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ABSTRACT

It has been well documented that inequities in science and mathematics achievement exist between males and females for a variety of reasons. Among the explanations for this are the notions that female students tend to perceive science/mathematics as a male dominated field of study, female students are less interested in science/mathematics, classroom atmospheres and instructional practices do not foster female learning in science/mathematics, and female students harbor stereotypical ideas about science/mathematics and scientists in general. This paper outlines the Sisters in Science Program that was conceived to address such issues. It reports on a study that measured the relative effectiveness of the program's efforts to increase the interest, achievement, attitude, and awareness of girls in science and mathematics. Results indicate that the program met its stated goal with respect to enhancing fourth grade female attitudes, interest, and awareness toward school science and mathematics and toward science and mathematics both as a part of a larger enterprise and as potential career pursuits. The project also met its stated goal with regard to increasing the students' mathematical skills; however, the project did not meet its stated goal of increasing the students' science skills. Contains 20 references. (Author/JRH)

Confronting the Gender Gap in Science and Mathematics: The Sisters in Science Program

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Abstract

It has been well documented that inequities in science and mathematics achievement exist between males and females for a variety of reasons. Among the explanation are the notions that; female students tend to perceive science/mathematics as a male dominated field of study, female students are less interested in science/mathematics, classroom atmospheres and instructional practices do not foster female learning in science/mathematics, and female students harbor stereotypical ideas about science/mathematics and scientists in general. The article outlines the *Sisters in Science Program* that was conceived to address such issues. The goal of the program is to increase the interest and literacy of school aged females in science and mathematics.

Confronting the Gender Gap in Science and Mathematics: The Sisters in Science Program

The *Sisters in Science Program (SISP)* was conceived within the context of rising public opinion that there exists a gender gap in science and mathematics achievement (Kahle and Meece, 1994). Inherent in the program's focus in the recognition that female-specific intervention programs have a lasting impact on school success (Kaplan & Aronson, 1994). 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 *SISP* addresses the call for national reform, it is also in line with local science and mathematics education reform. When the *SISP* was developed it was found to supplement recently begun initiatives in 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. Urban Systemic Initiative). Thus, it can be stated that the *SISP* is a vehicle for both local and national reform in science and mathematics education.

As was mentioned, female students are lagging behind their male counterparts, as early as 9 years old, in science/mathematics achievement for a variety of reasons (Mullis & Jenkins, 1988). 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 .

One focus of the research on gender inequity in science and mathematics has been the classroom environment. Researchers suggest that teachers beliefs about student ability effects the manner in which female students operate in the classroom (Shepardson & Pizzini, 1992). Such research identifies teachers as the agents of gender bias. Also, female students tend to differ from their male cohorts in their receptivity to and participation in science and mathematics education. It has also been noted that female students contribute less often to classroom discussion than their male classmates. In fact, the very conversations girls have and the matters they concern themselves with (i.e. interactional issues) is different from boys (Theberg, 1993). Finally, currently implemented science and mathematics education, which is often competitive and individualistic runs counter to female learning styles which are more cooperative and interdependent in nature. Shakeshaft (1995) says that science and mathematics classes have expectations that simply exclude girls leading to lower participation and achievement.

A female's perception of science and mathematics also contribute to inequity in achievement. It has been found that female students harbor stereotypical ideas about science/mathematics and scientist in general. They often feel that it is a male dominated field (Kelly, 1985). Weinberg (1995) did a meta-analysis of the literature on gender difference and student attitudes, concluding that there is a correlation between students' attitudes about science/mathematics and their achievements in science and mathematics.

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).

Constructivism, an epistemological perspective of knowledge acquisition, serves as the foundation for many of the aforementioned suggestions regarding science and mathematics education reform. In the constructivist framework, learning is both social and dialogical in nature. Meaning, as human beings interact with objects in their environment they construct mental models of their environment. The constant interaction of human and environment creates learning about the world (Driver, 1995). Kenneth Gergen, a social constructivist, proposes that individual knowing is not determined by a single person but by a collection of persons in a position to render judgment..."What I say remains nonsense until you assent to its meaningfulness and vise versa." (p. 24, Gergen, 1995). In short, people learn in partnership with other individuals and that knowledge is socially agreed upon knowledge.

What then do science and mathematics educators need to do in order to foster science learning? Driver (1995) offers science and mathematics education some suggestions. 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, 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.

The *SISP* offers a multilevel intervention centered around the constructivist learning model. To this end, cooperative exploratory hands-on science and mathematics education tasks along with self reflection are being employed to facilitate learning. Within this framework of constructivist learning, the *SISP* 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. 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).

Program Description

The *SISP* intervention allows for cooperative interdependent exploration of science and mathematics concepts within a single sex learning environment. The rationale being 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 model as mentioned briefly in the aims and background sections is as follows. Females have been found to lag behind their male counterparts in science and mathematics achievement. The reason being, current science and mathematics education practices run counter to the intuitive learning style of female students. In addition, females tend to view the field of science and mathematics as a male domain, often leading to the reluctance of girls to go into science and/or mathematics as a field of study or career. The proposed *SISP* has been designed to provide female students a "girls only" environment that employs hands-on cooperative activities and discussions around science and mathematics careers. The constructivist centered, single sex paradigm allows girls to be girls in the presence of other girls so as to facilitate increased science and mathematics interest, achievement, positive attitude, and awareness.

The proposed objectives of the *SISP* : (1) increased interest in science and mathematics, (2) increased positive attitude toward science and mathematics, (3) enhanced awareness of academic and career opportunities in science and mathematics, and (4) increased achievement in science and mathematics were met via the implementation of a series of twenty 90 minute after-school science and mathematics programs of which preservice teacher enhancement was a part.

These after-school activities for females included environmental service learning projects and reflection sessions. The activities included such things as developing community environmental awareness campaigns, conducting surveys of the schools' and neighborhoods' recycling plans, testing for levels of pollution in their schools and in their homes, identifying pollutants found in garbage, air, water, etc., and creating an environmental newsletter that will be distributed throughout their respective schools.

The students also engage in reflection activities designed to help them better understand their personal learning, challenge stereotypical notions about science/mathematics and to develop critical thinking skills. These reflection activities included writing, interactive discussions, and creative expression through the arts.

As part of the program's perservice enhancement component, students in a science and mathematics education methods course at Temple University facilitated the program session along with their instructor. The preservice teachers' coursework explored gender-equity issues in the classroom. These 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 programs.

The after-school science programs were scheduled to meet once each week at each school from October through May of the academic year. For 20 weeks, fourth grade girls at both schools performed science and mathematics activities utilizing various science process skills and problem solving tasks. Approximately sixteen of those weeks were devoted to actual experimentation. The other four weeks, two in the beginning and two at the end were devoted to data collection.

Methodology

Principals from two Philadelphia public elementary schools accepted the program designer's offer to run an after-school science and mathematics program for fourth grade females. The fourth grade females at each school were invited to participate in the after-school program. There were no stipulation for females' participation in the program other than being able to attend the sessions between 3:00 p.m. and 4:30 p.m. one day a week.

The maximum number of females that could participate in each schools' program is equal to the number of female students in each of the schools' fourth grade classes. Thus, thirty to forty females could potentially participate at each schools' program. Additionally, during the 20 week programs approximately 30 perservice teachers worked at one of the two sites (i.e. approximately 15 Temple students site) during the fall semester. Another group of about 30 Temple students worked at each school during the spring semester. The ratio of students to facilitator was roughly 3:1, given maximum student participation.

Design

In an attempt to measure the relative effectiveness of the *SISP's* efforts to increase the interest, achievement, attitude and awareness of girls in science and mathematics knowing, a pre-post test design was employed. Pre-post test instruments were administered to female students at the start of the first and second after-school sessions and again during the final two sessions of the programs. 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 *SISP*, 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 15 items each with a 3-point response scale (yes, no, don't know). This instrument was adapted from various original questionnaires: Children's Initial Questionnaire (Rennie, Parker, and Hutchinson, 1985); Perceptions of Science and Scientists (Kahle, 1987); Science Attitude Scale (Meyer & Koehler, 1988); and Women in Science Scale (Erb and Smith, 1984) to reflect the cogntivie capacities of young learners.

Objective four, to increase achievement in science and mathematics was measured by a science process skills instrument and a mathematics skills instruments 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

There were fifty-three (53) complete sets of data for the science skills test and sixty-eight (68) complete sets of data for the mathematics skills test. Analysis of co-variance was used as the statistical test for the purpose of revealing the extent of change from pre- to post-test for the science and mathematics instruments. The analysis of co-variance for post-test scores, using the corresponding pre-test scores as the co-variant yielded the following results: (See Table 1).

Insert Table 1 about here

Student questionnaires regarding their interests, attitudes, and awareness were completed by 65 students and were analyzed using a pre and post design. Changes were analyzed utilizing the chi-square statistical procedure. The data were analyzed in four sections (school science, school mathematics, science/mathematics, other). The first three sections were analyzed using the chi-square statistics (See Table 2). Items in the "other" category were presented in tabular form only (See Table 3).

Insert Table 2 about here

Insert Table 3 about here

Discussion

With respect to the result from the science process skills instrument there was no statistical significant changes for the girls participating in the program This is a combination of small losses and small gains for the two schools involved. Clearly, to the extent that the instrument is appropriate to the problem, the outcome did not meet the expectation of an increase in the science process skills. Skills tested for 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), and estimating lengths. All of these appear in the Philadelphia Schools by the end of the fourth grade. Of the skills tested for, the student responses were most nearly correct for observing and measuring on both the pre- and post-tests, and for classifying on the post-test. For the identification of variables, a very limited response was given, students confused the controlled and responding variables. No one gave a correct answer for the responding variable. Similarly, the obtaining of an average was nearly never answered correctly on the pre- and post-tests. The test itself may been the problem, in that it did not reflect directly the experiences utilized in the program, but rather was based on skills employed in the aspects of the program. This lack of a direct connection may have possibly limited the responses for these students. Relatively few of them mentioned "sisters" in the context of their school science experience in responding to the questions at the end of the test. A second possibility stems from the clear displeasure expressed by students with their previous science experience, including references to reading and talking being the primary characteristics of these experiences. Reading ability could also have been a factor in their performance on a paper and pencil test requiring reading of the questions.

With respect to the results of the mathematics skills instruments, while the changes in results from pre- to post-test administration were not statistically significant, clear areas of gain were seen. The skills tested for included: basic number manipulation (addition, subtraction, multiplication, and division), use of decimals, multiplication and division by zero, various formats for expression, word problems of the one step variety, number sentences, coin money equivalence, pie graphs of fractions, reading of a bar graph, appropriateness of distance measuring units, and simple figure perimeter and area. Again, these are elements of the fourth grade curriculum, but as with science, they do depend on prior experiences, including their reading ability. From the outset, the students best skill performances were in the areas of addition, subtraction, and multiplication of small numbers. Multiplication involving 3-digit numbers, division and anything involving decimals produced problems. Word problems simply eluded them on the pre-test. On the post-test, however, a modest number of them were willing to try the word problems and a few reached correct numerical solutions. The pie graphs showing fractional equivalence were a strong point. A majority of them were able to identify correctly the fractional equivalence by the post-test. Likewise, progress appeared in interpreting the bar graph. While the lack of a statistically significant result was disappointing, the amount of change that was observed was within the range of expectation for the program. Considering that the gain in math skills was an adjunct rather than a primary result, and assuming that the effort in mathematics by the regular classroom teachers was on the same level as the effort in science, then the math results can be interpreted as favorable. A part of the difference in results for math and science may lie in the lower demand for reading skill on the math test than was the case on the science test.

With respect to the results of the <u>interest, attitude, and awareness index</u> 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 three items presented singly as response percents, 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 generalized response that they "like school" was something of a surprise, but placed in the context of the program can be taken as an indication of increased attitude. The pre to post results can reasonably be taken as an indication of the success of the program in increasing the students interest, attitude, and awareness in science and mathematics. A further question remains, however, will this be sustained when the program ends its support of t he school's effort in promoting science and mathematics performance and interest.

Conclusion

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' mathematical skills. However, the project did not meet its stated goal with respect to increasing the students science skills. Although, there is a possibility that this was at least in part a function of the instrument chosen to gather data in that poor language skills of the students and a lack of direct reference to the activities of the project may have reduced its effectiveness. Program modifications are being taken into account to further refine the assessment instruments and closer align the after-school activities with the classroom science and mathematics activities.

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Table 1 *Analysis of Co-variance*

Science Skills (pre to post changes)			
N = 53	F = 1.2796	p>0.20	Non-significant
Mathematics Skills (pre to post changes)			
N = 68	F = 0.8282	p> 0.20	Non-significant

Table 2 *Analysis of Attitudinal Instrument Data: Pre to Post Changes*

School Science		
X2 = 3.0010	$p>0.08$	Non significant
School Mathematics		
X2 = 20.5453	$p<0.01$	Highly significant
Science/Mathematics		
X2 = 10.7633	$p<0.05$	Significant

Table 3 *Analysis of Attitudinal Instrument Data: Tabular Form of "Other" Category*

Item 1	Yes 84%	No 2%	Don't Know 14%
Item 4	Yes 96%	No 0%	Don't Know 4%
Item 15	Yes 89%	No 8%	Don't Know 3%

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