

***Sisters in Sport Science:
A Sport-Oriented Science
and Mathematics Enrichment Program**

**Penny L. Hammrich, Ph.D.
Kathy Fadigan, Ed.D.
Tina Sloan Green
Temple University**

**Greer M. Richardson, Ph.D.
LaSalle University**

**Beverly Livingston, Ph.D.
Widener University**

Introduction

Sisters in Sport Science(SISS) addresses the need for urban girls to gain equitable access to science and mathematics education by using sport as a vehicle for learning. Specifically this need is based on the rising public concern over the equity gap in science and mathematics; recognition of the significant impact intervention programs targeting urban girls have on school success; and the call for systemic educational reforms that recognize the limits girls face in post secondary education and employment opportunities.

The *SISS* program addresses the diversity inherent in learning by using sport as the context through which scientific and mathematical principles can be explored. Through the vehicle of sport not only are girls learning the underlying principles of science and mathematics embedded in the mechanics of performing a sport; but also, they are also learning the scientific principles in an atmosphere that embraces the psycho-social-emotional connection to learning. For instance, each day girls learn how to ride a bike, throw a ball, and/or jump rope. They learn these activities in an environment that is non-competitive and non-threatening academically. What they are not aware

of is the scientific and mathematical principles laden in performing these activities. In the classroom girls learn these scientific and mathematical principles in a context that is foreign to their everyday experiences. They learn about the trajectory of a golf ball without connecting this principle with the actual practice of hitting a golf ball. What is unique to the concept of the *SISS* program is that the academic and the everyday experiences of girls can be bridged. To this end, the teaching and learning process embraces not only the academic principles of learning but captures the psycho-social-emotion process of learning. In doing so the context of learning science and mathematics is enriched for the girls.

While programs that address the equitable achievement for all students in science and mathematics are not new, using sports as a vehicle through which science and mathematics interest and achievement can be attained is unique. This approach bridges the application of concepts embedded in science and mathematics to the mechanics of performing a sport. Sports provide a unique and innovative approach to reaching girls in a friendly atmosphere while learning concepts usually too abstract for them to grasp due to their limited experience and exposure. By using sports as a vehicle for learning scientific and mathematical principles, the *SISS* program responding to the national call for creating innovative programs that provide access to the latest strategies in promoting science literacy.

Rationale

The previous decade has witnessed many voices calling for reform in the teaching of science and mathematics. The federal government identified six National Education Goals that boasted that the United States would be first in the world in science and mathematics by the year 2000 (Culotta, 1990; Vinovski, 1996); and it is presently launching a series of exams in reading and mathematics to improve student achievement and increase the status of American students in

an ever-increasing global marketplace (Baker, 1997). Most recently, the NO CHILD LEFT BEHIND legislation supports the mission of working to improve elementary and secondary math and science achievement (2001). Furthermore, policymakers, scientists and mathematicians have focused on change to develop the scientific and mathematical knowledge that will produce a healthy economy and maintain a meaningful democracy (Tate, 1994, Barlow, 1999). Reform, however, does not over overnight. Systemic reform must remain on the national agenda if we as a nation hope to attain the goals posed by the federal government and such professional organizations as the National Council of Teachers of Mathematics and the American Association for the Advancement of Science.

While the standards provide a map for improving the science and mathematics education of all students; the barriers urban schools face and the communities to which they belong are lacking the necessary resources to provide adequate science and mathematics programs. However, when examining the conditions of many urban schools and the communities to which they belong the reform necessary to reach such improved student achievement seems daunting (Barlow, 1999; Kozol, 2000). The goal of lifelong learning in science, mathematics and technology is difficult to realize when many urban students have little access to the Internet and fewer textbooks, manipulatives and science equipment than suburban students. In particular, minority students (i.e., African-Americans, Latinos and women) and students from low socioeconomic backgrounds confront great challenges in choosing and performing well in science, mathematics and technology related fields (Hammrich, 1997; Hammrich, 1998; Hammrich et.al., 2000; Hammrich, 2002; Hanson, 1996; Oakes, 1990). Innovative programs must provide access to the newest and most advanced tools in science, mathematics and technology. Furthermore, awareness of cultural differences, including learning style, need to be an integral part of the format, organization and

content of an effective program. A current view of how individuals receive and process information proposes several (rather than just one) independent forms of information processing, including logical-mathematics, linguistic, musical, spatial, bodily kinesthetic, interpersonal and intra-personal (Gardner, 1993). Because individuals may differ in their specific profile of “intelligence’s,” education needs to be diverse in its offerings, both in terms of content and format of instruction, in order to be effective (Nieto, 1996). Sports are a means by which educators can address the forms of information processing mentioned above in both content and format.

The *SISS* program supports and furthers this vision by providing mathematical and scientific concepts through the vehicle of sports. In doing so, the program is reaching students on multiple levels of intelligence’s and strengthening the education of students in science and mathematics by creating an unique and diverse atmosphere.

The American Association of University Women (AAUW, 1998) publication “Gender Gap: Where Schools Still Fail Our Children” posits a variety of other positive affects that sports can have on children. They suggest that “sports participation in general is linked not just to higher academic achievement but also to better physical and mental health and greater leadership capacity...Like classroom interactions, sports can either challenge or reinforce stereotypes about girls’ and boys’ roles” (p.74) and”...Unique capacity of school sports to prompt students and adults to question their own assumptions about gender (p.77).

Girls and minority youth in the late elementary through middle school years tend to struggle with self-esteem, physical fitness, skill development, goal setting, and problem solving (AAUW, 1998). Sports are one ideal mechanism to reach girls and minority youth during these uncertain years in which they explore their self-identities. Research links physical activity for girls to higher self-esteem, positive body image, and lifelong health (AAUW, 1998) and

“...involvement in activities valued by school (athletics and the arts) leads to higher self-esteem, positive attitudes toward school, and less self-destructive behavior” (AAUW, 1998, p. 77). By using sports as a vehicle for learning scientific principles, the SISS program is responding to the national call for creating innovative programs that provide access to the latest strategies in promoting science literacy.

The *SISS* program seeks to address gender equity in science by providing girls exposure to sports and science and encouragement to participate in related activities. The program is designed for sixth, seventh, and eighth grade girls attending urban middle schools and furthers the vision of its predecessor program: Sisters in Science (Hammrich, 1997; Hammrich, 1998; Hammrich et.al., 2000; Hammrich., 2002) which was geared toward similar fourth and fifth grade girls. Like its predecessor's, *SISS's* vision is to increase girls' positive attitudes, achievement, and exposure to science. However, *SISS* is unique in that it teaches science concepts within the contexts of playing sports. By doing so, the program is successfully reaching students in a variety of ways and strengthening the education of students in science and mathematics by creating a unique and diverse pedagogical atmosphere.

Context of the Program

Since 1994, the College has collaborated with area Philadelphia Schools in the development of the *Sisters in Science Equity Reform Project (SISS)*. The project includes three programs ranging from elementary to middle school: *Sisters in Science*, *Daughters with Disabilities (or All Sisters in Science)*, and *Sisters in Sport Science*, the program to be described in this paper. The *Sisters in Sport Science* program provides a third level of intervention to both leverage the success of the prior two programs (*Sisters in Science* and *Daughters with Disabilities*) and sustain a longitudinal analysis of how girls are achieving at the middle school level.

The overall goal of the *SISS* program is to design, implement, evaluate, and disseminate a field-based program aimed at fostering the resilience of inner-city middle school girls, in science and mathematics through the vehicle of sports. The program builds upon the existing science and mathematics curriculum through specific activities and learning methods shown to increase girls' interest and achievement in science and mathematics through the vehicle of sports. The following objectives are pursued.

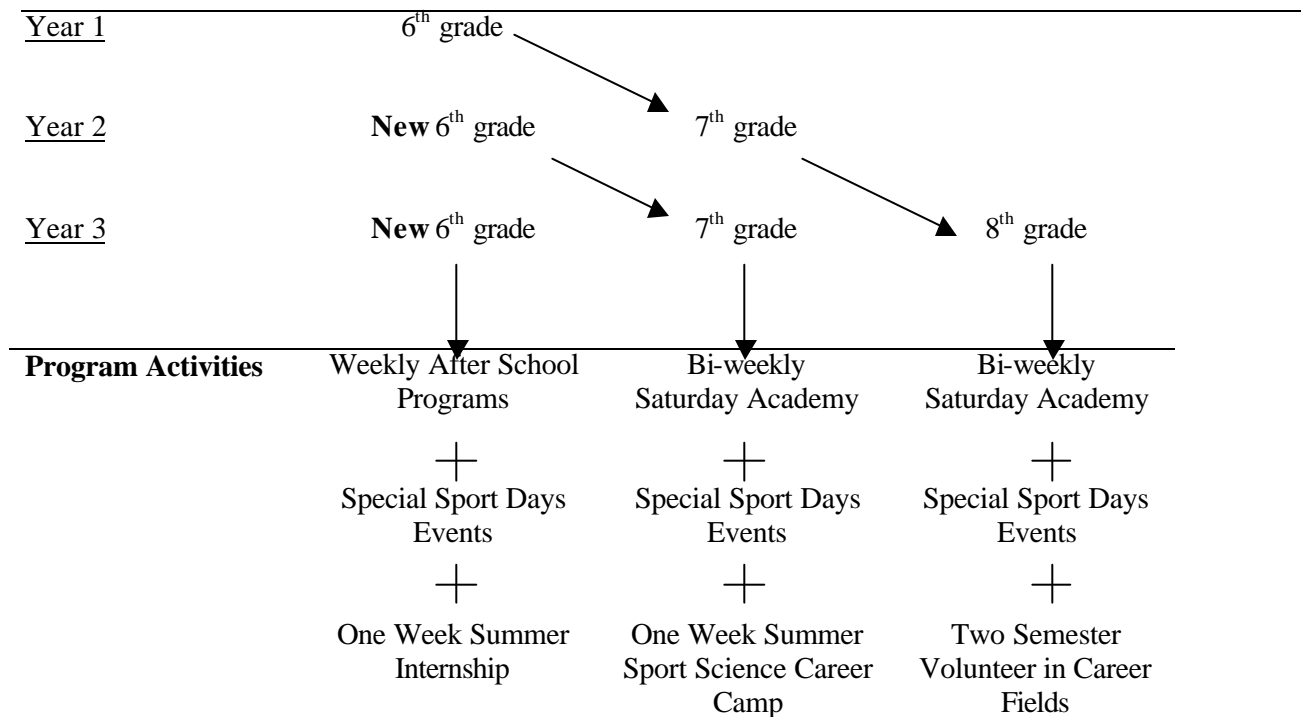
- Objective 1: To increase science and mathematics achievement of middle school girls through the vehicle of sports.
- Objective 2: To increase the number of effective teachers and coaches who use sports as an avenue for teaching, problem solving, and communicating about science and mathematics.
- Objective 3: To enhance the self-identities of middle school girls who come from disadvantaged environments.
- Objective 4: To increase middle school girls' careers awareness of science, mathematics and sport related fields.
- Objective 5: To increase families' and caregivers' knowledge of sports as an effective way to foster science and mathematics achievement.

The *SISS* program is designed as a three-year intervention involving middle school girls from six middle schools over a three-year period (see Figure 1). The *SISS* program provides girls: (1) an all girls atmosphere where girls can learn science and mathematics by participating in sports; (2) a learning environment that is non-competitive and non-threatening academically; (3) various enrichment extra-curricular activities that engage girls in science and mathematics learning through after school programs, special sport science events, summer internships, summer sport

science camps, Saturday academy programs, and academic internships; (4) interactions with professional women athletes, scientists, and mathematicians; (5) career connections in the fields of science, mathematics, and sport. Through the utilization of minority athletes, middle school teachers, university students, providing summer internships, career camps, academic internships, and the inclusion of families the program has a direct impact on girls, parents, and the science and mathematics curriculum by focusing on sports as a vehicle for science and mathematics learning. All sport science activities are matched to the Philadelphia middle school science and mathematics standards and national benchmarks. The goal is to expand on the scientific and mathematical concepts taught during the school year through the vehicle of sports. By enhancing the capacity to promote science and mathematics literacy through the utilization of sports, the project is supplementing other systemic initiatives at Temple University and the School District (Sisters In Science, Daughters with Disabilities, Collaboration for the Excellence in Teacher Preparation, Alliance for Minority Participation in Science and Mathematics, and the Urban Systemic Program).

Figure 1

Three Year Intervention Model



The curriculum enhancement is standards based and has an equity focus. Each activity features a specific sport and the science and mathematics utilized in performing the sport and features an athlete from the sport and a scientist or mathematician. The entire three-year supplemental curriculum includes 10 sports, 40 science and mathematics standards driven activities that feature a sport as the mechanism through which the science and mathematics is learned (see Figure 2). The ten sports featured in the curriculum program include: (1) five team sports – volleyball, basketball, soccer, hockey, and softball; and (2) five individual sports – fencing, golf, tennis track (running), track (throwing). The project achieves the goals and objectives through 5 components: (1) after school programs; (2) Saturday academies; (3) special

sport day events; (4) academic and summer internships; and (5) careers connections (Hammrich, . 2002).

Figure 2
Sisters in Sport Science Curriculum

6 th Grade	7 th Grade	8 th Grade
Basketball – Motion	Track-Field – Aerodynamics	Softball – Energy Transformations
Tennis – Geometry	Track-Running - Biomechanics	Hockey – Simple Machines
Fencing – Forces	Soccer – Mechanical Engineering	Lacrosse – Projectile Motion
Golf – Mechanics	Volleyball - Kinesiology	

Sample Activity

The following section describes a *SISS* Saturday Academy activity relating track & field to physical science. Sample activity concepts include the following:

Activity

Science Concept: Projectile Motion

Sport Connection: Track & Field – Shot Put

Research Question: What throwing angle gives the greatest overall distance?

Career Connections: a) Mae Jemison – astronaut, b) Connie Price-Smith – shot putter

Objectives

- Students will **work cooperatively** in groups to conduct the projectile activity with each student contributing to the overall activity.
- Students will correctly **identify and describe variables** that influence the overall distance an object travels when it is thrown.
- Students will **predict** which angle results in a greater distance for the projectile.
- Students will **control variables** during the projectile experiment.
- Students will **measure** the distance the projectile travels for each trial.
- Students will correctly **compute the average** distance for each trial.
- Students will **graph their results** collectively as a class and display the graph on the chalkboard.
- Students will **interpret the graph** in order to determine which angle produces the greatest distance when shooting the dart gun.

Students will **compare their results** to the angle a shot putter uses when releasing the shot put.

During a Saturday program, seventh grade girls participate in a total three activities (and lunch) over the course of a four-hour period. The morning begins with a one-hour sport activity. On this particular morning the girls learn the basics of the shot put out on the track. Lead by a female athlete, the girls begin with some stretching and warm ups and then progress to the technique and actual throwing of the shot put.

The second hour of the program takes place in the computer lab. In their electronic journals the girls propose a new Olympic throwing event. They identify the object to be thrown and at least three rules for their new imaginary event. Creativity reigns, and the girls are preparing to toss dictionaries, siblings, money, and floppy discs. The technology activity concludes with an introduction to conducting meta-searches on the internet. The girls search for information about the featured female athlete, shot putter Connie Price-Smith, and scientist, Mae Jemison.

After a thirty-minute break for lunch the girls begin their one and a half hour science lesson. The theme for the day is projectile motion and controlling variables. The instructors and some student volunteers demonstrate projectile motion by tossing a tennis ball back and forth. Students are introduced to the terms projectile and trajectory. Another demonstration using a toy dart gun allows students to observe the distance a projectile travels when released from a horizontal (0 degree) position and from a slightly vertical position (approximately 30 degrees). Students observe that combining horizontal and vertical motion allow the dart to travel a greater distance.

The students' goal for the day is to determine what angle provides the greatest distance when shooting a toy dart gun. Working in cooperative groups of four to six students, each group of girls test two different assigned angles between 0 and 90 degrees. Students are instructed to perform five trials for each designated angle. In setting up the experiment, the girls are required to

control the height the toy gun. Using a meter stick, one group member is responsible for ensuring that the toy gun is exactly one meter above the floor.

All of the girls take turns performing the various tasks involved in the experiment. One girl fills the role of the shooter. Another group member is required to hold the protractor next to the gun and help the shooter position the gun at the correct firing angle. The remaining group members are stationed several yards away from the shooter, in a location where they are not in the path of the dart, but can easily mark the spot where the dart initially lands. Students are given colored, circle-shaped stickers to mark the location of the dart's landing.

After each trial the shooter and one of the other group members measure the distance the dart traveled using a measuring tape. The results are recorded onto a worksheet. When all of the trials have been completed, the group calculates the average distance for each of the angles tested. All of the groups then post their combined results on a graph on a chalkboard or a large piece of chart paper hung somewhere in the room.

Students determine which angle produced the farthest shooting distance. This is usually somewhere close to 45 degrees. Students then discuss their results. If time permits students can alter some of the variables such as the height the toy gun is held or the weight of the projectile.

Methods and Results

For each of the after school and Saturday academy activities, the middle school students took individually administered pre and posttests covering skills and concepts inherent to the science and mathematics concepts they studied during the activity. The instruments were developed by the science faculty on staff and the items were carefully matched with the content of the activity. A sample question includes the following examples: What does the word velocity mean? What is speed? What is a projectile? What is a trajectory? Each question was scored as

correct or incorrect. The students responses were open ended allowing the girls to express their understanding of the content. There were four questions for each activity. In reporting the scores for each activity the four questions were grouped into either correct or incorrect for the entire activity concept. Pretests were administered at the beginning of the day's activity , and posttests were administered at the end of the day's activity. The pretest and posttests were identical instruments.

Gain scores were analyzed using a simple *t* test. Based on raw scores, the percentage of correct responses was used as the measure. The data consistently shows statistically significant mean increases from pre to posttest ranging from 27 to 60 percentage points ($p < .001$ in each case). Looking at these gains in a different way, in every case, the lower quartile on the posttest exceeded the upper quartile on the pretest. All of the results from the after school and Saturday academy are summarized in Table 1.

Table 1
Pre- and Posttest Mean Scores and Standard Deviations

Sport-Science	n	PreTest: m	SD	PostTest: m	SD	Gain
Tennis-Geometry	52	29	22.1	84	17.3	55**
Fencing-Forces	40	38	21.4	86	14.2	48**
Basketball-Motion	32	27	16.5	77	23.3	50**
Golf -Mechanics	50	34	19.4	93	8.6	59**
Volleyball- Aerodynamics	48	28	19.4	77	22.5	49**
Soccer –Mechanical Engineering	35	28	19	88	12.2	60**
Track(field) – Aerodynamics	33	36	22.3	90	12.5	54**
Track(running) – Biomechanics	42	33	15.5	60	18.7	28**

Notes. Scores are raw scores, reported as a percent of correct responses.

**Denotes statistically significant gains ($p < .001$).

Additionally, we point out that of the sixth graders who completed the 6th grade program 67% returned as 7th graders. Furthermore, 54% of all students who completed the 7th grade program returned to participate as 8th graders. We believe that these retention rates speak volumes about our students' attitudes toward the program.

Also with respect to girls grades at the beginning of the year compared to the end of the year, *t*-test results showed that the girls achievement scores (grades) in both mathematics and science increased significantly ($p < .05$) during the year pre to post.

Discussion

The only quantitative analysis of the *SISS* program we have been able to perform thus far are the analyses of simple gain scores of participants presented in the previous section along with their classroom grades in science and mathematics prior to and after participating in the program. With no potential comparison available as to what gains would be expected in the absence of

summer camp, we can draw no strong conclusions regarding the effects of our program at this points. Thus, while these results are suggestive of a positive effect of the *SISS* program, nevertheless they must be regarded as preliminary and not generalize able. However, we have ample anecdotal evidence that the *SISS* program has had a positive effect on the lives of many of the students. The journals kept by the middles school students are one source of such evidence. In reflecting about the program, the features cited most frequently by these students is that they are having fun (“this is fun”), enjoying the program (“I really like participating in this program”), and learning science and mathematics (“I am learning about angles, measurement, and reflection”). Some of the girls were able to see connection among the things they were learning in the program and what they are studying in school (“Throwing a ball is like learning about trajectory in school”). Another positive benefit of the program is that of the parents surveyed prior to and after their daughters participating in the program, parents increased their awareness of the connection of sport to science and mathematics by 60 percent (33% awareness at the beginning to 83% at the end of the year).

Implications

While programs that address the equitable achievement for all students in science and mathematics are not new, using sports as a vehicle through which science and mathematics interest and achievement can be attained is unique. This approach bridges the application of concepts embedded in science and mathematics to the mechanics of performing a sport. Sports provide a unique and innovative approach to reaching students in a friendly atmosphere while learning concepts usually too abstract for them to grasp due to their limited experience and exposure.

Another unique feature of this project is the focus on middle schools science and mathematics. It responds to a dearth of attention to this level in public schools and fills a gap in the

relevant literature. Middle school students often experience a drop in grades due to lack of organizational skills and difficulty adjusting to the requirements of several teachers. Learning science and mathematics principles through participating in sports will help students through this transition phase and will reduce the chances of “falling through the cracks”.

The project is also targeting students who have participated at the elementary school level in *Sisters in Science*. The middle schools chosen are the elementary school’s feeder schools. This program will allow the students to continue in an intervention program aimed at helping them succeed in science and mathematics. It will also allow the researchers to longitudinally track girls who participated in *Sisters in Science* and then continue to participate in the *SISS* program creating a second level intervention or double treatment.

In conclusion, one project or one group of committed science and mathematics educators alone cannot tear down all of the barriers for girls in the areas of science, mathematics, and technology. One set of dedicated teachers, mentors, or undergraduates by themselves cannot change the often negative course of employment or postsecondary education for future female scientists or mathematicians previously described in the professional literature. But this project clearly is a start. On-going, pro-active involvement by the girls themselves can both teach important science and mathematics skills, while simultaneously expanding new horizons through early transition awareness.

What became evident in the program implementation was that (a) parental behavioral expectations for their daughters have important implications for females’ interest and achievement in science and mathematics; (b) 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;

(c) 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.

What we have learned over the course of implementation of the program is that any such intervention program would be strengthened if designed so that: (a) students come to see the intervention program as an extension of their formal education; (b) older students serve as mentors and role models for younger students; (c) students are presented means for academic success; (d) students are presented with avenues towards possible careers; and (e) students are expected to succeed academically. *SISS* is one possible approach to academic enhancement for students living in the urban environment. The results indicate that the program is serving the population of students well. A similar program would likely serve equally well with other students in similar urban settings.

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*A paper based upon work supported in part by a grant from the National Science foundation (Grant No. 0002073). Any opinions, findings, conclusions, and/or recommendations expressed in this paper are those of the author and do not necessarily reflect those of NSF.

About the authors...

Dr. Penny L. Hammrich, Associate Professor of Science Education and Associate Dean for Research at Temple University, is the creator and Principle Investigator of the National Science Foundation sponsored programs entitled *Sisters in Science*, *Daughters with Disabilities*, *All Sisters in Science*, and *Sisters in Sport Science*. Dr. Hammrich is also a Senior Research Associate for the Mid-Atlantic Laboratory for Student Success where she directs two programs one called *A Head Start on Science and Communication K-2* and *Science and Communication grades 3-5*. Her areas of research include gender equity, science curriculum, nature of science, and the science standards. She has published over 30 articles and made over 100 presentations in this area.

Dr. Kathy Fadigan, is the Program Coordinator for the *Sisters in Sport Science* program.

Dr. Greer Richardson, is the Co-PI on the *Sisters in Sport Science* program. She is an Assistant Professor of Educational Psychology at LaSalle University.

Dr. Beverly Livingston, is an Assistant Professor of Science Education at Widener University. She is the former program coordinator of the *SISS* program.

Professor Tina Sloan Green is a Professor of Kinesiology at Temple University. She is a Co-PI on the *SISS* program. Professor Sloan Green is also the President of the Black Women in Sport Foundation.