A VOLUME IN
OUT-OF-SCHOOL-TIME STEM PROGRAMS FOR FEMALES
IMPLICATIONS FOR RESEARCH AND PRACTICE

Out-of-School-Time STEM Programs for Females

Implications for Research and Practice

Volume I: Longer-Term Programs

edited by

Lynda R. Wiest | Jafeth E. Sanchez
Heather Glynn Crawford-Ferre

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Lynda R. Wiest, *Series Editor*

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For my parents, Joan Wiest and the late Lindy ("Sam") Wiest,
who inspired me to value education
—Lynda R. Wiest

For my loving husband, Christopher M. Sanchez,
who supports my every dream
—Jafeth E. Sanchez

For my nana, Earnestine Bland,
who shared with me the love of writing and the written word
—Heather Glynn Crawford-Ferre

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INTRODUCTION

Why OST STEM Programs for Females?

Lynda R. Wiest, Jafeth E. Sanchez,
and Heather Glynn Crawford-Ferre

The science, technology, engineering, and mathematics (STEM) disciplines play a pivotal role in societal progress and economic prosperity (Riegle-Crumb, King, Grodsky, & Muller, 2012). Their contributions to societal well-being, coupled with the poor performance of U.S. students internationally, has led to calls for building a more STEM-proficient workforce (Davis & Hardin, 2013; Dillivan & Dillivan, 2014). STEM fields possess high status and offer career promise (e.g., stable, growing, high-paying occupations), providing important employment opportunities that can influence people's life quality (Riegle-Crumb et al., 2012; Shapiro, Grossman, Carter, Martin, Deyton, & Hammer, 2015). It is thus disconcerting that females show less interest and confidence in STEM (Ross, Scott, & Bruce, 2012; Shapiro et al., 2015) and are underrepresented in STEM pursuits, including career preparation through persistence in careers, as well as recreational involvement, such as participation in clubs and contests (Wiest, 2011).

Out-of-school-time (OST) programs, which are on the rise, are increasingly suggested as one strategy for supporting and encouraging females in STEM (Afterschool Alliance, 2013; McCombs et al., 2012). These

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programs offer less formal but structured learning environments ranging from a few hours to a week or longer during summer, weekend, and after-school time (Mohr-Schroeder et al., 2014; Wilkerson & Haden, 2014). OST STEM programs are typically designed for participants to explore STEM content and careers, apply STEM to real-world settings and develop awareness of the utilitarian value of STEM, and inspire interest in STEM (Afterschool Alliance, 2013; Mohr-Schroeder et al., 2014; Wilkerson & Haden, 2014). Accordingly, participants in OST STEM programs have shown improved achievement, interest, and confidence in STEM and greater awareness of STEM role models and careers (McCombs et al., 2012; Mohr-Schroeder et al., 2014; Shapiro et al., 2015). Ways to address the content vary and can include, for example, enhancing, augmenting, or integrating content (White, 2013), but use of experiential learning is common across programs (Bevan & Michalchik, 2013; Dillivan & Dillivan, 2014; Mohr-Schroeder et al., 2014). Programs of greater intensity and duration have been found to be more effective for learning and retention (Mosatche, Matloff-Nieves, Kekelis, & Lawner, 2013).

The chapters in this volume detail OST STEM programs for females that run one week or more in length. Table I.1 provides an overview of the featured programs. (Note that an unsuccessful effort was made to locate contributing authors for programs outside the United States.)

The seven programs that appear in this book range from one week to one year in length. Four are commuter (day) programs, and three are residential (overnight) programs. Most are held on college campuses. Program participants range from upper elementary through high school students, with 25–60 girls attending each program. All are female, but the type of girl targeted differs (e.g., underserved girls, girls with a particular background or interest in STEM, or a random mix). The staff, who tend to be educators and students, are either all female or mostly female. The cost to participants for the sample programs in this book is either free (five programs) or several hundred dollars with tiered costs based on family financial status (two programs). Various types of internal and external support are integral to program sustainability.

In this book, the chapter authors describe their programs, the effectiveness of those programs, and practical implications of data they have collected on their programs. Terminology note: Despite older conceptions of sex as biological and gender as psychosocial, the term *gender* has increasingly replaced *sex* in discussions of females and males in the social sciences (e.g., Haig, 2004; Hubbard, 1996) and thus is the term of choice in this book.

TABLE I.1 Overview of Programs Featured in This Book

Name	Year Began[a]	Location	Main STEM Focus	Website
Las Chicas de Matemáticas	1999	Colorado	Math	http://www.unco.edu/nhs/mathsci/mathcamp/
Matherscize	1999	Ohio	Math	http://u.osu.edu/erchick.1/matherscize-3/
Techbridge	2000	California, Washington (state), Washington, DC	Science, technology, engineering	www.techbridgegirls.org
Eureka!-STEM	2012	Nebraska	Science, technology, engineering, math	N/A (embedded in UNO STEM Outreach page at http://www.unomaha.edu/college-of-education/office-of-stem-education/community-engagement/index.php)
Northern Nevada Girls Math & Technology Program	1998	Nevada	Math, technology	http://www.unr.edu/girls-math-camp
GOALS for Girls	2008	New York	Science, technology, engineering	https://www.intrepidmuseum.org/GOALSforGirls
All Girls/All Math	1997	Nebraska	Math	http://www.math.unl.edu/programs/agam

[a] "Year Began" means the first year the program was conducted, although it might have been developed the previous year.

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CHAPTER 1

A DOOR TO STEM POSSIBILITIES

Las Chicas de Matemáticas

Hortensia Soto-Johnson

ABSTRACT

The lack of women in STEM-related careers is a growing concern, especially in light of the projected need for STEM professionals. Las Chicas de Matemáticas, a free residential camp, is designed to address this concern by promoting STEM-related careers to high school girls. Due to its prominent role in all STEM fields, college-level mathematics is the focus of the camp. This chapter contains a description of the structure of the camp, as well as the manner in which the program influences young women's confidence in their ability to do mathematics, informs them about STEM-related careers, and piques their interest in learning advanced mathematics. Of particular interest is how this challenging content, taught through inquiry-based learning, promotes creativity and is instrumental in furthering the participants' interest in mathematics. This has instructional implications for other in- and out-of-school activities related to STEM.

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Each of us has that right, that possibility, to invent ourselves daily.
If a person does not invent herself, she will be invented.
So, to be bodacious enough to invent ourselves is wise.

—Maya Angelou

For decades, there has been concern with the lack of women pursuing and completing science, technology, engineering, and mathematics (STEM)-related careers. It is especially disconcerting that women's disinterest in STEM fields begins at an early age. The literature indicates that although girls tend to perform as well as boys in elementary school, they start to doubt their mathematics and science abilities in middle school at about age twelve (Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, 2000; Eccles, 1989). This lack of confidence persists through high school (Eccles, 1989) and might be one factor that influences the low representation of women in college STEM courses (National Science Board, 2006). It is especially alarming that women who do pursue and complete STEM-related careers are not well represented in academia and in industry. For example, although women earn 41% of PhD's in STEM fields, they make up only 28% of tenure-track faculty in those fields (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011). Further, recent reports show that men make up two-thirds of the staff for Google, Facebook, and other major technology companies (Guynn, 2014).

These dire statistics can be attributed to many factors. For instance, during their adolescent years girls tend to suffer from low self-esteem, which contributes to poor academic performance and suppressed ambitions (Jobe, 2002/2003). Unfortunately, both parents and teachers unintentionally cultivate this low self-esteem in young women. For example, parents tend to attribute their son's success in mathematics and science to natural talent and their daughter's success to effort and hard work (Aschbacher, Li, & Roth, 2010; Eccles, 1989). Moreover, parents tend to view mathematics as more important for the future of their sons than their daughters. While young women tend to articulate a desire to pursue careers that help and nurture people, most parents are not well-informed about STEM-related careers that focus on the well-being of others, such as humanitarian engineering. Thus, parents often fail to encourage their daughters to pursue more mathematics and science coursework.

Some teachers also contribute to gender bias in STEM. In particular, they fail to provide young women with role models, who can be instrumental in helping young women envision themselves succeeding in STEM-related careers (Seymour, 2006; Seymour & Hewitt, 1997). Given these realities, it is no wonder that a 2011 report by the Executive Office of the President of the United States promotes support systems that attract women into and retain them inthe STEM workforce. Such support systems may include mentoring by successful women in STEM-related careers, opportunities to engage in STEM-related activities, and encouragement to pursue STEM-related careers. These support systems must begin as early as elementary school so that young girls pursue advanced STEM-related courses and extracurricular activities during their middle and high school years. These support systems are also imperative during and after college, especially because women do not secure a high percentage of STEM jobs in academia or in industry.

The primary purpose of this chapter is to describe the program Las Chicas de Matemáticas, which is designed to promote STEM-related careers to high school girls. Given the prominent role that mathematics plays in all STEM fields, the program focuses on mathematics. A secondary aim of this chapter is to report how this program influences young women's confidence in their ability to do mathematics, informs them of STEM-related careers, and piques their interest in learning advanced mathematics. The delivery of this program is informed by research on dispositions and motivation toward learning mathematics, learning environments that inspire women to pursue STEM-related careers, and characteristics of successful outreach programs.

RELATED LITERATURE

In his summary of research on student dispositions toward mathematics, Beyers (2011) found varied interpretations of the notion of disposition, which he categorized into three constructs. From mathematics education literature, Beyers identified "the existence of dispositional cognitive, affective, and conative mental functions that contribute to a student's mathematical disposition" (p. 71). Cognitive dispositional mental functions with respect to mathematics include perceiving, recognizing, conceiving, judging, reasoning, and similar mental actions. Affective dispositions focus on one's identity with mathematics, that is, beliefs about oneself as a mathematics learner, beliefs about the value and usefulness of mathematics, and attitudes toward mathematics. The last disposition construct, conative, is associated with amount of effort, persistence, and diligence that one dedicates to learning mathematics. Teachers, role models, and peers, as well as significant family members, can influence students' disposition in all three of these constructs (Aschbacher et al., 2010; Beyers, 2011; Eccles, 1989; Jobe, 2002/2003) and, consequently, students' mathematics learning.

Soto-Johnson, Craviotto, and Parker's (2011) work suggests that the interplay among motivation, environmental factors, and disposition toward mathematics can influence whether mathematically high-performing young women pursue advanced mathematics. In their study, environmental factors such as relationships with parents, teachers, and peers, as well as participation in extracurricular mathematics activities, such as MathCounts, motivated the high school girls to do well in their mathematics courses. Such environmental factors and participation in extracurricular activities also influenced the high school girls' positive, confident disposition toward mathematics. Consequently, this enthusiastic disposition toward mathematics motivated the girls to do well and to create career goals that require a strong mathematics background. Finally, the high school girls' motivation to do well, combined with their mathematics-related career goals, promoted a positive, confident disposition toward mathematics. Thus, there is a strong interplay between disposition toward mathematics and motivation to do well in mathematics. In an effort to motivate and improve young women's disposition toward mathematics, Soto-Johnson et al. (2011) recommend that teachers "create learning environments where students can collaborate with one another and learn mathematics conceptually" (p. 138). This message is echoed in other literature (e.g., Eccles, 1989; Jobe, 2002/2003; Laursen, Hassi, Kogan, & Weston, 2014).

According to Eccles (1989), learning environments that are competitive, promote social comparisons, incorporate drill and practice, and minimize student–teacher interactions do not motivate middle and high school females to study mathematics and science. Eccles notes that learning environments that do benefit females use hands-on activities, non-sexist materials, cooperative formats that ensure full participation by all students, and career counseling. She says a noteworthy aspect of such learning environments is that they "facilitate the motivation and performance of minority students and low achieving males as well" (p. 53). Jobe (2002/2003) also found that reform teaching methods that emphasize verbal and visual problem-solving methods combined with teamwork benefit both girls and boys. Besides learning STEM content, both genders learn important interpersonal skills, such as cooperation, negotiation, conflict resolution, and listening. Similar results have been found with students enrolled in college-level mathematics courses (Laursen et al., 2014).

Laursen et al. (2014) investigated the impact of inquiry-based learning (IBL) in college mathematics courses. Teachers who taught using IBL methods dedicated over 60% of the class time to facilitating mathematics discussions through student-centered activities where the students presented their work, engaged in small-group work and discussions, and integrated technology. Teachers who taught using non-IBL methods spent 87% of the class time talking to the students. The research team found that students enrolled in IBL courses tended to show greater student leadership and ask more questions. Laursen et al. further noted:

> Students in IBL math-track courses reported greater learning gains than their non-IBL peers on every measure: cognitive gains in understanding and thinking; affective gains in confidence, persistence, and positive attitude about mathematics; and collaborative gains in working with others, seeking help, and appreciating different perspectives. (p. 409)

In controlling for gender, the findings suggest that women enrolled in IBL courses had the same cognitive and affective gains as their male counterparts. The women's subsequent grades were also as good as their male peers, but their collaborative gains were higher than the males enrolled in the IBL courses. Women enrolled in non-IBL courses did not fare as well. They "reported substantially lower cognitive and affective gains than did their male classmates" (p. 411). Laursen et al. suggest that this particular result most likely reflects the women's weaker perception of their ability rather than a true difference in performance.

In sum, some literature suggests that IBL classroom environments favorably influence women's success with STEM curricula from kindergarten to college-level courses. Such teaching practices have produced similar positive results when integrated with outreach efforts in science (Laursen, Liston, Thiry, & Graf, 2007), technology (Matarić, Koenig, & Feil-Seifer, 2007), engineering (Weinberg, Pettibone, Thomas, Stephen, & Stein, 2007), and mathematics (Chacon & Soto-Johnson, 2003). For example, Laursen et al. (2007) argue that K–12 students become more interested in science and develop new perceptions about the field when they engage in hands-on activities with authentic scientists who visit the classroom. Through such visits, teachers also learn current scientific content and how to teach it creatively. Chacon and Soto-Johnson (2003) showed similar results for mathematics. The high school girls who participated in their summer program learned about the role of mathematics in STEM-related careers from women in STEM fields. These interactions, along with other camp activities, favorably influenced their perceptions of mathematics. Matarić et al. (2007) emphasized the importance of developing creative, accessible, and affordable STEM educational materials. Accordingly, they worked with K–12 schools to develop hands-on robotics courses, along with teacher training materials. Given that most teachers are not trained to teach robotics classes, the teacher materials facilitated implementation of the activities. Weinberg et al. (2007) found that girls who participated in a robotics program and who had good mentors "experienced an increase in self-concept and increased expectations of success in science and math due to the program" (p. 3). These researchers conclude that programs that "effectively modify social and cultural beliefs may be particularly promising in encouraging girls to pursue STEM areas for study and careers" (p. 4). Durlak, Weissber, and Pachan (2010) also note the importance of promoting personal and social skills as part of out-of-school-time (OST) program efforts. In particular, they advocate for skills designed to enhance self-efficacy and self-esteem.

The free OST program described in this chapter, Las Chicas de Matemáticas, incorporates many of the recommended research-based practices regarding disposition and motivation toward learning mathematics, as well as a learning environment that inspires women to pursue STEM-related careers and incorporates characteristics of successful outreach programs. Details are also provided on how this program integrates inquiry-based and hands-on learning, offers female role models in STEM-related careers, and promotes personal and social skills.

PROGRAM DESCRIPTION

Before introducing the camp at the University of Northern Colorado (UNC), the project director (PD) and a colleague implemented a scaled-down version of Las Chicas de Matemáticas (http://www.unco.edu/nhs/mathsci/mathcamp/) at the PD's previous institution. In 2008, the PD and two other mathematics faculty collaborated to conduct the first camp at UNC. The camp was offered each year from 2008 to 2014, except 2011 due to a lack of funding, and it will be offered again in the future as funding allows. The purpose of this free residential camp is to introduce 32 Colorado high school girls to the independence of college life, collegiate mathematics, STEM careers, and female role models who are passionate about mathematics. In this section, I describe the camp, the staff and their roles, and challenges that arise with this camp.

Camp Details

After securing funds to offer the camp free of charge to all participants, advertising for the camp commences. In February before each summer camp, the PD advertises the camp via past camp participants and through a Colorado mathematics email list that reaches K–12 teachers, academic counselors, and college professors who have signed up to be on the listserv. It is also advertised through the National Girls Collaborative Project (www.ngcproject.org). The application deadline is mid-March, and applicants are notified about acceptance decisions by the first of May. The time gap is needed for handling the large number of applicants, approximately 200 per year.

Any young woman who has successfully completed a course equivalent to the first year of algebra and who will enter grades 9–12 in the upcoming academic year is eligible to apply. Applicants must complete and submit the application form found at the Las Chicas de Matemáticas website, along with a statement indicating why they are interested in attending the camp. They must also include a letter of recommendation from a current mathematics teacher who can attest to the applicant's success in mathematics and other personal attributes such as persistence, level of engagement in mathematics courses, leadership, an ability to work well with others, and so forth. In selecting the final 32 participants, the PD seeks diversity in age, school size, residence location in Colorado, and race/ethnicity based on surname. Although this diversity is important, the applicant's letter of intent is instrumental in the final decision. Specifically, the PD strives to select applicants who want to be the first in their family to attend college, who speak passionately about mathematics, or who have minimal opportunities for such an experience due to geographic isolation. The applicants speak passionately about mathematics through comments that indicate math is their favorite subject, that they did not like math until a teacher encouraged them, that math is like a fun puzzle, or "I want to be a mathmagician."

Selecting the camp participants is challenging and is further complicated by the fact that past participants re-apply. Several participants attended the camp three years in a row and one would have attended four years had a 2015 camp been held. Having return participants is advantageous because they help newcomers adjust to the busy schedule, make friends, and overcome homesickness. The past participants are especially supportive in assuring the newcomers that they will be able to do the college-level mathematics. In an effort to give other young women an opportunity to participate in the camp, the number of returning campers is limited to eight participants per year. The eight are chosen based on how well they adapted to the challenging mathematics, got along with the other participants, and developed into leaders. The PD attempts to distribute returning participants among the grades 10–12 applicants.

The camp generally occurs during the second week of June, beginning on a Sunday afternoon and ending on Friday evening. Table 1.1 contains a typical camp schedule, which I discuss in this section. The journaling aspect of the camp is discussed in the Program Effectiveness section. After checking into the dormitory on early Sunday afternoon, the participants attend a parent/chica orientation with all camp staff. During this time a few returning chicas take time to share their past experiences as a camp participant. Over the years, the orientation has been followed by various activities. Initially, there was a picnic for the participants, parents, and staff, but this did not result in interaction among the chicas and it was expensive. Thus, in the most recent years the parents leave after the orientation and the chicas engage in icebreaker activities. One year the chicas worked in teams of four to participate in a scavenger hunt where they solved mathematical tasks/puzzles that allowed them to advance in the scavenger hunt. The