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Impact of a Girls Mathematics and Technology Program on Middle School Girls' Attitudes Toward Mathematics

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This research investigated the impact of an all-female, non-school-based mathematics program on middle-school-aged girls' attitudes towards mathematics. Girls who attended a Girls Math and Technology Program for two consecutive years completed the Modified Fennema-Sherman Mathematics Attitude Scale before and after attending the program. Confidence scores increased significantly, whereas score increases in perceived usefulness of mathematics and perceived teachers' attitudes toward the girls in mathematics were not significant. (The "mathematics as a male domain" subscale was not assessed due to a low reliability score.) Race and community background factors did not significantly affect the girls' scores. Implications of findings and key program features are discussed.

During their early years, students develop the skills and attitudes toward learning that form the basis for future academic growth (Boland, 1995). If students develop a negative learning pattern toward a subject, it is extremely difficult to change.

Females' lower mathematics achievement in comparison with males is one area of educational concern that appears to be attitudinally based. On the 2000 National Assessment of Educational Progress (NAEP), males attained higher scores than females at the three grade levels tested (fourth, eighth, and twelfth). Males' Scholastic Assessment Test–Mathematics (SAT-M) scores for the 2000-2001 school year topped that of females by 35 points (National Center for Education Statistics, 2002). Fox and Soller (2001) point out that performance differences on the SAT-M, which also appear on the Graduate Record Exam (GRE), can be costly for women in terms of college admissions and scholarship decisions.

The research reported here investigated whether voluntary participation in a Girls Math and Technology Program improved middle-school-aged girls' attitudes toward mathematics. Results are reported and discussed for a group of two-year program participants' initial and follow-up ratings of their personal confidence in mathematics, perceived usefulness of mathematics, and perceptions of their regular classroom teachers' attitudes toward themselves in mathematics. The data were also examined for Whites and Non-Whites, as well as rural and urban participants, to see if the program had a differential impact on some participants.

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Review of Related Literature

Attitudes toward mathematics, including perceptions of how appropriate mathematics is for females, play a prominent role in females' lower performance and participation in mathematics in relation to males. Based on their analysis of NAEP data trends, Bae, Choy, Geddes, Sable, and Snyder (2000) contend, "Achievement gaps appear more closely related to attitudes than to course taking" (p. 117). The data show that females are less likely than males to like or to think they were good at mathematics. Females also experience mathematics anxiety to a greater degree than males (Levine, 1995).

Females' dispositions toward—and hence achievement and participation in—mathematics are believed to be socialized, inculcated by a society that tends to view mathematics as a male domain and which perpetuates the idea that males are naturally more mathematically inclined (Hanson, 1997). Teachers sometimes contribute to girls' poor self-concept in mathematics. They may imply, for example, that girls do not need mathematics or they may react more negatively when girls ask questions of clarification than when boys ask (Jackson & Leffingwell, 1999). Jones and Smart (1995) consider lack of confidence to be a major factor affecting girls' low participation in mathematics.

Much interest in single-sex educational settings has appeared in recent years. Evidence from a variety of

researchers and educators speaks to increased confidence, achievement, or subsequent participation in higher-level coursework for girls in single-sex mathematics classrooms (e.g., Streitmatter, 1997; Wood & Brown, 1997). Participants in Streitmatter's (1997) two-year study of seventh- and eighth-grade girls in all-female mathematics classes reported an enhanced ability to learn the mathematics, an improved view of themselves as mathematicians, and a clear preference for this type of environment. One reason for girls' greater comfort level in this type of classroom may be their expressed concerns about intimidation by boys in mixed-gender mathematics settings, namely, fear of being dubbed smart or fear of asking questions that boys deem "dumb" or otherwise unacceptable (Durost, 1996). Moreover, boys tend to dominate classroom conversation, be called on in class, be permitted to call out in class more often than girls, and they receive more teacher attention, including more useful feedback (Durost, 1996; Sadker, Sadker, Fox, & Salata, 1993/94).

Numerous out-of-school Science, Mathematics, Engineering, and Technology (SMET) programs for girls, such as after-school clubs or summer programs, have had a positive impact on their participants in terms of knowledge acquired and—in particular—favorable attitudes gained (e.g., Karp & Niemi, 2000; Mawasha, Lam, Vesalo, Leitch, & Rice, 2001). Dobosenski (2001) maintains that these types of experiences should begin in elementary or early middle school. Common elements in successful SMET programs include: a comfortable learning climate (e.g., fun, noncompetitive, open to questions); career-related information and issues; development of SMET content knowledge acquired experientially; academic and social support that includes peers and adult role models; self-concept and confidence building through effective group work and successful performance in SMET activities (Campbell, 1995; Mawasha et al., 2001). Opportunities to see mathematics as female-appropriate permeate these program features.

Girls' interest in mathematics begins to wane at about the middle school level, which is also the juncture at which students make decisions about future course enrollments and career tracks. Therefore, middle school is a critical "make-or-break-it" point for girls in mathematics (Campbell, Denes, & Morrison, 2000). Researchers stress the importance of offering early intervention programs for underrepresented groups (e.g., girls and students of color). These programs would emphasize career preparation, improve mathematics skills, and develop interest and positive attitudes (Trentacosta & Kenney, 1997). The program this paper describes is one attempt to bolster and extend middle school girls' in-school mathematics experiences.

The Girls Math and Technology Program

The Girls Math and Technology Program[1] is available to Northern Nevada girls who will enter grade 7 or grade 8 the fall after they enter the program. The main program component is a five-day, residential summer camp held at the University of Nevada, Reno with classes held at the College of Education. The program includes two full-day Saturday sessions, one held in the fall and one in the spring of the following school year. The program began in the summer of 1998 and ran for four years by the time data analysis took place for this research.

Currently, applications are sent to all Northern Nevada public, private, and Native American schools. The typical class size is 28 girls who work with others of their own grade level. In 1998, 28 girls entering grade 7 participated in the program, followed by 56 girls entering grades 7 or 8 in 1999, 76 girls entering grades 7, 8, or 9 in 2000, and 57 girls entering grades 7, 8, or 9 in 2001. The girls are randomly selected to ensure a fair selection process, so students of varied ability, race/ethnicity, socioeconomic status, and community background have the opportunity to participate. Scholarships are available to participating girls with demonstrated financial need.

The mathematics topics addressed during the Girls Math and Technology Program include geometry, algebra, data analysis and probability, problem solving, and spatial skills. The girls also learn biographical information about historical and contemporary female mathematicians, and a guest speaker from the local community discusses her use of mathematics on the job.

Two to four all-female staff members are in each classroom at all times. The staff consists of a balanced mix of veteran teachers who are active in mathematics education and upper-division teacher education majors or beginning teachers. Each lesson is developed in accordance with the Nevada Mathematics Standards established for the grade level the girls will enter in the fall.

Two key program components designed to impact participants' attitudes positively include providing female role models and employing an instructional approach that involves hands-on, conceptual, collaborative learning in a non-threatening atmosphere. Although these features can be incorporated into the

regular classroom, they appear to be infrequent or at least inconsistent aspects of middle-grades mathematics instruction, as the girls' comments indicated in other research on this program (Wiest, 2003). Moreover, the single-sex nature of the program—in terms of both participants and staff—deviates from the typical mathematics classroom and was perceived to support the two program components noted above. Further discussion of critical program elements appears in the Discussion and Summary section of this paper.

Research Purpose

The purpose of this research was to investigate the impact of a same-sex, non-school-based mathematics program on middle-school-aged girls' perceptions of their attitudes towards mathematics.

1. Did the girls' perceptions of their personal confidence in mathematics, the usefulness of mathematics, mathematics as a male domain, and their teachers' attitudes towards themselves in mathematics improve over time after attending the Girls Math and Technology Program for two consecutive years?
2. Were the girls' attitudes influenced by their race (White or Non-White) or community background (urban or rural)?

Research Method

Sample

The research sample consists of 36 Northern Nevada girls who attended the Girls Math and Technology Program for two consecutive years. Each girl had started the program during the summer prior to entering grade 7 and returned a year later prior to entering grade 8. The girls' backgrounds are varied in terms of mathematics ability, socioeconomic status, and home community type. The sample includes 64% Whites and 36% Non-Whites (5% Black, 20% Native American, 5% Hispanic, 3% Asian, and 3% Biracial), of which 61% come from an urban area and 39% from a rural area.

Design and Procedures

The data-gathering instrument used in this research was the Modified Fennema-Sherman Mathematics Attitude Scale. This scale provides information about girls' attitudes toward mathematics in the following categories: personal confidence about the subject matter, usefulness of the subject matter, perception of the subject as a male domain, and perception of teachers' attitudes toward the respondent in the subject[2]. The Modified Fennema-Sherman Mathematics Attitude Scale contains 47 positive and negative statements on a five-point, Likert-type scale that ranges from "strongly agree" to "strongly disagree." The highest score possible is 235, with 5 points assigned to the most self- or mathematics-favorable choice on each of the 47 items. The confidence, usefulness, and teacher's attitudes subscales each contain 12 items with a highest possible score of 60. The male domain subscale contains 11 items with a highest score of 55.

The Modified Fennema-Sherman Mathematics Attitude Scale was given to the girls the first day (pre-test) of the Girls Math and Technology Program as well as the final day (post-test) of the week-long summer camp they attended for the first and second years, respectively.

Data Analysis

Pre-test and post-test scores on the Fennema-Sherman instrument were used for each girl in this sample. The scores consisted of totals for each of the four subscales.

A reliability analysis, using Cronbach's alpha, was conducted to test for internal consistency within each of the four subscales for the pre- and post-tests. Means and standard deviations were calculated for the four subscales for the pre- and post-test. To determine if the subscale scores improved, the means for the two tests in each of the four subscales were compared using a two-tailed, paired-samples t-test, with alpha set at the .10 level.

To determine whether the girls' attitudes were related to their race (White or Non-White) or community background (urban or rural), we conducted a one-way analysis of covariance (ANCOVA). Means and standard deviations were calculated for each level of the variables in all subscales for both pre- and post-tests.

Results

Internal consistency for each subscale was calculated using Cronbach's Alpha. For the pre-test, the highest alpha (.79) was obtained for teachers' attitudes, with .75 for confidence, .74 for usefulness, and .37 for male domain. For the post-test, the highest alpha (.87) was obtained for confidence, with .84 for teachers' attitudes, .81 for usefulness, and .61 for male domain.

Table 1

Modified Fennema-Sherman Mathematics Attitude Scale: Pre- and Post-Test Means and Standard Deviations

	Confidence			Usefulness			Teachers' Attitudes		
	N	M	SD	N	M	SD	N	M	SD
Pre-Test	33	50.70	6.62	32	55.34	5.22	33	49.70	7.51
Post-Test	33	53.48	7.15	32	56.31	5.33	33	50.51	7.51

The alphas for three of the subscales—confidence, usefulness, and teacher's attitudes—fell within the acceptable range of .70 or above. However, the reliability of the male domain subscale was below the acceptable range, with the pre-test analysis at .37 and the post-test at .61. Therefore, it was omitted from further exploration.

Girls' Attitudes Toward Mathematics

A paired-samples t-test was conducted to evaluate if the girls' attitudes improved over the two years they attended the camp. Table 1 shows mean and standard deviation scores for the two Fennema-Sherman Mathematics Attitude Scale tests: the pre-test at the beginning of the first year and the post-test at the end of the second year. The results show that the increase in the girls' confidence level was statistically significant (t (35)=2.65, p= .012). The girls' scores on the other two subscales did not increase significantly over the two-year period.

Race and Community Background

A one-way analysis of covariance (ANCOVA) was conducted on each subscale to evaluate if the girls' scores were influenced by their race and by their community background with the pre-test scores as the covariate. Race and community background factors did not significantly affect the girls' scores (see Table 2).

Discussion and Summary

The most influential aspect of the Girls Math and Technology Program is the positive impact it has on the girls' self-confidence in mathematics (and perhaps technology, which the instrument did not measure). Girls' and boys' confidence in their mathematics abilities do not differ in the early grades, but a lack of confidence becomes evident for girls as they enter middle school (Boland, 1995). This is particularly important because mathematics becomes more complex at this point in time (Boland, 1995).

Improvements in participants' perceptions of the usefulness of mathematics and their teachers' attitudes toward themselves were slight and were not statistically significant. In the case of mathematics' utilitarian value, scores were already somewhat high and thus were less likely to show a statistically significant increase. It may also be difficult for middle school students in general to appreciate the usefulness of mathematics, because they may be too old to accept rhetoric stating that mathematics is useful and they may be too young to associate school mathematics with their daily lives in a meaningful manner. It is disappointing that the girls' greater self-confidence in mathematics, as associated with this program, did not translate into more positive perceptions of their teachers' attitudes toward themselves. This may highlight educators' critically important role—and therefore the need for high-quality professional

Table 2

Modified Fennema-Sherman Mathematics Attitude Scale: Analysis of Covariance for Influence of Race and Community Background

	Confidence			Usefulness			Teachers' Attitudes		
Source	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*
Race	1	0.175	0.679	1	0.184	0.725	1	0.056	0.814
Area	1	1.795	0.191	1	0.56	0.815	1	0.457	0.505
Race x Area	1	1.492	0.232	1	0.006	0.94	1	0.079	0.781
Error	28	-33.19		27	-23.01		28	-56.8	

development in gender-equitable teaching—in mathematics instruction for middle school girls. It is not possible to determine from these data the impact perceptions of teachers' attitudes had on the girls' attitudes. Nevertheless, it is reasonable to assume that teachers, with whom students spend a great deal of time and who judge the value of students' work, influence students' academic self-perceptions.

According to these data, differences in race or community background did not appear to cause differential program impact. Instead, several shared attributes and interests predominated across the varied individuals who participated in this program. In other research on this program (Wiest, 2003), qualitative data in the form of personal interviews, camp-end surveys, and fall follow-up questionnaires showed some of these key commonalities to be gender, interest in mathematics, and a chance to meet new people and experience life away from home.

Several features led to this program's success (Wiest, 2003). The residential nature of the summer camp is a critically important aspect in that it allows girls from rural towns to participate. For instance, a group of parents drive their daughters seven hours from a remote Native American reservation to Reno in order to attend this program. By staying over night, the girls bond with each other and with the staff members over the course of the week, and they see that girls and women who like mathematics are "normal" people with many interests and abilities. One second-year camper's parent told the camp director, for example, that one thing that surprised and impressed her daughter the previous year was that the camp director had played football with the girls on the campus quad during an evening recreation time.

Another important program element, according to Wiest's (2003) qualitative data, is the type, amount, and quality of the mathematics content. The topics addressed in the program are made to be interesting and challenging in ways many girls have never experienced. Several girls noted that learning mathematics without homework or the pressure of earning a grade greatly reduced their anxiety compared with their school experiences.

This program's instructional approach, which centers about group work and hands-on learning in a supportive environment, also surfaced as a key program element (Wiest, 2003). The program's methods of instruction and comfortable climate seemed to differ from that which many of the girls encountered in school, and they better suited the girls' needs and learning styles.

Finally, Wiest (2003) found that the all-female staff is another strong component of the Girls Math and Technology Program. The role-model aspect of this program, including female instructors, a female guest speaker, and information about accomplished female mathematicians, helped the girls see themselves as potentially successful mathematicians in both the present and future. Several parents said that their daughters began talking about the importance of mathematics and considering mathematics-related careers in the months after the summer camp had ended.

This supplementary program for girls has the luxury of several benefits that the typical school does not. One is that instructors are chosen from among the most highly qualified local mathematics teachers. Another benefit not afforded to most schools—besides the single-sex nature of the participants and instructors—is the lower student-to-teacher ratio, with 2 to 4 instructors per 28 girls. This allows for more individual attention than most schools are able to provide.

Closing Comments

The National Council of Teachers of Mathematics (1995) notes that equity is a critical factor in the nation's economic viability. The workplace requires that all Americans, including minorities and women, have the mathematics skills needed to meet the demands of the global marketplace. Eliminating the social injustices of past schooling practices will require the support of policymakers, administrators, teachers, parents, and others concerned about excellence and equity in mathematics education. All children can learn challenging mathematics with appropriate support and an equitable learning environment, regardless of ethnicity, race, gender, or social class. Until females and other lower-achieving and underrepresented students attain parity in mathematics, supplemental programs such as the one discussed in this paper can provide important support mechanisms beyond that which schools may offer.

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[1] Interested individuals can obtain the manuscript entitled "Impact of a Summer Mathematics and Technology Program for Middle School Girls" by contacting Lynda Wiest at wiest@unr.edu.

[2] Teachers' attitudes refer to those of regular classroom teachers rather than instructors employed in this program. These attitudes center about teachers' interest in, respect for, and encouragement of the girls as present and future mathematicians. For more information, see the Fennema-Sherman Mathematics Attitude Scale at http://www.woodrow.org/teachers/math/gender/08scale.html.