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Out-of-School-Time STEM Programming for Females: One Strategy for Addressing Gender-Related Beliefs in Mathematics

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Abstract: *Females are underrepresented in science, technology, engineering and mathematics (STEM) disciplines. They also tend to display less favorable dispositions towards STEM than males. This study investigates the influence of a five-day residential summer mathematics and technology camp on middle school girls' beliefs about mathematics as a gendered domain. Participants showed a significant positive change in their perception of mathematics as a female domain and named the academic aspect of the camp as the most important program component. The meaning of these findings and the potential value of an out-of-school-time STEM program for girls are discussed.*

Keywords: *females; mathematics; STEM; summer program; dispositions*

Review of the Literature

The United States lacks a well-prepared workforce in STEM (science, technology, engineering, and mathematics) careers (Heaverlo, 2011; Paulsen, 2013). Workers in these fields tend to be White and Asian men (McGee, 2013), pointing to the need for a greater number of STEM-proficient females, racial/ethnic minorities, people with disabilities, and individuals from low-income backgrounds to contribute to STEM occupations (Davis & Hardin, 2013; White, 2013). However, U.S. students show weak STEM performance in international contexts (Davis & Hardin, 2013; Dillivan & Dillivan, 2014), and underrepresented groups face additional challenges. Females, for example, grapple with less favorable dispositions toward STEM than males, including weaker self-beliefs and confidence, as well as lower interest (Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013; Lubienski, Robinson, Crane, & Ganley, 2013; Ross, Scott, & Bruce, 2012). It appears that females' dispositions contribute more to the gender gap in STEM than achievement, although dispositions can influence STEM achievement and participation (Goetz et al., 2013; Riegle-Crumb, King, Grodsky, & Muller, 2012; Ross et al., 2012).

The need to support underrepresented groups in STEM to fuel the STEM workforce and to provide opportunities for better life quality for individuals from these groups is apparent. In this study, we focus on females as one such group with awareness of the compounding effects of intersecting identities, such as race/ethnicity and socioeconomic status. We discuss the potential contributions of an out-of-school-time (OST) program, specifically, a five-day residential summer camp, as one strategy for supporting females in STEM.

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Methods

Participants

Participants for the quantitative data reported here were 34 Nevada females ages 12-13 who attended the Northern Nevada Girls Math and Technology Camp in the summer of 2014. Qualitative data obtained as responses to open-ended questions came from 99 girls (64 rising seventh graders, 35 rising eighth graders) who attended the 2014 and 2015 camps and completed the camp-end evaluation.

Instruments

Mathematics as a Gendered Domain instrument. Participants completed the Mathematics as a Gendered Domain (MGD) instrument as a measure of gender-related beliefs (Leder & Forgasz, 2002). The three subscales are Mathematics as a Male Domain (MD), Mathematics as a Female Domain (FD), and Mathematics as a Neutral Domain (ND). When administered, the 48 items of the three subscales were presented in random order. Participants indicated the extent to which they agreed or disagreed with each statement using a five-point Likert scale. Sample items for the three subscales include:

MD: Mathematics is easier for men than it is for women.

FD: Girls are more suited than boys to a career in a mathematically-related area.

ND: Girls and boys who do well in a mathematics test are equally likely to be congratulated.

The highest total score possible on this instrument is 240, with five points assigned to each item. The highest scores possible for the subscales are 80 for the 16 MD items, 85 for the 17 FD items, and 75 for the 15 ND items. Participants completed the instrument the first evening of the camp prior to the beginning of mathematics instruction, and again at the end of the camp. Forgasz, Leder, and Kloosterman (2004) determined the construct and content validity for this instrument by reviewing research literature and seeking input from mathematics educators and students. Additionally, they report,

> A reliability analysis was conducted on the items comprising each of the three subscales of the mathematics as a gendered domain instrument. For each subscale, item-total correlations confirmed the internal consistency of the items. Cronbach's a [alpha] values for the three subscales were .90 for MD, .90 for FD, and .84 for ND. (p. 399)

Camp-end evaluation form. Near the end of the camp on the last day, the girls complete an evaluation form with items they rate on a five-point scale and numerous open-ended questions. The data shared here are derived from the following question on that form:

- Name up to three features of the program as a whole that you found most important.

Data Analysis

For the quantitative data, we used a paired-samples t-test to compare means for pre and post measures, testing for significance at the .05 level using a one-tailed test. Students' beliefs toward mathematics, as measured by the MGD instrument, were the dependent variables. Of the 34 participants, 31 pairs of scores were analyzed for those who completed the instrument at both the beginning and the end of the camp.

We analyzed the qualitative data (written comments) for themes. Through multiple readings of the comments, we identified themes and adjusted them, as needed, until we believed the themes reflected participant comments.

Results

Attitudes and Beliefs

Table 1 shows mean Mathematics as a Gendered Domain subscale scores for the beginning and end of the camp. No significant difference appeared between the pre and post measures on the Male Domain or Neutral Domain subscales. However, significant favorable change occurred on the Female Domain subscale ($t = 2.78$, $p < .05$), indicating that participants perceived mathematics as a female domain to a greater degree on the second administration of the instrument. Table 2 lists three items from the Female Domain subscale that showed statistical significance between the pre and post measures.

Table 1. Mathematics as a Gendered Domain Subscale Scores

Subscale	Pre		Post		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
MD	31.90	10.57	33.39	12.37	.850	.201	.152
FD	43.55	11.17	49.23	14.23	2.78*	.004	.499
ND	61.90	8.15	62.39	9.15	.349	.364	.626

Note. A paired-samples t-test was used to compare means for the pre and post measures for 31 pairs of scores, testing for significance at the .05 level using a one-tailed test.

Table 2. Statistically Significant Differences in Items on the FD Subscale

Items	Pre		Post		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
28. Compared to girls, boys give up more easily when they have difficulty with a mathematics problem.	2.06	.96	2.52	1.15	2.04*	.025	.366
32. In a mathematics class with both boys and girls, girls tend to speak up more than boys.	2.52	.99	3.22	1.20	2.83*	.004	.508
44. Girls are more likely than boys to say mathematics is their favorite subject.	2.51	1.02	3.03	1.30	1.83*	.038	.328

Note. A paired-samples *t*-test was used to compare means for the pre and post measures for 31 pairs of scores, testing for significance at the .05 level using a one-tailed test. Of the 48 items on the MGD instrument, these three items were significantly more favorable from the first to the second administration of the instrument.

Favorite Camp Components

Asked on the camp-end evaluation what they considered the most important three features of the program, the girls focused mainly on the academic aspects. Almost 60% of the comments named specific subject areas or noted new learning and improved mathematics and technology skills. For example, one rising seventh grader wrote, "Learning math for future jobs. And improving the world," and a rising eighth grader listed "the problem solving because it made me think in different ways." Some additional comments (6% of all comments) on the educational components of the camp centered on valuing the session on learning biographical information about women in STEM and student-centered instructional approaches. The next most favored aspects of the program were the social and recreational aspects, which garnered 13% of the comments. Examples include "meeting new people and becoming friends," "connecting with girls like me," and "fun activities after a long day's work." Finally, 6% of the comments commended the staff for being positive mentors and role models who they found encouraging, supportive, helpful, and accessible, and another 6% named spending time on a college campus—in particular, staying over night in dorms—as a top camp feature.

Discussion

These data indicate that an OST mathematics and technology program for girls can favorably influence program participants in terms of dispositions and perspectives, as well as STEM performance and participation. The study participants showed a significant positive change in their perception of mathematics as a female domain but not in relation to mathematics as a male or neutral domain. Perhaps this area of change is most important in that it might be better to see mathematics explicitly as female-appropriate than to see it as "not male" or even as neutral, which is more open to interpretation.

It is encouraging that the girls who participated in this program largely named academic program aspects as most important. This reminds us that girls (and students in general) can be "hooked" by and engaged in STEM academic content, even when challenging. We believe this is especially true when STEM material is presented in a comprehensible manner using active learning in a safe setting and when youth are helped to see the value of STEM to their lives and to the world at large. To a much lesser degree but listed second in importance were the social and recreational aspects of the program. It may be that the marriage of the social/recreational with the academic enhances learning and motivation for girls because it exercises a fuller range of human characteristics that synergistically serve to strengthen each other.

The three items on which the girls showed significantly more favorable scores from camp beginning to end (Table 2) reflect program values that are mirrored in instructional approaches and program "messages." We explicitly discuss the importance of perseverance during challenge and the fact that struggle does not imply lack of competence. This experience is, we say, indeed normal during the course of worthwhile learning and that productive effort can lead to better performance (e.g., Barnett, Sonnert, & Sadler, 2014). We not only expect and encourage the girls in our program to persevere in their mathematical tasks, but we expect them to collaborate with peers and share ideas in small-group and whole-class settings. The girls are responsible to explain and defend their work to their peers, and classmates comment on and pose questions about work shared publicly in the classroom. These learner-centered approaches seem to be important factors in favorably influencing the camp participants in mathematics and technology.

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