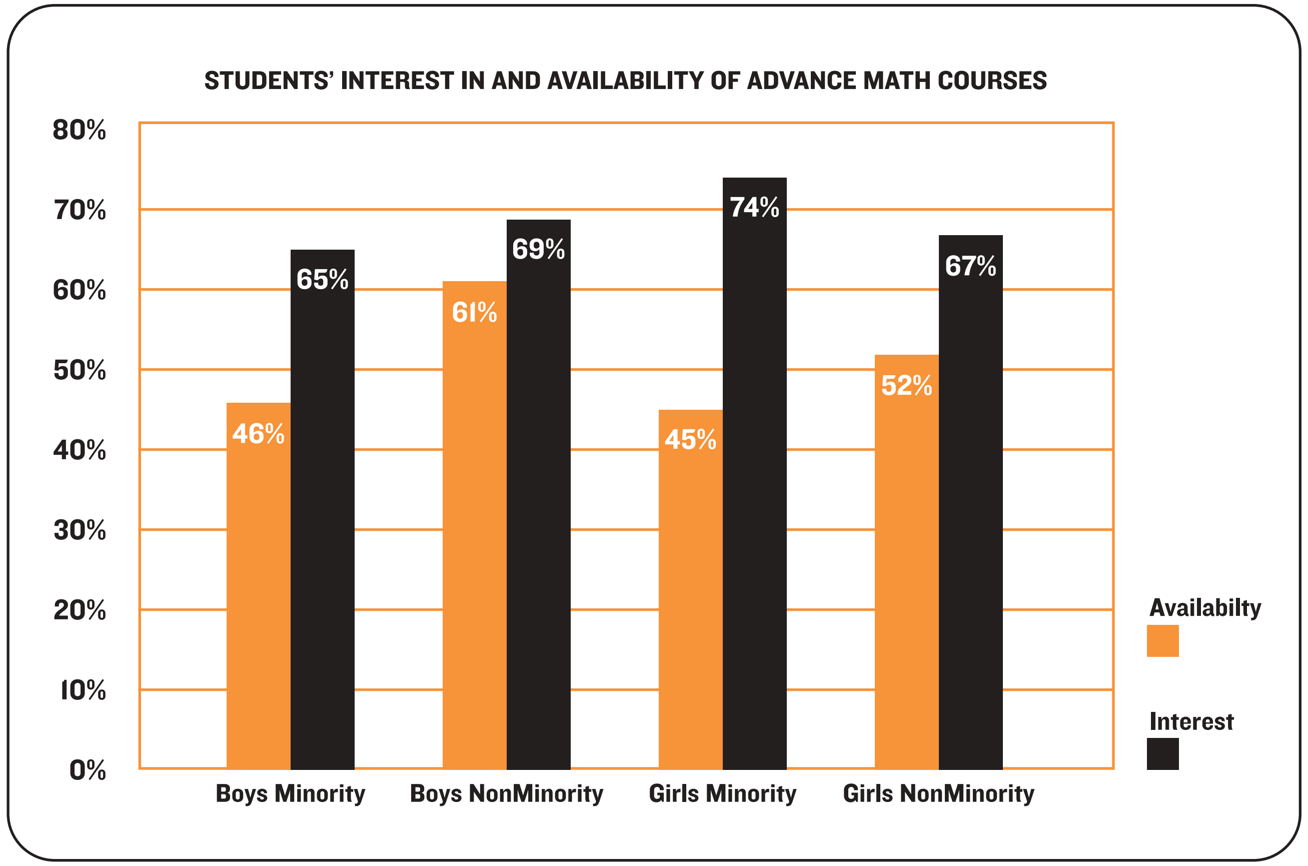
- **In 2000, males outscored females on the NAEP mathematics exam in grades 8 and 12; the difference at grade 4 was not statistically significant. The gap was largest for grade 12: 14% of females and 20% of males scored at or above the proficient level in this grade.[6]**
- **In 2000, Asian/Pacific Islander and white students had higher scores, on average, than Black or Hispanic students.[7]**

GENDER GAPS IN PARTICIPATION IN STEM ACADEMIC PROGRAMS

Mathematics and Science Course-Taking

- **Among college-bound seniors who took the SAT, nearly equal percentages of white, Black, and Asian/Pacific Islander college-bound girls and boys took four years of high school mathematics in 1999. A gap of 3 to 4 points existed between Hispanic males and females.[8]**
- **Among college-bound seniors who took the SAT, nearly equal percentages of white, black, American Indian, Mexican/Mexican American, and Asian/Pacific Islander college-bound girls and boys took four years of high school science in 1999. A gap of 3 to 4 points existed between Puerto Rican and other Latino/a students.[9]**
- **Among 1998 college freshmen, students with disabilities were less likely to have taken the recommended years of high school mathematics, biology, and physical science courses.[10]**

* To be consistent with the way data were reported, the term "Hispanic" is used when reporting NAEP and census data; in all other cases, the term "Latino/a" is used.



Interest in and Availability of Mathematics and Science Courses

A survey conducted by Harris Interactive for NACME of a nationally representative sample of 5th to 11th graders found that interest in taking advanced mathematics courses among minority girls exceeds that of nonminority girls, although the availability of such courses at their school was greater for nonminority girls (see graph above).[11]

The same survey also asked students why they decided not to take mathematics and science classes. Their responses are summarized below:

* They had not done well in other math or science classes (67%).
* They considered math and science classes boring (54%).
* They did not think they needed science and math classes to succeed outside of school (49%).
* Their friends did not take the classes (45%).
* They thought that only unpopular students took lots of math and science classes (40%).
* Their teachers and guidance counselors discouraged them from taking advanced classes (34%).
* Their schools did not offer enough math and science classes (31%).[12]

Students' reports about why they did not take science and math in school can help staff in after-school programs address student perceptions about mathematics and science and encourage girls to pursue such courses.

Computer Science and Technology

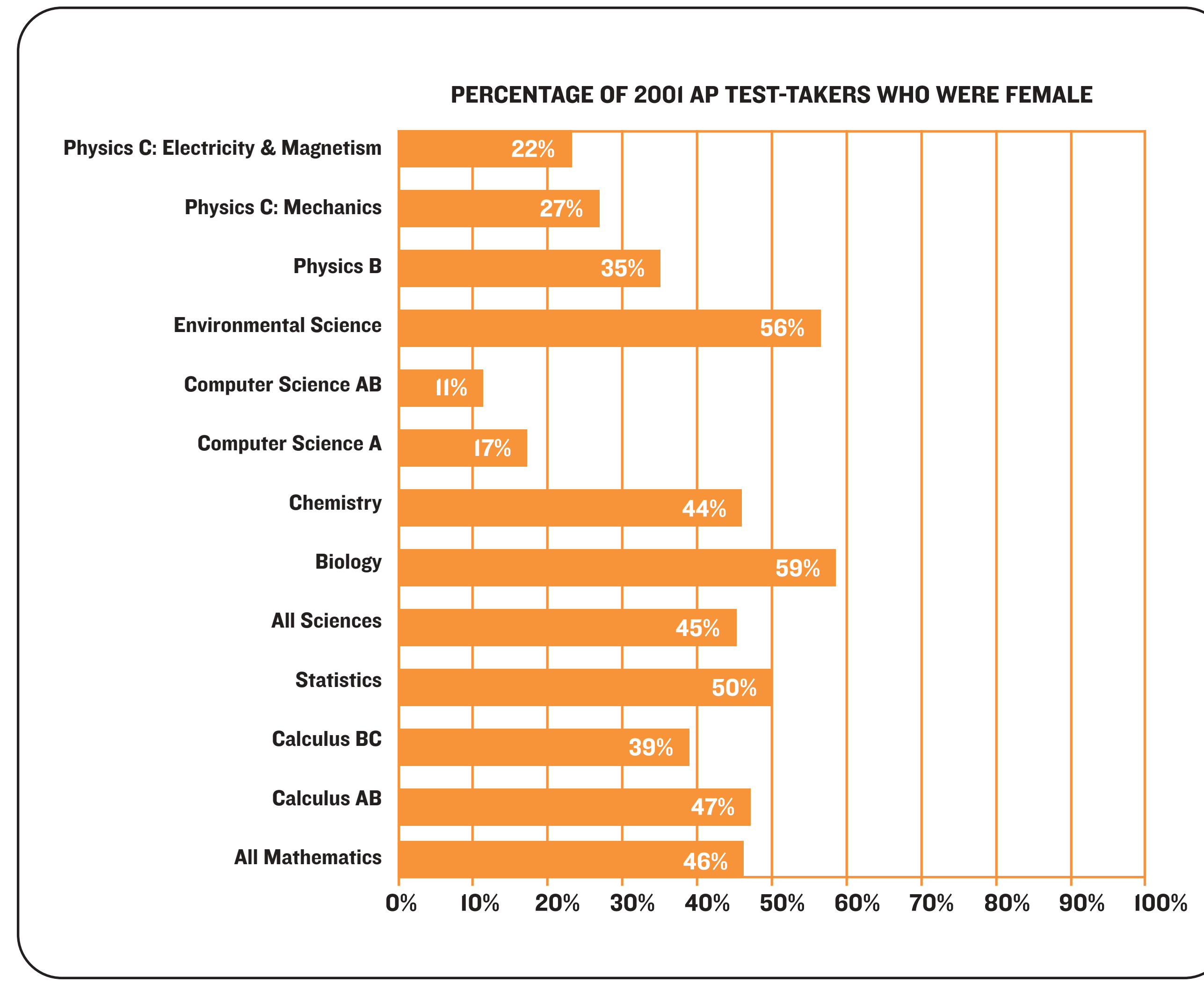
* Female high school graduates were less likely than their male peers (1% vs. 7.4%) to complete introductory technology coursework in high school in 1994.[13]
* Among the high school students who took the SAT college entrance tests in 1998 and 1999, 23% of students intending to major in computer and information sciences were female.[14]

Advanced Placement Test Taking

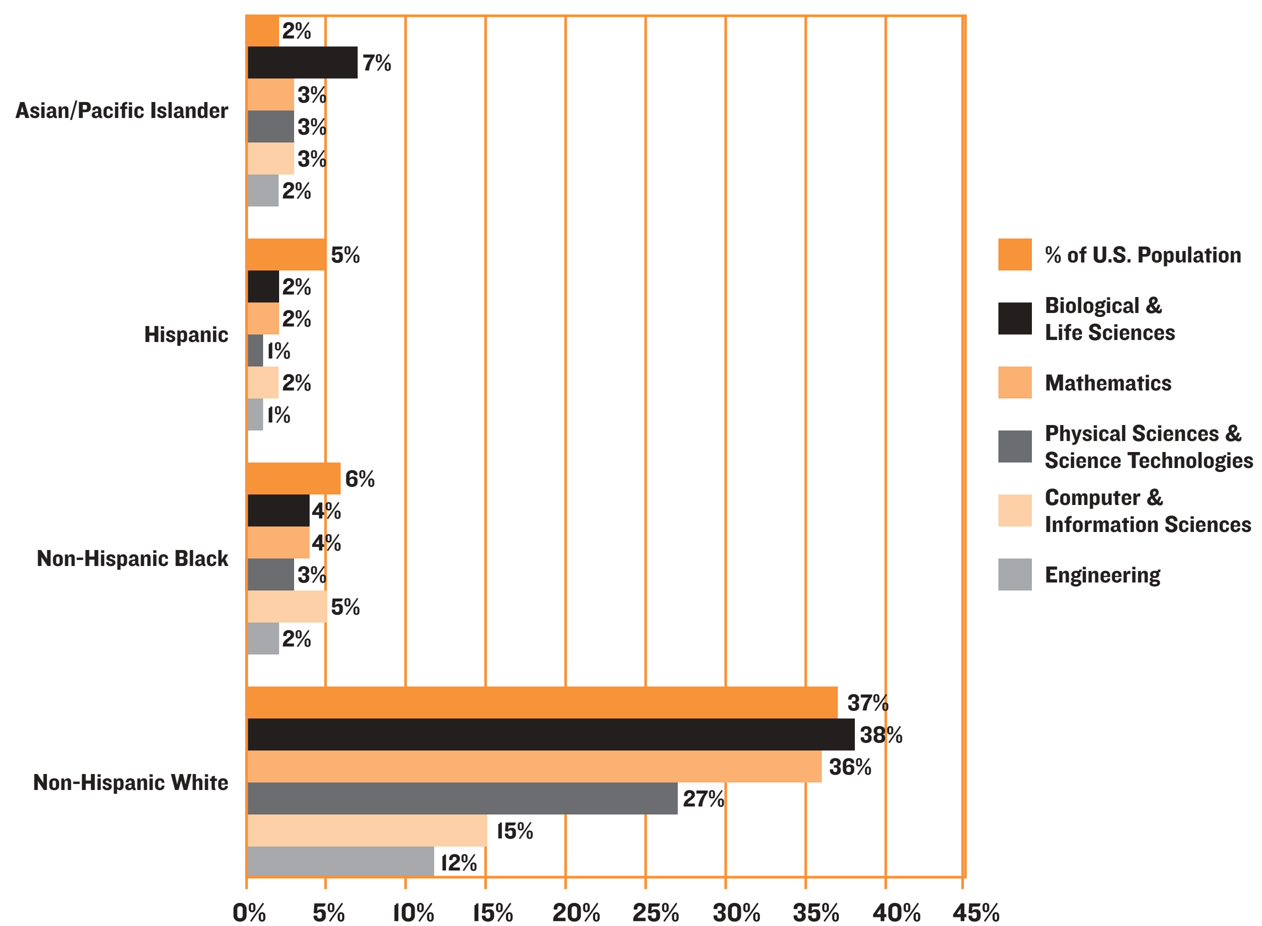
* Overall, 54% of all AP test-takers were female in 2001. However, girls and women are underrepresented in the areas of mathematics (with the exception of statistics) and science (with the exception of biology and environmental science) (see graph below).[15]
* Females were also less likely to receive a score of 3 (scores of 3 or higher usually receive college credit) in science (23 males per 1,000 12th graders vs. 20 females per 1,000 12th graders); in computer science (1 per 1,000 males vs. < 1 per 1,000 females); and in calculus (20 per 1,000 males vs. 17 per 1,000 females).[16] This finding held true for all racial/ethnic groups.[17]
* Across all racial/ethnic groups, more females took advanced placement exams in 1999. The female advantage was largest among African-American students.[18]
* Students with disabilities are less likely than those without disabilities to take advance placement courses.[19]

Postsecondary Education

* In 1996, women earned 47% of bachelor's and 39% of master's degrees, and 33% of doctorates in science and engineering.[20]
* In terms of engineering degrees only, women earned 18% of bachelor's and 17% of master's degrees, and 12% of doctorates.[21]



PERCENTAGE OF WOMEN IN U.S. POPULATION AND AMONG BACHELOR'S DEGREE RECIPIENTS BY RACE/ETHNIC GROUP, 1996



* Substantially more women than men are lost in the "pipeline" to a Ph.D. in science and engineering through attrition.[22]
* Students with disabilities attending two-year postsecondary institutions are slightly less likely than their peers without disabilities to major in a STEM subject. Among those at four-year institutions, students with disabilities are as likely as their peers without disabilities to major in a STEM subject.[23]
* Women of Hispanic, non-Hispanic Black, and non-Hispanic white descent are underrepresented among graduates with bachelor's degrees in mathematics or science (see graph above). Women of Asian/Pacific Islander descent represent the same or greater percentage of these graduates as they do the total U.S. population.[24]

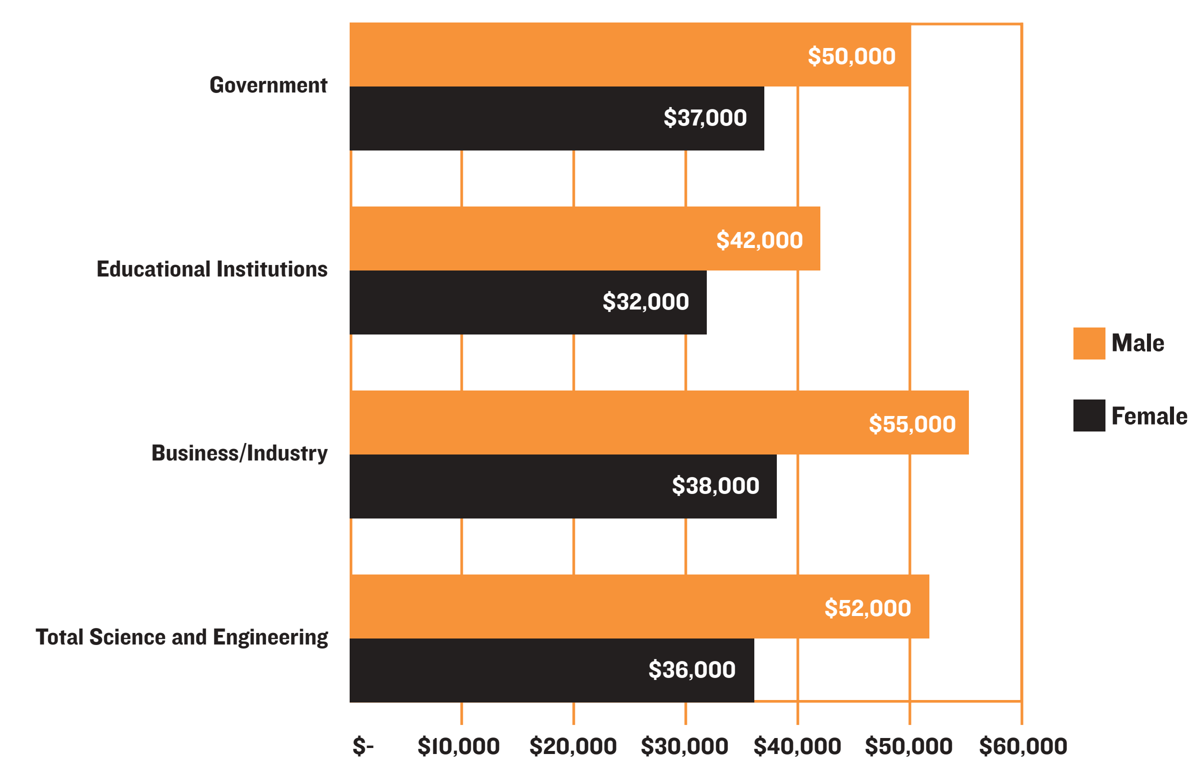
Gender Gaps in Participation in STEM Careers

* In 1997, 23% of scientists and engineers were female. Females comprised 52% of social and related scientists, 36% of life and related scientists, 27% of computer/mathematical scientists, 22% of physical and related scientists, and 9% of engineers.[25]
* Persons with disabilities comprised only 6% of scientists and engineers in the labor force.[26]
* Differences between persons with and without disabilities are small in terms of types of STEM occupations. Similar percentages with and without disabilities were engineers (42% vs. 41%), social scientists (11% vs. 10%), and computer scientists (25% vs. 28%).[27]
* In 1997, minority women accounted for less than 5% of all scientists and engineers in the labor force. Specifically, 1% were Black women, 1% were Hispanic women, 0.1% were American Indian women, and 2% were Asian women.[28]
* Women in science are more than twice as likely to report being unemployed and seeking employment as are men with similar credentials.[29]
* In 1997, scientists with disabilities were much more likely to be out of the labor force (31% vs. 11%) and unemployed (2.7% vs. 1.5%) compared with those without disabilities.[30]

Earning Gaps for Women in STEM Careers

* Women earn considerably less than men in science and engineering careers (see graph below). Controlling for years of experience, sector of employment (private, nonprofit, academic), and work activity (e.g. research, teaching) reduces but does not eliminate salary differences, indicating discrimination in terms of different salaries for equal work as well as different access to higher paying jobs. Among individuals with doctorates in the fields of science and engineering, there was a 21% salary advantage for men in 1995, down from 28% in 1979. Controlling for professional age, sector of employment, and work activity reduces the gap to 6%, with the biggest effects resulting from career age and sector.[32]
* Median salaries of scientists and engineers with disabilities are similar to those without disabilities.[33]

MEDIAN ANNUAL SALARIES OF U.S. SCIENTISTS AND ENGINEERS BY GENDER, 1997



Endnotes

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[3] U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress, 2000 Science and Mathematics Assessments. Retrieved 2/28/02 from http://nces.ed.gov

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[5] Ibid.

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[7] Ibid.

[8] Richard J. Coley, *Differences in the Gender Gap: Comparisons Across Racial/Ethnic Groups in Education and Work* (Princeton, NJ: Educational Testing Services Policy Information Center, 2001).

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About the Authors

Merle Froschl, co-founder and co-director of Educational Equity Concepts, Inc., has 35 years of experience in education and publishing. She has developed outstanding curricular and teacher training models in the field of educational equity and is a nationally known speaker on issues of gender equity and equality of opportunity in education. Ms. Froschl was co-principal investigator of several recent EEC projects: Science, Gender and Afterschool: Creating a Research/Action Agenda; Creating Afterschool Opportunities for Girls in New York City Settlement Houses; and Playtime is Science for Students with Disabilities. She has co-authored and edited a number of teacher's guides, and books, including *After-School Science PLUS: Hands-on Activities for Every Student*; *Playtime is Science: An Equity-Based Parent/Child Science Program*, and *What Will Happen If... Young Children and the Scientific Method* (Educational Equity Concepts). Ms. Froschl has published widely. Recent articles include: "Nothing to Do After School: More of an Issue for Girls"(*Double Jeopardy: Addressing Gender Equity in Special Education*, Albany, NY: SUNY Press, 2001), and "Science Equity in Action" (ENC Focus, September 2000).

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