What We Know about Girls, STEM, and Afterschool Programs

A Summary

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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 found to be related to girls' reduced participation in school science courses (1995). 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 appendix 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, 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 (Hansen, et al., 1995).

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). Again, the research is unclear as to whether there are sex differences in this ability (Clewell and Anderson, 1991). 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 (Leder and Fennema, 1990).

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 study conducted by the American Association of University Women (AAUW, 2000), 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 are 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 (see 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 (AAUW, 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 appendix 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 some learning styles to 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 include opportunities for youth to develop caring relationships with peers and adults and take 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, 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;

- 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).

The American Youth Policy Forum's analysis of nearly 50 youth program and practice evaluations yielded a list of effective program characteristics similar to Eccles and Gootman's above. Specifically, the forum advocates the following principles of effectiveness for youth programming and practice based on their analysis:

- 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, and work-based learning (James and Jurich, 1999).

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 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 (Scarf and Woodlief, 2000). In fact, even in teacher education texts, gender is barely mentioned. Zittleman and Sadker found in their content analysis of methods texts that, on average, only slightly more than one percent of content dealt with gender issues (2002). 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 (Nicholson, 1992).

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 for example, 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, 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, for example, 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;
- 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.

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

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.

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

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 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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Appendix

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.[1]

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]

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* 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.

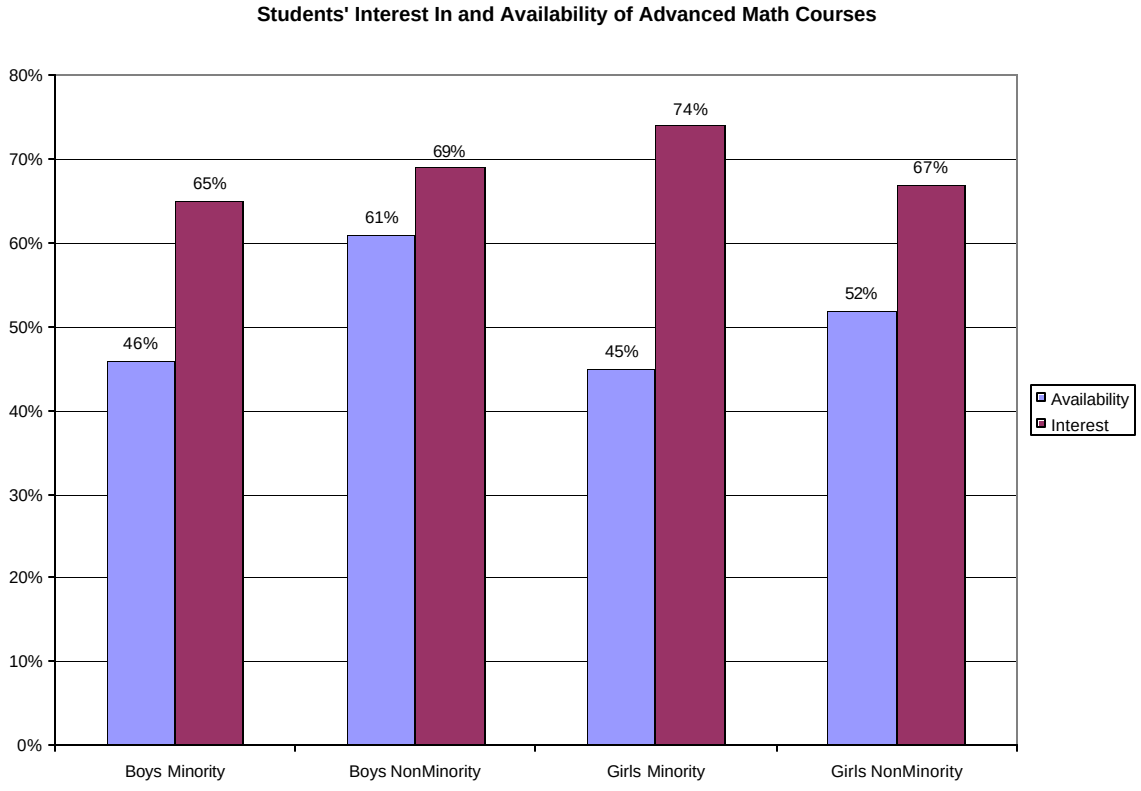
Gender Gaps in Participation in STEM Academic Programs

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]

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. [11] (See graph below.)



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]

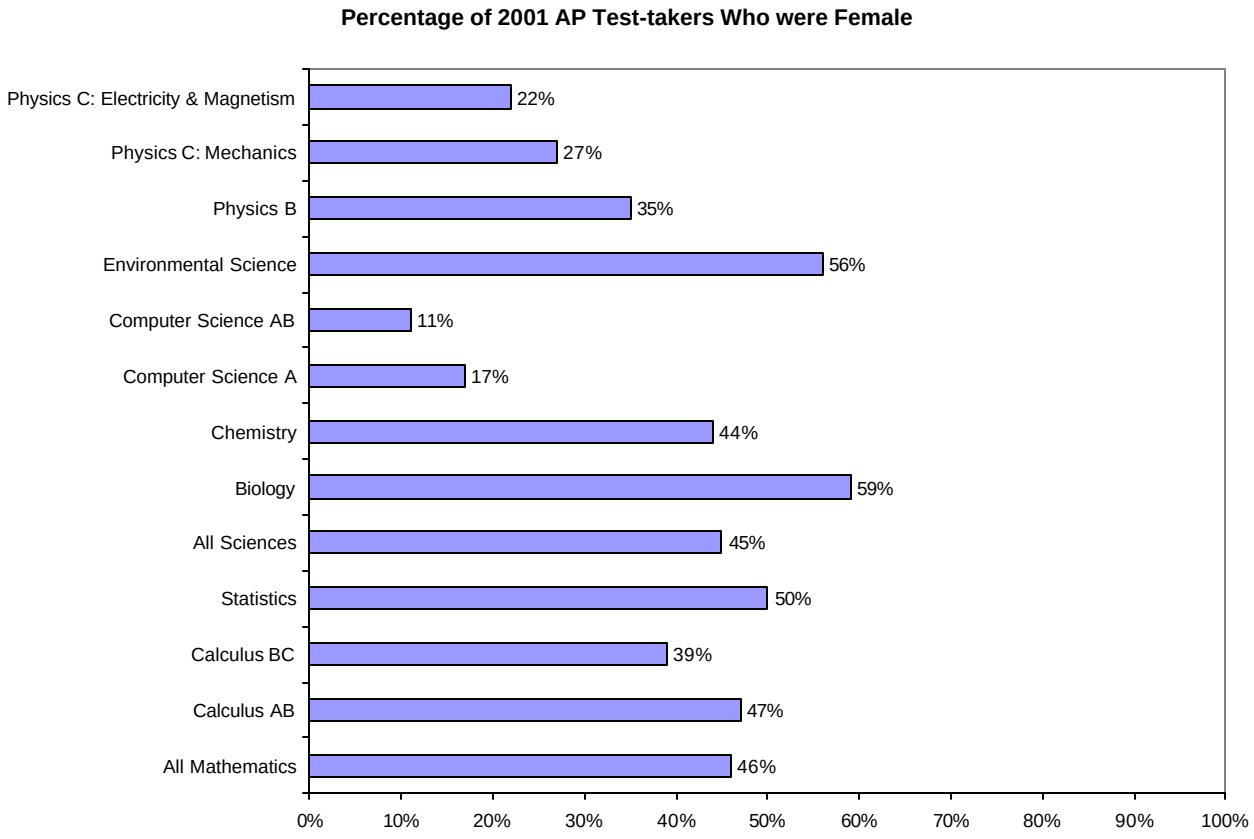
Students' reports about why they did not take science and math in school can help staff in afterschool programs address student perceptions about mathematics and science and encourage girls to pursue such courses.

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 women.[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).[15] (See graph below).



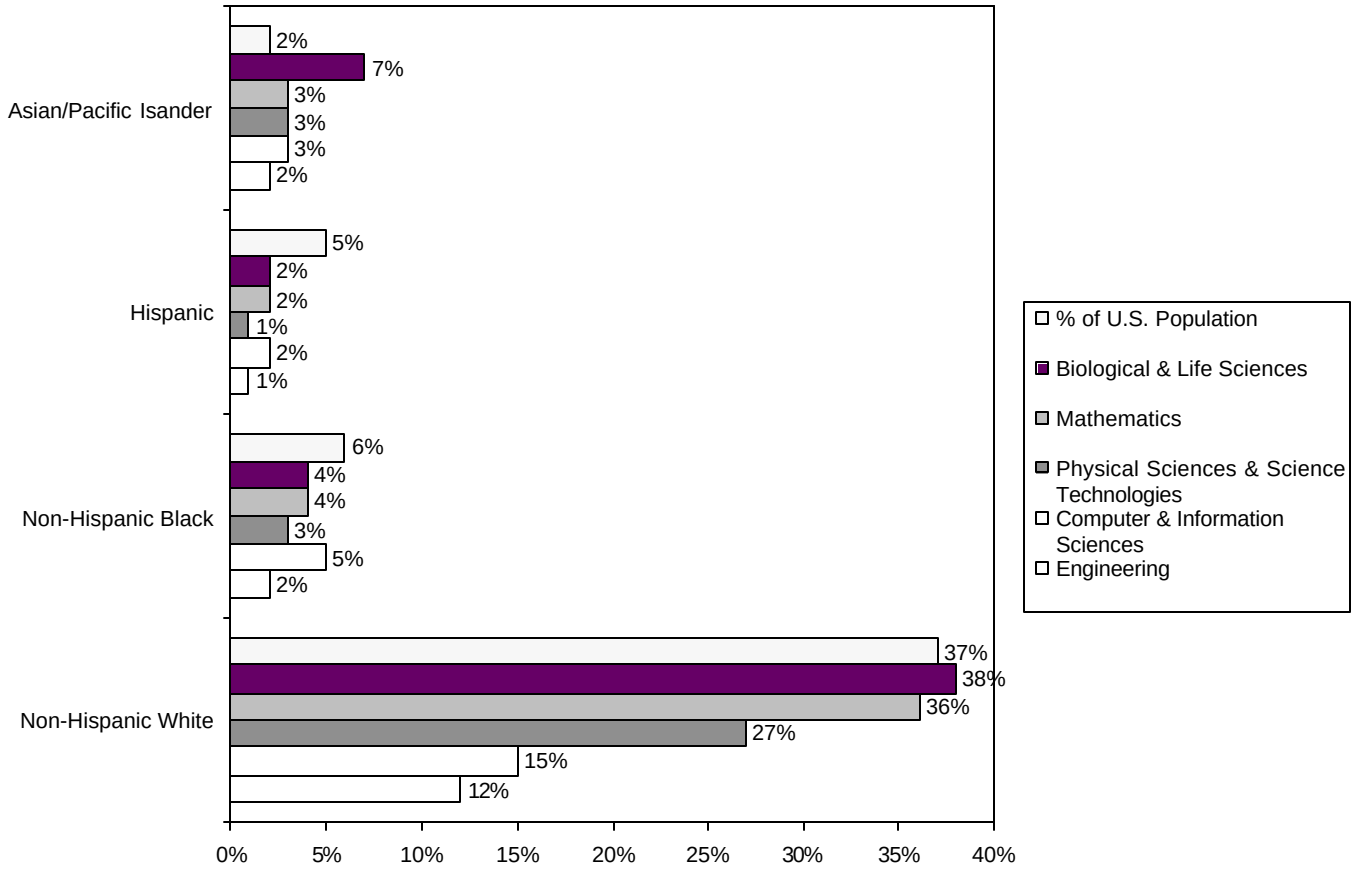
- Females were also less likely to receive a score of 3 (scores of 3 or higher usually receive college credit) in science (23 males per 1,000 12th graders versus 20 females per 1,000 12th graders); in computer science (1 per 1,000 males versus < 1 per 1,000 females); and in calculus (20 per 1,000 males versus 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]
- 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 below). Women of Asian/Pacific Islander descent represent the same or greater percentage of these graduates as they do the total U.S. population.[24]

Percentage of Women in U.S. Population and Among Bachelor's Degree Recipients,by Race/ethnic group, 1996



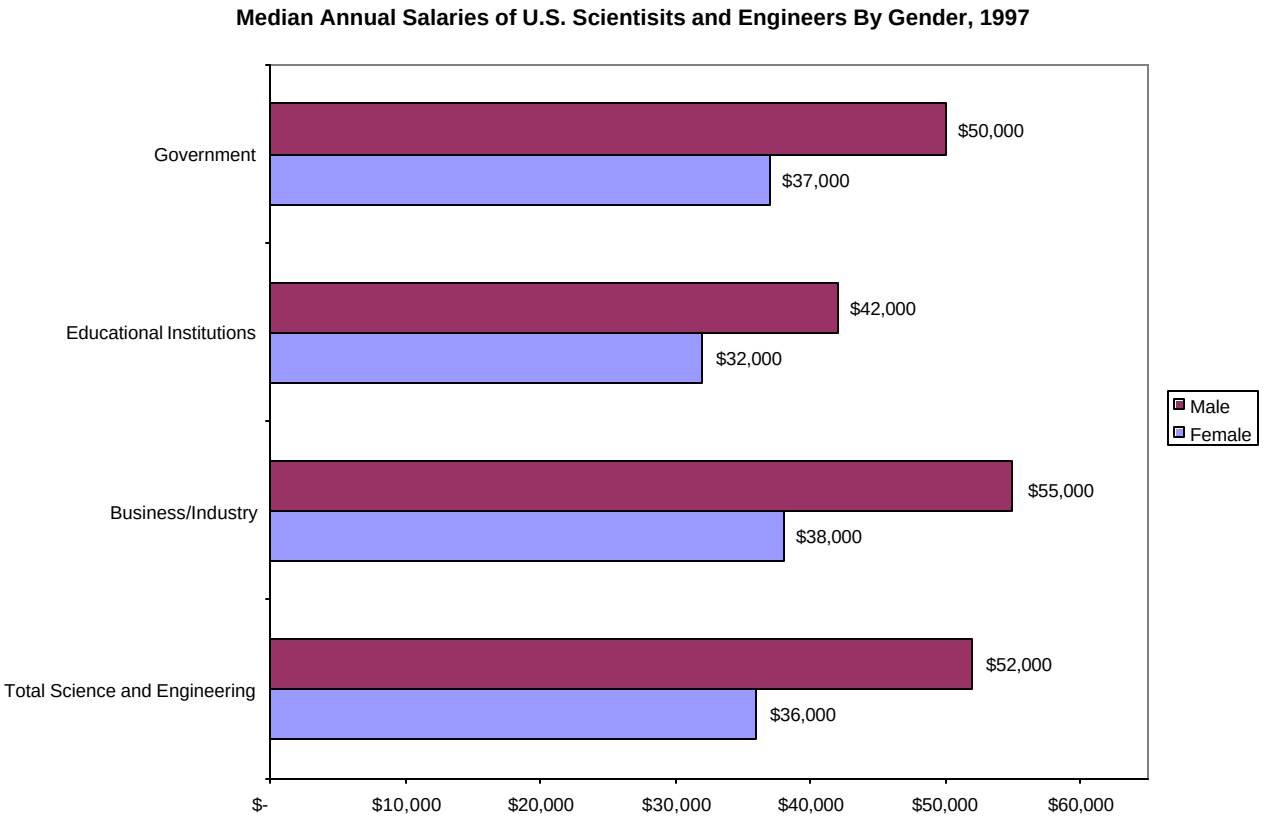
Gender Gaps in Participation in STEM Careers

- 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% versus 41%), social scientists (11% versus 10%), and computer scientists (25% versus 28%).[27]

- In 1997, minority women accounted for about 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% versus 11%) and unemployed (2.7% versus 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).[31] 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 from resulting from career age and sector.[32]
- Median salaries of scientists and engineers with disabilities are similar to those without disabilities.[33]



Endnotes

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