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ABSTRACT

This paper describes an intergenerational science program called Sisters in Science which fosters girls' interest and achievement in science. The program is designed to encourage and prepare girls and women for careers in math, science, and technology. A group of fourth grade girls from 19 classrooms across 6 elementary schools met once a week after school. The girls participate in gender-sensitive, constructivist, integrated mathematics and science instruction; 2 hours of instruction from preservice teachers from Temple University; and a 2-week summer camp experience. Findings suggest that the girls in the program increased their interest and achievement in science and mathematics. Data supports a positive pattern of change in the girls' science/math and language skills as evidenced by their class participation and the writing in their science journals. In addition, three policy and practical implications are cited from the study. First, programs must involve parents in the effort to foster the success of young females in science and mathematics. Second, involving intergenerational role models in school science and mathematics enhances female achievement in science and mathematics. And finally, program interventions evolve in stages of development, growth, and change. (Contains 52 references.) (CCM)

Sisters in Science:

An Intergenerational Science Program for Elementary School Girls

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Running Head: SISTERS IN SCIENCE

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Sisters in Science:

An Intergenerational Science Program for Elementary School Girls

Sisters in Science **like many other programs aimed at fostering girls interest and achievement in science, is designed to encourage more girls and women to prepare for the careers in math, science and technology that will dominate the 21st century.**

Introduction

A group of fourth grade girls are standing in an empty lot near their school. One girl asks, "How can we find out what used to be on the lot?" The girls begin to discuss the question in small groups. After a few minutes, the teacher asks the girls to share their thoughts regarding to the question. "We should ask my grandmother," one girls says. "We should go to the lot and dig," another girl suggests. As the girls share their ideas, a volunteer records their responses. After the girls have given all of their ideas, the teacher invites them to comment on the suggestions that they think will work best. They take a vote to reach a consensus. After the vote, there are three clear favorites. The girls have decided that they will (1) interview two grandparents who have lived near the lot all their lives to the class, (2) write a letter to the Temple University Department of Archeology to request that an archeologist consult with them on how to perform a dig, and (3) visit the Temple University Archives to research what was previously on the lot.

The girls, the teacher and the volunteer are all part of a program known as Sisters in Science. Those that observe the inner workings of the *Sisters in Science* program are impressed by the purposeful "busyness" of the girls. It is obvious that careful planning has resulted in a learning environment in which girls discover relationships and build knowledge bases and, at other times, apply knowledge in ways that are both appropriate and meaningful to their personal lives. Throughout the program, girls are working individually as well as in small groups or large groups. Parents and volunteers from the science community observer and participate in the learning process. Teachers demonstrate a contagious joy of life-long learning and teaching.

So once a week, fourth grade girls from 19 classroom across 6 elementary schools in Philadelphia, attend the after school component of the *Sisters in Science* program aimed at nurturing their interests, attitudes and career aspirations. These girls may be only 9 years old, but they are pretty sure what they want to be when they grow up. Some want to be ecologists, nurses or medical doctors. Others want to be engineers or veterinarians. Sisters in Science helps these girls to realize their goals by providing them with a 90 minute after school activity once a week. While the girls are in school they receive gender sensitive constructivist integrated mathematics and science instruction. In addition, for 2 hours once a week these girls and their male cohorts are presented with the same brand of instruction from Temple University preservice teachers. The girls also participate in a two week summer camp experience in which they explore the waterways of Philadelphia. Throughout the year girls interact with intergenerational volunteers in school, after school and during the summer. Finally, each after school participant explores various science and mathematics concepts with their respective caregivers through take home extensions and quarterly family events.

Barriers in Their Minds

Shirley M. Malcolm, of the American Association for the Advancement of Science (AAAS), said in her keynote address at the American Association of University Women (AAUW) conference "Girls Succeeding in Science, Math, and Technology: Who Works and What Works,"

"The effort to equalize educational opportunities for girls is far from complete." She notes, "Unlike some other nations, female students in the United States are legally guaranteed access to math and science courses. While our legal barriers to this education have been removed, there are often still barriers we face, these are 'barriers of the mind."(Malcolm, speech AAUW)

Many barriers still exist that prevent females from participating fully in science and mathematics throughout their lives. The organizational characteristics of science and mathematics play important roles in diminishing the achievement of females in science and mathematics (Bleier, 1984; Harding, 1986; Kahle and Meece, 1984; Keller, 1985, 1986, AAUW, 1990). Other researchers agree that females' perceptions about science and mathematics act as barriers to females' expressing interest in science and mathematics in school (Baker & Leary, 1995; Kelly, 1985; Shroyer, Powell, & Backe, 1991). Also, the perception that science and mathematics are masculine domains discourages females' from choosing science and mathematics related careers (Kelly, 1985).

In addition to females perceptions about science and mathematics, researchers have found that while both boys and girls enjoy math and science in elementary school, girls' interest and confidence in their abilities to excel in those areas declines sharply during adolescence. This is particularly true among females from economically and educationally disadvantaged families who have limited access to educational resources and are often forced to cope with stressful life experiences (Kueftle, Rakow, & Welch, 1983; Mullis & Jenkins, 1988' Schibeci & Riley, 1986; Simpson & Oliver, 1990; Vetter & Babco, 1989; Ware & Lee, 1988). For example, the AAUW's 1992 survey "Shortchanging Girls, Shortchanging America" reported that the percentage of girls who said they enjoyed math dropped from 81% in elementary school to 61% in high school.

The report found that girls were frequently discouraged from exploring fields such as math, science, and technology, often unintentionally, by parents and teachers who steered them toward traditional female occupations. For example, the National Science Foundation reported that women made up about half of those working in the social sciences, but accounted for only 8 % of the nation's engineers. The AAUW's report also uncovered a strong link between females students' confidence in their mathematics and science abilities and overall self-esteem.

The study noted, "As girls learn, they are not good at these subjects, their sense of self-worth and aspirations for themselves deteriorates." Similarly, the AAUW research found that both girls and boys "who like math and science have higher self-esteem, greater career aspirations, and are more likely to hold onto their dreams. Therefore, it is imperative to continue to instill positive accessible images about science and mathematics in the minds of girls. Positive perceptions will in turn lead to greater female participation in science and mathematics with respect to academic endeavors and career aspirations.

Barriers In The Classroom

Another line of research on gender inequity in science and mathematics focuses on the classroom environment. Studies have suggested that within classrooms, males and females receive a very different education (Jones & Wheatley, 1990). Girls have less exposure to science equipment than do boys. Girls also become less active in science classes as they progress through the grade levels (Klein, 1991).

One cause of disparities in the classroom is that teachers' beliefs about students' abilities affect the manner in which female students operate in the classroom (Shepardson & Pizzini, 1992). Such research identifies teachers as the agents of gender bias. Jones and Wheately (1990) looked at a variety of teacher behaviors during science instruction. They concluded that the manner in which the teacher praised students, responded to call outs, warned students, and questioned students differed by gender.

Female students also tend to differ from their male cohorts in their receptivity to and participation in science education. It has been noted that female students contribute less often to classroom discussion than their male classmates do. In fact, girls' conversations and the matters with which they concern themselves (i. e., interactional issues) are different from those of boys (Theberg, 1993). Finally, currently implemented science education, which is often competitive and individualistic, runs counter to female learning styles that are more cooperative and interdependent in nature. Shakeshaft (1995) says that science education classes have expectations that simply exclude girls leading to lower participation and achievement.

A girl's perception of science also contributes to inequity in achievement. It has been found that female students harbor stereotypical ideas about science and scientists. They often feel that science is a male dominated field (Hammrich, 1996). A meta-analysis (Weinburgh, 1993) of the literature on gender difference in students' attitudes toward science as well as the correlation between students' attitudes about science and their achievements in science. Weinburgh concluded that boys are more positive about science. Also, positive attitudes about science result in high achievement (Weinburgh, 1995).

Reformists believe that there are some essentials to encouraging female student success in the classroom. They include fostering a safe and nurturing environment, promoting problem-solving skills, creating collaborative experiences, using hands-on learning and allowing for open discussion about gender stereotypes (Allen, 1995; Mann, 1994).

Boland (1995) offers a set of strategies to promote gender equity in science and mathematics classrooms, shown in the following abbreviated list:

- Set goals
- Accept more than one right answer,
- Create equitable turn taking and use peer tutoring.
- Link math with careers in science,
- Display images of males and females in career roles.
- Utilize cooperative learning strategies
- Assign tasks equally,
- Monitor groups for equity,
- Vary teaching techniques
- Tap students learning styles,
- Encourage problem solving.
- Explore career options

Imparting gender-sensitive instruction is another way in which some researchers are addressing the issue of inequity in the classroom. In order to create gender-sensitive learning its necessary for educators to deal with issues pertaining to girls and their education rather than merely equalizing the treatment of males and females (Martin, 1996). Several strategies have been offered by Martin to ensure a gender-sensitive classroom. The first is to utilize female-appropriate teaching, learning strategies and approaches to science. The second is to address the needs and experiences of girls. The third is to emphasize the importance of the social dynamic in the construction of the classroom environment. The fourth is to acknowledge the contributions and barriers of women in science. The fifth is to incorporate the impact of private and personal aspects of girls' lives on their educational experiences. The sixth is to remove the barriers that prevent girls from pursuing careers in science (Martin, 1996).

Pedagogical Focus

The female-friendly instructional strategies, spoken about in Martin (1996), are essential to science learning for girls. Constructivism, an epistemological perspective of knowledge acquisition, serves as the foundation for many of the aforementioned suggestions regarding science and mathematics education reform. By definition, of which there are many, constructivism is an approach to learning. Constructivists believe that children learn by doing. Learning involves changing pre-existing schema using new information acquired through varied experiences (Damon et. al., 1997). In the constructivist framework, learning is both social and dialogical in nature. That is, as human beings interact with objects in their surroundings they construct mental models of their environment. The constant interaction of human and environment creates learning about the world (Driver, 1995). In short, people learn in partnership with other individuals and learn that knowledge is socially agreed upon.

The *Sisters in Science* program offers a multileveled intervention centered on the constructivist learning model. To this end, cooperative exploratory hands-on science and mathematics education tasks along with self-reflection are employed to facilitate learning. Within this framework of constructivist learning, the *Sisters in Science* program was designed to provide instructional methods that demasculize and demystify science and mathematics, promote women role models and career information, and allow for active involvement in a "female friendly" environment. While girls are "doing" science and mathematics their self-confidence and self-perceptions of their ability to do science and mathematics is enhanced (citation omitted for anonymity).

A Constructivist Centered Classroom

What then do science and mathematics educators need to do in order to foster science learning from a constructivist perspective? Reformists believe there are some essentials to encouraging female student success in the classroom. They include fostering a safe and nurturing environment, promoting problem solving skills, creating collaborative experiences, using hands-on learning and allowing for open discussion about gender stereotypes (Allen, 1995 & Mann, 1994).

Driver (1995) also offers some suggestions to science and mathematics education. She suggests that learners need to be given access to physical experiences as well as concepts and models of conventional science and mathematics. Science and mathematics learning should account for what the learner brings to the learning situation, as well as their purposes and ideas, which can differ for each socially constructed group, particularly, females. Finally, teachers need to be the presenter of experiences that enable students to make mental connections to pre-existing events.

In addition, the "Science for All Americans" (AAAS, 1985) report extends Driver's list by suggesting that students should have opportunities to: express themselves in oral and written form, work in teams, solve problems, question, explore and discover concepts, use authentic tools, and learn about related professions and professional contributions to the field.

Experiences Outside Of The Classroom

Declining interest in science and mathematics among females is additionally affected by experiences outside of school. Many females receive little or no reinforcement of their initial interest in science and mathematics from their families or social environment (AAUW, 1992). Research has reported that females and males have vastly different science and mathematics related experiences inside and outside the school (Kahle & Lakes; 1983; Linn, 1990; Rosser, 1990; Sjoberg & Imsen, 1988). Indirect and direct experiences that contribute to such difference include playing with scientific games and toys (Casserly, 1980; Hilton & Berglund, 1974), participating in science and mathematics activities at home (Kahle and Lakes, 1983; Mullis and Jenkins, 1988), taking science related field trips (Kahle and Lakes, 1983, parents' stereotypic behavioral expectations (Hoffman, 1977; Morgan, 1992), expectations for independence (Block, 1978; Hoffman, 1972), and parents' educational and vocational aspirations (Adelman, 1991; Brody and Fox, 1980).

Some females succeed academically in science despite the adverse circumstances (Bailey, 1996). Research has shown that when male and female high school seniors take the same amount and kind of science courses, females tend to outperform males (Adelman, 1991; Kahle and Meece, 1994; Mulls and Jenkins, 1988). Research suggests that it is not that females cannot and do not have the ability to succeed in science, but rather that obstacles arise in recruiting and retaining females in the science workforce (Kahle and Meece, 1994).

It seems logical to expect that females' positive attitudes toward science are fostered by instructional methods, role models, and peer and social factors inside and outside of the school. Research has documented that these factors play a significant role in promoting success in science for females (Bleier, 1984; Harding, 1986; Kahle and Meece, 1994; Keller, 1985, 1986).

The Program

In the context of broadening the concept of teaching and learning for all students by uniting the active participation of parents and intergenerational role models with other factors that promote females' success in science, Temple University's College of Education and Center for Intergenerational Learning developed the *Sisters in Science (SIS)* program, which is based on a *Experimental Project for Women and Girls in Science, Mathematics, and Engineering*, a program sponsored by the National Science Foundation (NSF).
SIS is one over 40 science education programs for Women and Girls, sponsored by NSF. NSF is one of several government-funded programs established to address gender inequality in science and mathematics education.

Monies for programs like SIS have come into existence via the passage of legislation. Such government actions include Title IX of the Education Amendments Act. Passed in 1972, Title IX was enacted to address the inequities in educational programs receiving federal dollars. In 1974, the Women's Educational Equity Act was passed. It expanded math, science, and technology programs for females. In 1994, a package of gender-equity provisions was included in the Elementary and Secondary Education Act. Among the provisions was the creation of teacher training activities that work to eliminate inequitable practices and to develop programs to increase girl's participation in math and science (Parkay & Hardcastle-Stanford, 1998).

SIS is a two year intervention designed to addresses the achievement inequities in mathematics and science for females. In year one, fourth-grade teachers, their female students, and the families of the girls participate in the program. In year two, the fourth graders, now fifth graders along with their teachers participate in the program. Additionally, a new group of rising fourth grade girls begin their first year of the program in anticipation of participation in the two-year intervention.

The rationale for SIS has its foundations in research on gender and achievement in science. Research suggests that female students have been found to lag behind their male counterparts in science achievement, is due in part to current science education practices that run counter to the intuitive learning style of female students. In addition, females tend to view the field of science as a male domain, often leading to the reluctance of girls to pursue science as field of study or a career (Hammrich, 1996). In response, SIS aims to serve female students with the intention of increasing girls' self-esteem, positive attitudes about science, interest in science careers, and sense of social responsibilities with regard to the environment.

The SIS intervention that begins with a focus on fourth-grade female students because research has foundthat the differential in student ahcievement is evident at 9 years of age for a variety of reasons (Hammrich, 1996). Research from the National Science

Foundation (1990) and the Task force on Women, Minorities, and Handicapped in Science and Technology (1989) has also noted that while efforts have been made to narrow this gap in achievement, little change has been realized (Hammrich, 1996).

The SIS program provides fourth girls with cooperative interdependent science exploration. The rationale is that when girls are allowed to work in a manner that is intrinsic to their collective learning style (i.e., with the manipulation of materials) learning will occur. Additionally, the program's designers are interested in the reformation of girls' perceptions of science education and science as a career option via reflective discussion as well as hands-on experience with science. At the core of the design is a program of research on fostering young females' positive attitudes toward science through building connections among schools, parents, and the community.

The program rationale asserts that when girls are allowed to work in a manner that is intrinsic to their collective learning style with the manipulation of materials, learning will occur. Additionally, the program's designers are interested in the reformation of girls' perceptions of science and mathematics education and science and mathematics as a career option via reflective discussion as well as hands on experience with science and mathematics.

The program's efforts are also consistent with the call for systemic educational reform that recognizes gender related learning style difference in science and mathematics (Tamir, 1988 & Versey, 1990). As the *Sisters in Science* program addresses the call for national reform, it is also in line with local science and mathematics education reform. When the *Sisters in Science* program was developed, it was founded to supplement recent initiatives introduced by the Philadelphia School District's Children Achieving Agenda. In addition, the program was also seen as a complement to currently functioning National Science Foundation initiatives in Philadelphia (e.g. the Urban Systemic Initiative). Thus, it can be stated that the *Sisters in Science* program is a vehicle for both local and national reform in science and mathematics education.

The project also provides support for parents and professional development opportunities for in- and preservice teachers. As an intergenerational program, retired and currently working women from the field of science, engineering, and mathematics, as well as female university students who are pursuing careers in science and science education, serve as role models for the girls and share life and work experiences. In addition to individual and small group mentoring, the role models also serve as resources for teachers on an ongoing basis and help in facilitating students and teacher understanding of how classroom experiences translate to experiences beyond educational settings and into urban environments.

SIS works to meet its goals through a variety of activities. The following are the activities of SIS:

ß TeacherTraining. Fourth grade teachers are taught how to deliver gender-sensitive constructivist integrated mathematics/science instruction.

ß Preservice Teacher Training. Preservice teachers receive training via their cooperating teachers, practicum supervisors, and methods course teachers.

* In School Program. For two hours once a week the females and their male cohorts are presented with gender sensitive constructivist integrated mathematics and science instruction.

ß After School Program. An after-school science enrichment program targets the fourth grade female students. Students receive gender-sensitive constructivist science education in a female-friendly environment on one afternoon each week at their school site.

* Saturday Academy. Weekly Saturday Academy events are held at Temple University for the fifth grade girls. The girls receive entended learning in science and mathematics building upon their fourth grade year participation. New learning includes incorporating technology and sport into the learning of science and mathematics.

ß Family Education. After-school program participants and their families attend events throughout the year. Families and their daughters are given "home extensions" that further extend their after school learning experiences.

ß Volunteer Corps. Retired and working science and science-related field professionals volunteer to work with after-school program participants. These retired and active science professionals interact with the girls in order to develop the students' connections with science and science-related careers and professions.

ß Summer Camp. Girls participate in a two week exploration of the city's waterways. Students attend field, build scale models of rivers, test local water quality, collect data on the animals and plant life indigenous to the are all while reflecting on their learning through dialogue and journaling.

Activities

The components of the program work in concert to provide 4th graders with a physical environment that is both psychologically, emotionally and socially safe and accessible to all students. The students' learning environment is orchestrated so that peers, teachers, and classroom volunteers, as well as other professional resource people, including Temple University graduate and undergraduate trainees, are constantly attending to the needs of each student.

The activities themselves engage *all* students in instructional experiences that challenge everyone involved. The activities clearly connect subject matter to real-world issues that are culturally relevant to students. During each meeting, students take responsibility for generating and gathering "data," posing questions and problems, generating possible explanations and proposing methods for evaluating the best explanations. Across all of the events, teacher, parents, volunteers, and Temple University students are providing a level of mentoring that extends the students learning base beyond the walls of the classroom.

Whereas in the past, "a curriculum" has often meant a set of *answers* to be transferred from teacher to student, the curriculum as outlined in the *Sisters in Science* program is a set of *questions* to be posed to a class (Skilton Sylvester, 1997, in press). In this way, the process of inquiry is co-constructed by the students and teachers and fosters a true community of learners. At the heart of each instructional experience is a gender sensitive, constructivist, integrated mathematics and science curriculum design. Each learning adventure utilizes real life situations to explore the subject matter. One such example of real-life subjects and situations includes the summer camp's focus on the waterways of Philadelphia. Instead of simply studying the names and structures of various bodies of water, students mapped local waterways, visited the water treatment plant that processed their waste water, built model rivers, located various lakes, rivers and tributaries in their region, and tested the quality of water from their own "backyards".

Each of the central studies of the *Sisters in Science* program is structured around one or more central questions, which provides a focal point for the classes' inquiry. Each central study is woven by both unifying themes and cross-cutting competencies. The four unifying themes are: systems, models, scale, and constancy/change. The unifying themes constitute those skills that allow people to play effective roles in the community. For example, in the context of the classes' study of city rivers, students learn about *systems* as they study the water cycle. Along the way, the students discover the three states of matter: liquid, solid, and gas, a lesson which is fundamental to understanding *constancy and change*. Students learn about *models* as they create their own rivers. In creating their model of the river, students need to utilize the principal of *scale*.

The five cross-cutting competencies are: participatory citizenship, communication, multicultural competencies; problem-solving; and school-to-career readiness, technological literacy (School District of Philadelphia, 1996). In the study of city rivers mentioned above, students ask the question: "How do the city rivers get clean so that people can drink the water?" In searching for answers to this question, students engage in visiting a city water treatment plan, researching (with the help of the Internet) ways of making drinking water safe, and writing local scientists for their answers and suggestions. This lesson involves *problem solving, technological literacy, participatory citizenship* , and *communication.* We might also ask, "How do different groups of people make the best of the city drinking water" This might lead to learning about different ways of life of different ethnic groups, a lesson that "culture" is about values, beliefs and practices that guide our daily lives -- helping students develop *multi-cultural competencies.*

Sample

Conducted at six schools located in inner-city Philadelphia, the program's first year involved 577 4th grade girls in six elementary schools, an intergenerational corps of women volunteers, 182 undergraduate elementary education students, and nineteen inservice teachers. The program seeks to:

- Improve young females' attitudes toward, interest in, and achievement in science and mathematics;
- Create a more positive learning environment for minority females and their families on academic and community/social levels; and,
- Increase the knowledge base and understanding of the influence parents and teachers have in promoting females' interest in science.

In order to attain these goals, the *Sisters in Science* program has three major components: (a) an in-school constructivist and gender-sensitive science program; (b) an after-school enrichment program; and (c) a "city rivers exploration" summer camp.

The in-school program was conducted for two hours a week per classroom at each of the six schools. Both fourth grade girls and boys participated in the in-school program. Classroom activities involved gender sensitive approaches to teaching science/mathematics and focused on the urban environment. As part of the program's teacher enhancement component, students in science education methods courses at Temple University facilitated the program sessions along with the classroom teacher. The preservice teachers' coursework explored gender-equity issues in the classroom. Students were introduced to the constructivist approach to learning in order to facilitate science knowing. They also learned about the community service learning concepts presented in the program.

The after-school program was conducted from 3:00-4:30 p.m. one day per week in each of the six schools. The program coordinator facilitated the after-school component with assistance from graduate and undergraduate elementary education students and members of the intergenerational volunteer corps. The after-school component extended the classroom activities by focusing on the big ideas of science such as systems, constancy/change, model, and scale. The students also engaged in reflection activities designed to help them better understand their personal learning, challenge stereotypical notions about science, and to develop critical thinking skills. These reflection activities included writing and interactive discussions.

The summer program was conducted for two weeks during July in order to reinforce learning that a occurred during the academic year. Females spent two weeks exploring the city rivers. Activities included taking four field trips to area environmentally focused sites, creating model rivers, and designing improvement plans to prevent the city rivers from becoming polluted. At the end of the summer program, the girls shared their learning with their families and other elementary school students from neighborhood schools.

In addition to direct instruction to students, SIS provides support for parents and professional development opportunities for in- and preservice teachers. As an intergenerational program, retired and currently working women from the field of science, engineering, and mathematics, as well as female university students who are pursuing careers in science and science education, serve as role models for the girls and share life and work experiences. In addition to individual and small group mentoring, the role models also serve as resources for teachers on an ongoing basis and help in facilitating students and teacher understanding of how classroom experiences translate to experiences beyond educational settings and into urban environments. At the core of the design is a program of research on fostering young females' positive attitudes toward science through building connections among schools, parents, and the community.

Method

Design

In an attempt to measure the relative effectiveness of the SIS program efforts to increase the interest, achievement, attitude and awareness of girls in science and mathematics knowing, a pre-post test design was employed. Qualitative observational data was also collected to measure the relative effectiveness on parental contribution, teacher awareness, and community involvement.

Pre-post test instruments were administered to female and male students at the start of the first and second in-school sessions and again during the final two sessions of the program. The administration of the instruments were divided over a two session period so as not to fatigue the young learners.

Instrumentation. In responding to the goals of the SIS program, specifically those regarding changes in participating students' science skills, mathematics skills, and attitudes toward science and mathematics in school, three instruments were constructed.

Objective one, two, and three, to increase girls attitude, interest, and awareness toward science and mathematics was measured by a questionnaire. The instrument contains 30 items each with a 5-point likert response scale (strongly disagree, disagree, neutral, agree, strongly agree). This Science Attitude Scale instrument was adapted from the (Meyer & Koehler, 1988) scale to reflect the cognitive capacities of young learners. The students perceptions were measured by using the Draw a Scientist instrument (Mason, Kahle & Gardner, 1989).

Objective four, to increase achievement in science and mathematics was measured by a science process skills and mathematics skills instrument specific to the fourth grade and tied to the syllabus for fourth graders in the Philadelphia Schools. These two instruments were validated in one or both of two ways. The skills instruments were developed from material contained in the current curriculum documents of the School District of Philadelphia, involved skills deemed to be critical, and thus were held to have content validity. In addition reliability figures were calculated on a test-retest correlation model, and confirmed using the Kuder-Richardson (formula 22) procedure.

Analysis

Attitude

The data set for the attitude preassessment comprised 414 completed questionnaires, representing 185 boys and 229 girls. These students represented six Philadelphia Schools in 19 classes. The responses were scored 1 = strongly disagree, 2 = disagreed, 3 = neutral, 4 = agree, 5 = strongly agree. Scores above 3.0 indicate the students agreed or strongly agreed with the statements on the subscale.

Table 1 shows that there were significant differences between girls' and boys' mean scores on the attitude scales of Girls & Science, Science Involvement and Teachers. Both girls and boys had positive attitudes towards girls' ability to do science. Although the girls' mean score (X = 3.88, N =229) was significantly higher than the boys mean score (X = 3.45, N =185). All students had positive attitudes towards their parents and the usefulness of science.

Girls had a higher mean score (X = 4.0) compared with boys (X = 3.8) towards their teachers' and parents' encouragement in science. Possibly this could be attributable to girls' tendency to be more positive in evaluating the behaviors of parents and teachers on likert-type scales compared with boys.

The data set for the attitude post assessment comprised 450 completed questionnaires, representing 194 boys and 256 girls. These students represented six Philadelphia Schools in 19 classes. The responses were scored 1 = strongly disagree, 2 =

disagreed, 3 = neutral, 4 = agree, 5 = strongly agree. Scores above 3.0 indicate the students agreed or strongly agreed with the statements on the subscale.

Table 1 shows that there were significant differences between girls' and boys' mean scores on the attitude scales of Girls & Science, Science Involvement and Teachers. Both girls and boys had positive attitudes towards girls' ability to do science. Although the girls' mean score (X = 3.96, N =256) was significantly higher than the boys mean score (X = 3.36, N =194). All students had positive attitudes towards their parents and the usefulness of science.

Girls had a higher mean score (X = 3.98) compared with boys (X = 3.79) towards their teachers' and parents' encouragement in science. Possibly this could be attributable to girls' tendancy to be more positive in evaluating the behaviors of parents and teachers on likert-type scales compared with boys.

Table 1. Science Attitudes Scale Mean Scores (Across All Scales)

	Fall (N=414)	Spring (N=450)
Males (N=185/194)	3.45	3.46
Females (N=229/256)	3.88*	3.96*

* significant difference

Perceptions

The students perceptions were measured by having them do the instrument Draw a Scientist (Mason, Kahle & Gardner, 1989). Frequency counts were taken on their drawings (see Table 2). On both the pre and post a majority (82% and 92% respectfully) drew male scientists. There wasn't a significant change. Likewise with the girls on the pre and post a majority (71% and 71% respectfully) drew female scientists. Again there wasn't a significant change.

Table 2. Frequency of Responses for Draw A Scientists Test

	Fall '97 (N=477)		Spring '98 (N=433)	
	Male n=211	Female n=266	Male n=194	Female n=239
Drawing Male	174	50	179	48
Drawing Female	9	189	8	170
Drawing Both	3	10	2	14
Can't Determine	25	17	5	7

Science/Mathematics Skills Test

There were 486 compete sets of data for the science/mathematics skills for the Fall 1997 test administration. There were 418 complete sets of data were analyzed for the Spring 1998 test administration. Pre and post mean scores were obtained on both the boys and girls. (see Table 3) The seven skill totals were computed along with the total test score means. The following is a list of what each skill measured:

- Skill One — observation
- Skill Two — symmetry
- Skills Three/Four — classification
- Skill Five — measuring using non standards units
- Skill Six — description of a measuring procedure (averaging)/estimation
- Skills Seven/Eight — observation/predictions
- Skills Nine through Twelve — recognition of variables in an experimental procedure, graphing, and interpretation

Table 3. Means for Skills Test

		Fall '97 (N=486)		Spring '98 (N=418)	
		Male	Female	Male	Female
Skill	Max. Points	n=210	n=276	n=192	n=226
1	5	4.41	4.46**	4.48*	4.60*
2	4	3.53	3.66	3.71	3.69
3/4	4	2.71	3.00	3.12*	3.28* **
5	4	1.49	1.58	2.14*	2.26*
6	3	.95	.97	.88	.96
7/8	6	3.28	3.43	3.74*	3.72*
9-12	12	2.98	2.95	4.40*	4.46*
Total	38	19.44	20.21**	23.09*	24.40*

* significant difference pre to post

** significant difference pre to pre with girls being favored

Analysis of variance was used as the statistical test for the purpose of revealing the extent of change from pre to post test for the science/mathematics skills test. The analysis was conducted four ways: pre and post for the boys changes, pre and post for the girls changes, girls pre versus boys pre, and girls post versus boys post. Although the sets were not matched samples the variance ratio of the sets indicate that the data sets were random samples.

The analysis for the first analysis (pre and post for the boys changes) yielded the following results: (see Table 4).

Table 4. Analysis of Pre to Post Changes for Boys
(N = 210 Pre/N = 192 Post)

Skill 1	F = 63.2141	P< 0.00	significant
Skill 2	F = 2.2748	P>0.1037	non-significant
Skills 3/4	F = 8.5835	P<0.00	significant
Skill 5	F = 27.8285	P<0.00	significant
Skill 6	F = 1.4974	P>0.22	non significant
Skills 7/8	F = 10.5982	P<0.00	significant
Skills 9-12	F = 24.6826	P<0.00	significant
Skill Total	F = 60.3434	P<0.00	significant

The analysis for the second analysis (pre and post for the girls changes) yielded the following results: (see Table 5).

Table 5. Analysis of Pre to Post Changes for Girls
(N = 274 Pre/N = 226 Post)

Skill 1	F = 82.6618	P< 0.00	significant
Skill 2	F = 1.5936	P>0.2039	non-significant
Skills 3/4	F = 7.8404	P<0.00	significant
Skill 5	F = 29.6232	P<0.00	significant
Skill 6	F = .1069	P>0.90	non significant
Skills 7/8	F = 8.7136	P<0.00	significant
Skills 9-12	F = 46.1816	P<0.00	significant
Skill Total	F = 75.3226	P<0.00	significant

The analysis for the third analysis (girls pre versus boys pre changes) yielded the following results: (see Table 6).

Table 6. Analysis of Girls Pre Versus Boys Pre
(N = 274 Girls/N = 210 Boys)

Skill 1	F = 106.6848	P< 0.00	significant (girls)
Skill 2	F = .0742	P>0.80	non-significant
Skills 3/4	F = 1.3459	P>0.20	non-significant
Skill 5	F = 1.1492	P>0.20	non-significant
Skill 6	F = 1.8986	P>0.20	non significant
Skills 7/8	F = .0449	P>0.80	non-significant
Skills 9-12	F = .0490	P>0.80	non-significant
Skill Total	F = 7.0595	P<0.00	significant (girls)

The analysis for the fourth analysis (girls post versus boys post changes) yielded the following results: (see Table 7).

Table 7. Analysis of Girls Post versus Boys Post Changes
(N = 226 Girls/ N = 192 Boys)

Skill 1	F = 2.5140	P>0.10	non-significant
Skill 2	F = 1.6961	P>0.20	non-significant
Skills 3/4	F = 3.7824	P<0.05	significant (girls)
Skill 5	F = .6861	P>0.40	non-significant
Skill 6	F = .5258	P>0.50	non-significant
Skills 7/8	F = 1.9839	P>0.10	non-significant
Skills 9-12	F = .0393	P>0.80	non-significant
Skill Total	F = 2.9678	P>0.08	non-significant

Stanford Nine National Test

Results were also obtained on the Stanford 9 national test. All fourth grade classroom take this national test each year. There was a gain on the scores for each school for each year of the intervention. No statistical test was run to see if their was a significant difference on the gain scores. (see Table 8).

Table 8. Stanford Nine Point Scores for Science

Schools	1996-1997	1997-1998	Growth
Childs	71.3	72.5	1.2
Clymer	43.9	51.6	7.7
Dunbar	56.5	63.5	7
Ferguson	55	63	70.5
Morrison	70.5	79.2	8.7
Olney	62.6	77.5	14.9

*Note: Scores for Harrison Elementary were unavailable

Discussion

With respect to the results from the science/mathematics process skills instrument there were a mixture of statistically significant changes for the boys and girls participating in the program This is a combination of small losses and small gains for the six schools involved. Clearly, to the extent that the instrument is appropriate to the problem, a majority of the outcomes did meet the expectation of an increase in the science process skills. Skills tested were: observation, recognition of variables in an experimental procedure, graphing (using bar graphs), and interpretation of graph results, classification, measuring using non-standard units, description of a measuring procedure (finding an average), symmetry and estimating lengths. All of these appear in the Philadelphia curriculum by the end of the fourth grade. Of the skills tested, there was a significant change from pre to post for both the boys and girls for observation, recognition of variables in an experimental procedure, graphing (using bar graphs), and interpretation of graph results, classification, measuring using non-standard units, description of a measuring procedure (finding an average), and estimating lengths. The two skill items that were nonsignificant pre to post for both the boys and girls were symmetry and measuring with non standard units.

When comparing the pre girls to the pre boys and the post girls to the post boys significance was only identified for two skill levels for the pre comparison and one for the post comparison. On the pre test comparison significance was found in skill 1 and on the total test. On the post test comparison significance was found in skill 3/4 only. Therefore we did not find gender differences. Only pre/post differences for both boys and girls were found to be significant. This indicated that the girls and boys are performing equally well at the start and end of the year.

With respect to the Stanford Nine science and mathematics scores. All six school saw an increase in their scores over the years of SIS intervention. No statistical test was run on the data. There was a range of growth scores for the six schools from 1.2 to 14.9 with the average gain score 7.9 overall. In addition, the schools participating in the SIS program out scored the other Philadelphia fourth grade schools by an average 50 percent. While it is not possible to single out the SIS intervention as the only contributing factor to the increase in scores, it is highly likely that the SIS intervention helped contribute to the gain in science and mathematics scores. Principals at all schools were very generous in their praise for SIS intervention being a contributing factor for their schools' score increases.

With respect to the results of the Science Attitude Scale the results were quite positive; i.e., the students showed very positive changes in attitude toward school science and mathematics and toward the possibility of pursuing a career involving some aspect of science and/or mathematics. The high percentages of positive responses suggest a recognition that there is a level of community responsibility on the part of all of us, with specific emphasis on girls. The pre to post results can reasonably be taken as an indication of the success of the program in increasing students' interest, attitude, and awareness in science and mathematics. However, a further question remains, will this be sustained when the program ends its support of the school's efforts in promoting science and mathematics performance and interest.

Highlights of Findings

The *Sisters in Science* program seeks to increase elementary girls' interest and achievement in science and mathematics, create a more positive learning climate for minority school girls and their families on academic and community/social levels, and increase the knowledge base and understanding of parents with respect to their influence in promoting girls' interest and achievement in science and mathematics. The program met its stated goal with respect to enhancing fourth grade females attitude, interest, and awareness toward school science and mathematics and toward science and mathematics both as part of a larger enterprise and as potential career pursuits. The project also met its stated goal with respect to increasing the students' science/mathematical skills.

Findings to date show that the girls in the program have increased their interest and achievement in science and mathematics. The girls in the program have an increased understanding of science and math learning and see the relevance of science and math to their everyday lives. Data also show a positive pattern of change in the girls' science/math and language skills as evidenced by their class participation and the writings in their science journals.

Other noteworthy findings include the observation that parents have become increasingly active in their daughters' science and math activities as shown by parents' involvement in the family science programs, after-school programs and field trips. These findings are especially encouraging because both schools are located in inner city neighborhoods plagued by extreme poverty.

Implications

Several policy and practical implications can be drawn from the work of the *Sisters in Science* program. First, programs must involve parents in the effort to foster the success of young females in science and mathematics. Parental behavioral expectations for their daughters have important long-term implications for females' interest and achievement in science and mathematics. Second, involving intergenerational role models in school science and mathematics programs has been shown to enhance females' achievement in science and mathematics. Intervention programs that are specifically designed to include role models have a strong and positive impact on females' achievement in science and mathematics and assist females to identify with science and mathematics as possible areas for study or employment. Third, program interventions evolve in stages of development, growth, and change. In order to promote the sustained success of females in science and mathematics, there must be a conscious effort to provide support for collaboration among schools, parents, and the community as ideas for useful strategies are developed, implemented, and evaluated.

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