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Chapter 23
Females in Mathematics: Still on the Road to Parity

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Females have gained ground in mathematics in some countries in recent years. In the United States, for example, high school females compare favorably with males in course grades and amount of mathematics coursework completed (National Center for Education Statistics 2007). However, nonspecific rallying cries of the popular press—and, at times, the mathematics education community—that females are now on par with males in mathematics are troublesome in that they threaten continued, needed support for females in mathematics. Many scholars have found initial or widening gender differences in achievement and, especially, less favorable dispositions in females appearing by at least the middle grades (Andreescu et al. 2008; Blue and Gann 2008; Ginsburg et al. 2005; Halpern et al. 2007a; Lawhead et al. 2005; Ma and Cartwright 2003; Penner and Paret 2008; Stevens et al. 2007). Andreescu et al. (2008) state, "It is during the middle school years, an age when children begin to feel pressure to conform to peer and societal expectations, that they start to lose interest and fall behind in most, but not all countries" (p. 1257).

In this chapter, I provide evidence that many areas of concern and inequity remain for females in mathematics, warranting continued and concerted support from the field of education. Although most data are drawn from U.S. sources, research from a variety of other countries is included to help illuminate this worldwide issue. After sharing brief background information about the current (mis) perceptions of gender equality in mathematics, I compare male and female mathematics achievement, course completion, career paths, and mathematics-related dispositions, discuss the role teachers, parents, and society play in relation to females in mathematics, and suggest strategies for a quality mathematics education for females.

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Perceptions of Gender Equality in Mathematics

Recent research findings in the United States indicating that girls now perform as well as boys on standardized tests in mathematics have garnered much attention. Based on their analysis of state achievement data from ten states, Hyde et al. (2008) conclude: "The general population no longer shows a gender difference in math skills" (p. 495). The study spawned popular press articles that announced such headlines as "In Math, Girls and Boys Are Equal" (Seattle Times News Services 2008). These claims have generated much talk of gender equality in mathematics and even female advantage. In her equity address at the 2008 National Council of Teachers of Mathematics (NCTM) annual meeting, Carol Malloy commented: "Our girls are now doing as well, if not better, than boys in our schools [in mathematics]" (Malloy 2008). In a recent newsletter piece, several members of the U.S. organization Women and Mathematics Education expressed a similar sentiment, one claiming that girls now "do as well or better than boys in middle school math" (Carr 2007, p. 5). *Las Vegas CityLife* reporter Jason Whited said he had "talked to some researchers who say that parity between girls and boys almost exists in math, so it's time to focus on boys['] deficiencies [presumably in reading and writing]" (March 3, 2008 email). Likewise, reporter Troy Reinhardt of the Northern Nevada magazine *Family Pulse*, emailed me (March 21, 2008) that one academic informant had told him: "Data prove girls are ahead of boys in almost every department and indicator." These examples demonstrate perspectives I have experienced in increasing number from individuals both within and outside of the mathematics education community at local through national levels.

It is encouraging that females have made some important strides in mathematics in relation to males in such areas as high school mathematics grades and coursework. Nevertheless, the mantra of "sameness" that has stemmed from these gains poses potential harm to females' continued progress in mathematics by threatening policy, research, and education efforts to support girls' continued needs. Concerns persist for females in relation to mathematics performance (e.g., standardized test scores), participation (e.g., career choices), and dispositions (e.g., attitudes and beliefs). A more comprehensive and refined picture is in order to examine group tendencies related to females in mathematics.

Mathematics Achievement

Despite Hyde et al.'s (2008) conclusion of gender equality in standardized test data, females consistently score below males on the mathematics-based sections of important standardized national and international tests, namely, the ACT, SAT (SAT Reasoning Test), GRE (Graduate Record Exam), NAEP (National Assessment of Educational Progress), TIMSS (Trends in International Mathematics and Science Study), and PISA (Programme for International Student Assessment) (Educational Testing

Service 2007; Institute of Education Sciences 2004, 2009; Liu et al. 2008; McGraw et al. 2006; National Center for Education Statistics 2009; Organisation for Economic Co-operation and Development 2007). For example, boys attained 33 points higher than girls on the mathematics portion of the SAT (533 versus 500 of 800 possible points), a gap that has remained fairly stable for some time (Institute of Education Sciences 2009), and they significantly outperformed girls in 35 of 57 countries on the PISA (Organisation for Economic Co-operation and Development 2007). Some of these tests (specifically, the ACT, SAT, and GRE) are considered high-stakes assessments because they can affect decisions about college admissions, including entrance into top-tier universities, as well as scholarships or other awards (Dwyer 2007; Liu et al. 2008; Schmidt 2008). According to Liu et al. (2008), even small differences can have large practical effects, for example, on girls' dispositions (discussed later).

In terms of specific mathematics topics, one prominent achievement area where males outperform females is geometry and visuospatial skills (Halpern et al. 2007a; Liu et al. 2008; McGraw et al. 2006; Newcombe 2007). Halpern et al. (2007a) state:

> Linkage of mathematical and visuospatial skill has important consequences, because high levels of both of these skills are required for careers in fields, such as physics and engineering, in which women are typically underrepresented.... These two variables appear to be more strongly linked in females than males, suggesting that females may be particularly hampered in mathematical domains if they have reduced visuospatial skill. (p. 9)

Thus, individual mathematics topics must be considered in addition to global achievement levels in examining gender differences in mathematics performance.

Gender gaps favoring males are particularly pronounced at the highest achievement levels, including not only standardized test scores but also participation and performance in national/international mathematics competitions and identification among the profoundly mathematically gifted (Andreescu et al. 2008; Halpern et al. 2007b; McGraw et al. 2006; Preckel et al. 2008). For example, only 123 of 1782 participants (6.9%) in 27 top-ranked countries who participated in the precollegiate International Mathematical Olympiad from 1998 to 2008 were female (Andreescu et al. 2008). Figures range from 0% female in Iran, Japan, and Poland to 24% in Serbia/Montenegro, the next highest percent being 15% in Slovakia. Females reach double-digit percents in only 7 of the 27 countries. Andreescu et al. (2008) conclude that there is an "extreme scarcity of females who excel at the highest level in mathematics" (p. 1256). Although not all score differences are statistically significant, they predominantly favor males. Moreover, in some cases this "excellence gap" is growing. The proportion of males who scored at the advanced level of NAEP in both grades 4 and 8, for instance, increased more than that of females from 1996 to 2007, widening the existing gender gap (Plucker et al. 2010).

U.S. females perform well in high school mathematics coursework (National Center for Education Statistics 2007). Both male and female students had higher combined mathematics and science grade point averages (GPAs) in 2005 than in 1990, but the gap that consistently favored females increased from 0.12 to 0.20 points during that time period. (Females' GPAs increased from 2.42 to 2.76 and males' GPAs from 2.30 to 2.56 on a scale of 4.0.) However, an important consideration is the contention that grades can mask true achievement, given that grades may be inflated or diminished by credit given for effort (e.g., homework completion, class attendance) and good behavior. Indeed, research shows a strong positive correlation between effortful/dutiful behavior, such as class attendance, amount of study time, and homework completion, and course grades (e.g., Broucek and Bass 2008; Sarawit 2005). Although these behaviors may yield increased learning, class attendance in and of itself sometimes earns credit that is figured into course grades. Girls have been shown to be more self-disciplined and more motivated to succeed; they thus exert greater and qualitatively different effort by attending class, paying attention, studying, and completing homework more frequently than boys (e.g., Duckworth and Seligman 2006; Institute of Education Sciences 2007; Kenney-Benson et al. 2006; Siebert et al. 2006). Girls' higher grades, then, may to some degree reflect appropriate student behavior rather than pure mathematics achievement.

Course Completion and Career Paths

High school coursework completed appears to associate with future career paths (Ayalon 2003; Ma and Johnson 2008). Overall, U.S. females do well in this arena. In 2005 they earned 0.2 more mathematics and science credits (24 hours of classroom instruction) than males compared with 0.1 fewer credits in 1990, despite the fact that this figure has risen steadily for both sexes (National Center for Education Statistics 2007). Girls and boys take similar course sequences through precalculus (e.g., Bozick and Ingels 2008). However, boys take more calculus, AP (advanced placement) calculus, and computer science coursework and more AP calculus and computer science exams than females (College Board 2008; Halpern et al. 2007a; Institute of Education Sciences 2009). This is a crucial distinction. Ma and Johnson (2008) point out that grade 12 girls who complete high school calculus are *3.16 times more likely* to major in science as girls who do not. (There is no comparable effect for boys.) They explain: "Apparently, completing the most difficult, most advanced, and most rigorous course in school mathematics can promote females to think boldly about prestigious careers.... Calculus is a powerful career filter that critically screens females for prestigious occupations" (p. 75).

Even where mathematics achievement compares favorably by gender, such as high school grades attained and amount of coursework completed, as noted earlier, females' participation in many areas of mathematics, such as mathematics clubs/contests, college majors, and careers, remains low in relation to males (Boaler and Sengupta-Irving 2006; Grevholm 2007; Mendick 2006). Mendick (2006) notes: "In stark contrast to these shifting patterns of results [narrowing gender gaps in mathematics exam scores and grades in England], the choice to study maths once it becomes optional remains highly gendered" (p. 7). Grevholm (2007) describes the situation in Sweden similarly. Likewise, Boaler and Sengupta-Irving (2006) express concern about the lack of continuity between girls' earlier mathematics performance and their later mathematics-oriented choices:

> Girls are opting out of mathematics *despite* their advanced performance in secondary school. The low participation of girls and women at high levels of mathematics and related fields is an important issue, and one that probably begins in school…and becomes more accentuated as levels increase. (p. 210)

Hyde et al.'s (2008) report of gender equality in mathematics stated that 48% of females earn bachelor's degrees in mathematics. This figure, which was several years old at the time of publication, has since declined (see below). Moreover, the authors failed to compare that percent to the proportion of females who earn bachelor's degrees across all majors. They also neglected to discuss trends across advancing degrees. Table 23.1 shows degrees earned by females in the United States in 2006–07. The proportions of women who earned mathematics and statistics degrees fall well below that of females earning those same degrees across all majors. A chi-square test shows that bachelor's degrees earned in mathematics and statistics by gender, for example, differ significantly from expected outcomes based on overall degree figures for all majors, $\chi^2(1, N=14{,}954)=1079.17, p<001$. (No other analyses were performed.) The data also tend to reflect even lower proportions of females at higher degree levels for mathematics and statistics.

In 2008, Computer and Mathematical Science occupations ranked third in mean annual wages ($74,500) out of the U.S. Bureau of Labor Statistics' (2009a) 22 major occupational groups. Women comprise only 25% of these workers (U.S. Bureau of Labor Statistics 2009b), indicating that even women who do get mathematics and computer science degrees are translating this preparation into directly related careers in much lower proportions than males. In terms of higher education positions, just 23% of U.S. mathematical scientists with doctorates who are employed in universities and four-year colleges are women, and only 36% of these are tenured, compared with a 62% tenure rate for their male peers (National Science Foundation 2009). Moreover, men outnumber women as both students and faculty at the most competitive, prestigious institutions (Dwyer 2007).

Mathematics-Related Dispositions

A vitally important area to consider for understanding the status of females in mathematics as a foundation for providing them with a quality mathematics education is that of dispositions. Females display more negative affect toward mathematics

Table 23.1 Percent of degrees conferred to females in the United States, 2006–2007. (Source: Institute of Education Sciences (2009))

	Associate's degree (%)	Bachelor's degree (%)	Master's degree (%)	Doctor's degree (%)
Major				
All majors	62.2	57.4	60.6	50.1
Mathematics and statistics	33.7	44.1	41.5	29.8

than males, including poor attitudes in general, anxiety, weak self-concept and self-confidence, lower interest and motivation, less enjoyment and pride, and greater hopelessness and shame (Frenzel et al. 2007; Ginsburg et al. 2005; Halpern et al. 2007a; Ma and Cartwright 2003; McGraw et al. 2006; Preckel et al. 2008). They judge their competence and performance more harshly than males (Chatard et al. 2007; Frenzel et al. 2007; Halpern et al. 2007a; Lloyd et al. 2005), are less likely to attribute high achievement to ability (Dickhäuser and Meyer 2006; Georgiou et al. 2007), and see less value in mathematics (Frenzel et al. 2007). Females tend to perceive mathematics ability as natural rather than developed, a potentially harmful belief (Dweck 2007) that needs to be countered by teaching girls that mathematics ability can be improved (Halpern et al. 2007a).

Dispositions have been found to associate with mathematics performance and participation (Antunes and Fontaine 2007; Crombie et al. 2005; Meelissen and Luyten 2008; Watt et al. 2006). Therefore, some researchers contend that improving girls' attitudes and beliefs will improve their performance and participation in mathematics (Halpern et al. 2007a; Ma and Johnson 2008). Ma and Johnson (2008) say: "Fostering a positive attitude toward mathematics could hold the key to retaining both females and males in advanced mathematics coursework and eventually attract them to the STEM [science, technology, engineering, and mathematics] fields" (p. 77). However, even if girls feel efficacious toward mathematics, they need to believe that mathematics-related careers are both appropriate for and available to them; this and their interest level are important factors in decisions to pursue such occupations (Stevens et al. 2007).

Achievement may in turn influence mathematics dispositions, resulting in a bidirectional relationship (Georgiou et al. 2007; Ma and Johnson 2008). For example, boys' higher mathematics scores may negatively influence girls' dispositions, making girls less likely to enter mathematics careers, whereas greater success might cause girls to engage in mathematics to a greater degree (Liu et al. 2008). However, high test scores and grades are not in themselves enough to benefit women (Antunes and Fontaine 2007; Stromquist 2007). Antunes and Fontaine (2007) explain:

> Good marks [grades] are not enough to sustain girls' maths self concept at the same level as that of boys. Girls have to deal with less favourable stereotypes than boys and need to deal with teachers' practices, which do not support their self-concept. (p. 86)

Thus, relationships among gender, dispositions, and mathematics are important and complex.

Role of Teachers, Parents, and Society

Evidence suggests that females receive less STEM support from salient individuals both in and out of school. In school, both teachers and peers have a strong impact on girls' experiences in the mathematics classroom. Teachers have a heavy responsibility for the way teaching and learning experiences play out. Fredua-Kwarteng

(2005) asserts: "Mathematics teachers are the primary architects of the culture in mathematics classrooms" (p. 8) and thus, teacher leadership is required "to address gender disparity in mathematics learning outcomes" (p. 15). Unfortunately, teachers' attitudes are one area of concern. In general, teachers hold lower expectations for girls' performance, give girls less encouragement and sometimes even discourage them, interact more with boys, and ask boys higher-level questions (Asimeng-Boahene 2006; Fredua-Kwarteng 2005; Jones and Dindia 2004). They tend not to accept different ways of learning, which is detrimental to females (Lim 2004). As early as the first and second grades, female teachers' own mathematics anxiety negatively influences female students' attitudes and achievement, a serious concern given that most elementary teachers in the United States are female (Beilock et al. 2010). At the doctoral level, women in mathematics have described limited or negative relationships with the predominantly male faculty, feelings of invisibility, a lack of mentoring, advising, and other guidance, feelings of awkwardness and not fitting into this male-dominated field, and a general lack of moral support and encouragement (Herzig 2004). Young adolescent girls, too, have portrayed themselves as invisible or side characters in male-centered classrooms, and they experience harassment from male peers, more passive roles in small-group activities, and use of gender-biased instructional materials (Asimeng-Boahene 2006; Lim 2004).

Parents are significantly less likely to give activity-related STEM materials to daughters and to encourage daughters to participate in out-of-school STEM activities compared with sons (Jacobs and Bleeker 2004; Simpkins et al. 2005). This is important because STEM-related parent expectations, behaviors, and involvement have been shown to influence student performance, participation, and attitudes (Jacobs and Bleeker 2004; Simpkins et al. 2005; Yan and Lin 2005). Mentoring is another prominent area for females in the academic arena. A MentorNet (2008) study of 2,500 higher education STEM students showed that although females are significantly more likely than males to report the importance of mentoring for successful degree completion, they are more likely than males to indicate lack of support in all three factor categories: role modeling, academic/career, and, especially, psychosocial.

Society in general continues to fuel mathematics distaste irrespective of gender, but it targets females more than males. Female-unfriendly STEM messages abound through oral tradition and media transmission and seem to go unnoticed or at least unchallenged by many laypersons and professionals. A quick Web search for the unthinkable message "I'm too pretty to do math" finds many vendors marketing the logo to females on commercial merchandise, such as t-shirts and magnets. In the popular American film *Mean Girls* (Messick et al. 2004), actor Lindsay Lohan's character is told more than once that it would be "social suicide" for her to join Mathletes, a mathematics competition team. In class, she pretends not to understand mathematics in order to impress a particular boy. (The later undercurrent that this is inappropriate is overshadowed by the fact that this "normal" social scene reflects dominant youth culture.) Steinke's (2005) research findings on film portrayal of women in science-oriented careers indicate some improvement over past images but that harmful stereotypes persist. Morge's (2008) recent research showed that college students considered the popular media to influence their beliefs about mathematics and that the media presented successful males more often than females. Thus, female-unfavorable societal images in mathematics-oriented disciplines continue to pervade U.S. culture.

Most experts argue convincingly that gender differences in mathematics are predominantly, if not wholly, culturally driven (e.g., Boaler and Sengupta-Irving 2006). The fact that females show different achievement, as well as course and career choices, within and across cultures and even across community types supports this contention (cf. Andreescu et al. 2008; Guiso et al. 2008; Halpern et al. 2007a; Li 2007; Marks 2008). Based on their study of gender differences in PISA test performance across countries, Guiso et al. (2008) conclude: "Girls' underperformance in math relative to boys is eliminated in more gender-equal cultures" (p. 1165). Another fact supporting culturally driven difference is females' ability to respond favorably to intervention measures rather than being "biologically captive" to perform at a predetermined level (e.g., Wiest 2010). Similarly, Stromquist (2007) points out: "The fact that girls' progress in mathematics has been improving over time…suggests that math ability is not innate but susceptible to social influences and instruction" (p. 37). Further, differences do not appear to exist from birth but rather to manifest themselves at a pivotal time in social development, again supporting sociocultural rather than biological influences. A great deal of recent research also emphasizes gender stereotypes (e.g., "stereotype threat") as another key detrimental social factor working against females in mathematics (e.g., Chatard et al. 2007; Steele et al. 2007). Thus, many contextual factors, including families, peers, cultural norms, teaching environments, and educational policy, craft a culture that provides a different experience for males and females in mathematics, one that has more negative consequences for females (e.g., Boaler and Sengupta-Irving 2006; Geist and King 2008; Halpern et al. 2007b; Marks 2008).

Quality Mathematics Education for Females

Understanding the current status of females in mathematics and related influential factors, as presented in this chapter, is an important backdrop to seeking quality and equity in mathematics education for girls and women. As noted earlier, evidence points to the middle grades as an important crossroad not only for developing appropriate knowledge, skills, and dispositions, but also for considering future course and career paths. It seems reasonable to argue that the seeds of gender differences in mathematics are sown earlier than when they first appear, making the precursor period an important intervention zone. Thus, efforts at supporting and encouraging girls in mathematics would be worthwhile in the elementary grades.

Data provided in this chapter point to a number of recommendations for improving mathematics education for females. I offer the following suggestions as selected strategies for elevating the status of females in mathematics. These approaches apply variably to school personnel (e.g., educators, counselors, and administrators), policy and test makers, parents, researchers, and other education stakeholders.

- *Provide, encourage, and support rigorous, high-quality curricular and supplementary experiences.* In particular, foster girls' geometry and visuospatial skills and encourage girls to take calculus. Develop or suggest additional experiences with clubs, contests, and out-of-school-time programs (e.g., summer, after-school, weekend, online). Provide and encourage use of mathematics-oriented materials and activities and model their use.
- *Hold high expectations for all students' performance, participation, and dispositions.* Structure equitable learning that requires comparable school experiences and classroom participation for all students.
- *Foster positive dispositions toward mathematics (through discussion, modeling, etc.).* This includes such areas as interest in the subject matter, awareness of the utilitarian value of mathematics in occupational and everyday life, and the productive role of effort with confidence in personal abilities to improve mathematics knowledge and skills.
- *Improve testing and use of test scores.* Develop quality assessments that emphasize important mathematics knowledge, skills, and reasoning. Teach students test-taking skills, and use tests as only one of varied measures for describing and making decisions about student performance. Consider factoring dutiful/effortful behavior modestly, if at all, into performance measures.
- *Provide networking and mentoring opportunities involving female peers and adult role models.* Posters, online environments, guest speakers, peer tutors, and other such mechanisms can provide positive modeling and support for females in mathematics.
- *Provide information on mathematics-oriented careers and preparation for those careers, as well as encouragement to consider these career options.* Further, promote gender equity in mathematics-related occupations, such as hiring, promotion, and retention practices that are favorable to both sexes.
- *Promote societal change that results in more positive portrayals of mathematics and females in mathematics.* This includes providing feedback to media sources and critically analyzing the media with young people.
- *Use a nuanced approach to researching and analyzing gender differences in mathematics.* Consider, for example, various types of performance, participation, and dispositions, as well as girls' potentially different experiences based on race/ethnicity, social class, and other identities.

Closing Comments

The need for sustaining focused attention to females in mathematics is evident. Policymakers, researchers, educators, parents, and others must continue to address this need. Although some studies indicate no gender differences in mathematics (e.g., Georgiou et al. 2007; Hyde et al. 2008), substantial data reveal disconcerting conditions for females in relation to males in most countries of the world. Even when small, these differences typically favor males, and the cumulative effect of the concerns detailed in this chapter, left unchecked, is potentially disastrous for women's personal lives and society at large. The U.S. House of Representatives formalized this national concern in June 2008 by passing a resolution that calls for recognizing, supporting, and increasing the number of women in the STEM fields (GovTrack.us 2008). At the personal level, mathematics preparation and participation can relate to life quality, including financial security. Factors involved in this relationship are women's low participation in the higher-paying positions afforded by mathematics-related careers and the fact that U.S. women earn 80% of the median weekly earnings of males for full-time work in general (U.S. Bureau of Labor Statistics 2009b), have a 5.2-year greater life expectancy than males (National Center for Health Statistics 2009), and are disproportionately represented among the impoverished (U.S. Department of Health and Human Services 2008).

The conversation about females in mathematics must extend beyond global achievement levels. It must encompass other and subtler areas of performance (e.g., specific mathematics topics), as well as participation (e.g., mathematics courses, degrees, and careers), dispositions, and quality of experience. For example, females who attain mathematics outcomes similar to males but suffer detrimental effects to their dispositions should remain on the radar screen for concerned researchers and educators. Semantic distinctions are important in claims that females "do as well" as males in mathematics. This language must be clarified as to whether it refers to test scores, school grades, dispositions, quality of experience, career choices, or other important indicators of the female condition in mathematics.

This call for continued attention to gender differences is not a look at difference for its own sake or an implication that females have an intellectual shortcoming in mathematics. Rather, it is to encourage a realistic stance that acknowledges the differences described in this chapter and that girls *can* succeed in mathematics on their own merit; however, social and cultural factors mediate females' performance, participation, and dispositions. Females require continued encouragement and support from professionals and the community at large in the area of mathematics. This support includes the types of suggestions made above for providing females with a quality mathematics education. It might also include educating females themselves about gender stereotyping in relation to mathematics (Steele et al. 2007). In addition to finding ways to support females within the existing climate, environmental factors that work against females' mathematics success should come under continual scrutiny—and pressure, where warranted—to function in more positive and productive ways.

To improve the status of females in mathematics, educators, parents, and others should employ the types of strategies suggested in this chapter. Gender issues in mathematics should be actively addressed in pre-service and in-service teacher education, and they must remain on the mathematics education research agenda. Boaler and Sengupta-Irving (2006) note: "It is curious and troubling to note that few researchers study or consider gender and mathematics as an academic field in the twenty-first century" (p. 207). They call for continued research to address lingering inequities. They suggest a focus on contextual factors while acknowledging girls' strengths and cognitive preferences. Attention to affect (e.g., attitudes and beliefs) should also be of concern to researchers and practitioners in efforts to make progress in the area of females and mathematics (cf. Frenzel et al. 2007). Liu et al. (2008) contend: "Gender gaps need to be studied before they can be closed. Especially, so far as there is no solid evidence that gender differences have been eliminated, nor can we justify that the existing difference [in mathematics] is indeed negligible" (p. 20). (See also Lubienski 2008.) Future research should focus on environmental influences (e.g., social, cultural, scholastic) without implication that differences relate to actual gender differences in mathematics ability (e.g., Boaler 2007). Such studies will require sophisticated analyses to "do justice" to examining the complex phenomena involved in gender issues in mathematics (Boaler and Sengupta-Irving 2006; Lubienski 2008), such as examining how other social identities (e.g., race/ethnicity and social class) intersect with gender. One research area made evident by the data presented in this chapter is that of investigating why girls' gains in performance, coursework taken, and early career intentions have not translated into a higher proportion of women in STEM fields. Clearly, the attrition rate needs nuanced explanation. High-quality research is vitally important to provide awareness and information that can help policymakers, education personnel, families, and society at large support girls on a positive trajectory in mathematics that can one day lead to gender parity.

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References

Andreescu, T., Gallian, J. A., Kane, J. M., & Mertz, J. E. (2008). Cross-cultural analysis of students with exceptional talent in mathematical problem solving. *Notices of the AMS, 55*(10), 1248–1260.

Antunes, C., & Fontaine, A. M. (2007). Gender differences in the causal relation between adolescents' maths self-concept and scholastic performance. *Psycologica Belgica, 47*(1–2), 71–94.

Asimeng-Boahene, L. (2006). Gender inequity in science and mathematics in Africa: The causes, consequences, and solutions. *Education, 126*(4), 711–728.

Ayalon, H. (2003). Women and men go to university: Mathematical background and gender differences in choice of field in higher education. *Sex Roles, 48*(5/6), 277–290.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS), *107*(5), 1860–1863. http://www.pnas.org/content/107/5/1860.

Blue, J., & Gann, D. (2008). When do girls lose interest in math and science? *Science Scope, 32*(2), 44–47.

Boaler, J. (2007). Paying the price for "sugar and spice": Shifting the analytical lends in equity research. In N. S. Nasir & P. Cobb (Eds.), *Improving access to mathematics: Diversity and equity in the classroom* (pp. 24–36). New York: Teachers College Press.

Boaler, J., & Sengupta-Irving, T. (2006). Nature, neglect and nuance: Changing accounts of sex, gender and mathematics. In C. Skelton, B. Francis, & L. Smulyan (Eds.), *The SAGE handbook of gender and education* (pp. 207–220). Thousand Oaks, CA: SAGE.

Bozick, R., & Ingels, S. (2008). *Mathematics coursetaking and achievement at the end of high school: Evidence from the Education Longitudinal Study of 2002 (ELS:2002)* [NCES 2008-319]. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences. http://nces.ed.gov/pubs2008/2008319.pdf.

Broucek, W. G., & Bass, W. (2008). Attendance feedback in an academic setting: Preliminary results. *College Teaching Methods and Styles Journal, 4*(1), 45–48.

Carr, M. (Ed.). (2007, fall). *Women and mathematics education.* Newsletter.

Chatard, A., Guimond, S., & Selimbegovic, L. (2007). "How good are you in math?" The effect of gender stereotypes on students' recollection of their school marks. *Journal of Experimental Social Psychology, 43*(6), 1017–1024.

College Board. (2008). *The fourth annual report to the nation.* New York: Author. http://professionals.collegeboard.com/profdownload/ap-report-to-the-nation-2008.pdf.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B. M., DuBois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrollment intentions: Gender similarities and differences. *Sex Roles, 52*(5/6), 351–367.

Dickhäuser, O., & Meyer, W.-U. (2006). Gender differences in young children's math ability attributions. *Psychology Science, 48*(1), 3–16.

Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology, 98*(1), 198–208.

Dweck, C. S. (2007). Is math a gift? Beliefs that put females at risk. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science? Top researchers debate the evidence* (pp. 47–55). Washington, DC: American Psychological Association.

Dwyer, C. A. (2007). Overview: Gender equity from early childhood through postsecondary education. In S. S. Klein et al. (Eds.), *Handbook for achieving gender equity through education* (2nd ed., pp. 605–607). Mahwah, NJ: Erlbaum.

Educational Testing Service. (2007). *Graduate Record Examinations (GRE): Factors that can influence performance on the GRE General Test: 2005–2006.* Princeton, NJ: Author.

Fredua-Kwarteng, E. (2005). *A perspective on gender disparity in mathematics education.* (ERIC Document Reproduction Service No. ED 493 750). http://eric.gov:80/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1b/f0/78.pdf. Accessed 26 June 2008.

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics—A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education, 22*(4), 497–514.

Geist, E. A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology, 35*(1), 43–52.

Georgiou, S. N., Stavrinides, P., & Kalavana, T. (2007). Is Victor better than Victoria at maths? *Educational Psychology in Practice, 23*(4), 329–342.

Ginsburg, A., Cooke, G., Leinwand, S., Noell, J., & Pollock, E. (2005). *Reassessing U.S. international mathematics performance: New findings from the 2003 TIMSS and PISA.* Washington, DC: American Institutes for Research.

GovTrack.us. (2008). *H. Res. 1180, 110th Congress: Resolution recognizing the efforts and contributions of outstanding women scientists,…* http://www.govtrack.us/congress/billtext.xpd?bill=hr110-1180. Accessed 31 Oct 2008.

Grevholm, B. (2007). Critical networking for women and mathematics: An intervention project in Sweden. *Philosophy of Mathematics Education Journal, no. 21.* http://people.exeter.ac.uk/PErnest/pome21/.

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and math. *Science, 320*(5880), 1164–1165. http://research.chicagogsb.edu/IGM/docs/ZingalesCulturGenderMath.pdf. Accessed 25 Nov 2008.

Halpern, D. F., Aronson, J., Reimer, N., Simpkins, S., Star, J. R., & Wentzel, K. (2007a). *Encouraging girls in math and science: IES Practice Guide*. Washington, DC: U.S. Department of Education, National Center for Education Research, Institute of Education Sciences.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007b). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*(1), 1–51.

Herzig, A. H. (2004). "Slaughtering this beautiful math": Graduate women choosing and leaving mathematics. *Gender and Education, 16*(3), 379–395.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494–495.

Institute of Education Sciences. (2004). *Highlights from the Trends in International Mathematics and Science Study: TIMSS 2003* [Mathematics]. http://nces.ed.gov/pubs2005/timss03/math5.asp. Accessed 31 Oct 2008.

Institute of Education Sciences. (2007). *Student effort and educational progress: Student attitudes and aspirations: Time spent on homework* [Indicator 21]. http://nces.ed.gov/programs/coe/2007/section3/indicator21.asp. Accessed 25 Nov 2008.

Institute of Education Sciences. (2009). *Digest of education statistics 2008*. Washington, DC: U.S. Department of Education, National Center for Education Statistics. http://nces.ed.gov/programs/digest/d08/.

Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development, 106,* 5–21.

Jones, S. M., & Dindia, K. (2004). A meta-analytic perspective on sex equity in the classroom. *Review of Educational Research, 74*(4), 443–471.

Kenney-Benson, G. A., Pomerantz, E. M., Ryan, A. M., & Patrick, H. (2006). Sex differences in math performance: The role of children's approach to schoolwork. *Developmental Psychology, 42*(1), 11–26.

Lawhead, P., Loyd, R., Schep, M., Laws, M., & Price, K. (2005). Experiences in math, science and technology summer camps for young females. *ACM-SE 43: Proceedings of the 43rd annual Southeast regional conference* (Vol. 1). New York: Association for Computing Machinery.

Li, Q. (2007). Mathematics, science, and technology in secondary schools: Do gender and region make a difference? *Canadian Journal of Learning and Technology, 33*(1), 41–57.

Lim, J. H. (2004). Girls' experiences in learning school mathematics [online]. *Focus on Learning Problems in Mathematics, 26*(1).http://www.unlv.edu/RCML/win04.html. Accessed 30 Nov 2008.

Liu, O. L., Wilson, M., & Paek, I. (2008). A multidimensional Rasch analysis of gender differences in PISA mathematics. *Journal of Applied Measurement, 9*(1), 18–35.

Lloyd, J. E. V., Walsh, J., & Yailagh, M. S. (2005). Sex differences in performance attributions, self-efficacy, and achievement in mathematics: If I'm so smart, why don't I know it? *Canadian Journal of Education, 28*(3), 384–408.

Lubienski, S. T. (2008). On "gap gazing" in mathematics education: The need for gaps analyses. *Journal for Research in Mathematics Education, 39*(4), 350–356.

Ma, X., & Cartwright, F. (2003). A longitudinal analysis of gender differences in affective outcomes in mathematics during middle and high school. *School Effectiveness and School Improvement, 14*(4), 413–439.

Ma, X., & Johnson, W. (2008). Mathematics as the critical filter: Curricular effects on gendered career choices. In H. M. G. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessment of individual, social, and cultural influences* (pp. 55–83). Washington, DC: American Psychological Association.

Malloy, C. E. (2008, April). *Iris M. Carl equity address.* Presentation at the National Council of Teachers of Mathematics' Annual Meeting and Exposition, Salt Lake City, UT.

Marks, G. N. (2008). Accounting for the gender gaps in student performance in reading and mathematics: Evidence from 31 countries. *Oxford Review of Education, 34*(1), 89–109.

McGraw, R., Lubienski, S. T., & Strutchens, M. E. (2006). A closer look at gender in NAEP mathematics achievement and affect data: Intersections with achievement, race/ethnicity, and socioeconomic status. *Journal for Research in Mathematics Education, 37*(2), 129–150.

Meelissen, M., & Luyten, H. (2008). The Dutch gender gap in mathematics: Small for achievement, substantial for beliefs and attitudes. *Studies in Educational Evaluation, 34*(2), 82–93.

Mendick, H. (2006). *Masculinities in mathematics*. New York: Open University Press.

MentorNet. (2008). *Students' perceptions of the value and need for mentors as they progress through academic studies in engineering and science*. San Jose, CA: Author. http://mentornet.net/studentperceptions/.

Messick, J., Michaels, L. (Producers), & Waters, M. S. (Director). (2004). *Mean girls* [DVD]. Paramount Home Entertainment.

Morge, S. P. (2008). Media influences on mathematics-related beliefs. *Academic Exchange Quarterly, 12*(4), 232–237.

National Center for Education Statistics (NCES). (2007). *America's high school graduates: Results from the 2005 NAEP high school transcript study* [NCES 2007467]. Washington, DC: U.S. Department of Education, NCES. http://nces.ed.gov/nationsreportcard/pdf/studies/2007467_4.pdf.

National Center for Education Statistics (NCES). (2009). *The nation's report card: Mathematics 2009*. Washington, DC: Institute of Education Sciences, U.S. Department of Education. http://nationsreportcard.gov/math_2009/. Accessed 12 April 2010.

National Center for Health Statistics. (2009). *Health, United States*, 2008. Hyattsville, MD: U.S. Department of Health and Human Services. http://www.cdc.gov/nchs/fastats/lifexpec.htm.

National Science Foundation. (2009). Women, minorities, and persons with disabilities in science and engineering. http://www.nsf.gov/statistics/wmpd/pdf/tabh-27.pdf. Accessed 31 Jan 2010.

Newcombe, N. S. (2007). Taking science seriously: Straight thinking about spatial sex differences. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science? Top researchers debate the evidence* (pp. 69–77). Washington, DC: American Psychological Association.

Organisation for Economic Co-operation and Development. (2007). *PISA 2006: Science competencies for tomorrow's world* [executive summary]. Paris: Author.

Penner, A. M., & Paret, M. (2008). Gender differences in mathematics achievement: Exploring the early grades and the extremes. *Social Science Research, 37*(1), 239–253.

Plucker, J. A., Burroughs, N., & Song, R. (2010). *Mind the (other) gap! The growing excellence gap in k-12 education*. Bloomington, IN: Indiana University, Center for Evaluation and Education Policy. http://ceep.indiana.edu/mindthegap/. Accessed 12 Apr 2010.

Preckel, F., Goetz, T., Pekrun, R., & Kleine, M. (2008). Gender differences in gifted and average-ability students: Comparing girls' and boys' achievement, self-concept, interest, and motivation in mathematics. *Gifted Child Quarterly, 52*(2), 146–159.

Sarawit, M. (2005). *A study of the relationship between teamwork [sic: termwork] and achievement: A case study of the freshmen class at the Naresuan University International College*. http://www.nuic.nu.ac.th/QA/edoc%5Crsh_005.pdf. Accessed 24 Nov 2008.

Schmidt, P. (2008, March 25). Elite colleges' scramble to enroll high SAT scorers may undermine diversity. *The Chronicle of Higher Education*. http://chronicle.com/news/article/4188/elite-colleges-scramble-to-enroll-high-sat-scorers-may-undermine-diversity.

Seattle Times News Service. (2008, July 25). In math, girls and boys are equal. *The Seattle Times*. http://seattletimes.nwsource.com/html/nationworld/2008071972_math250.html.

Siebert, J., Litzenberg, K., Gallagher, R., Wilson, C., Dooley, F., Wysocki, A. (2006). Factors associated with students' academic motivation in agricultural economics classes. *American Journal of Agricultural Economics, 88*(3), 750–762.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2005). Parents' socializing behavior and children's participation in math, science, and computer out-of-school activities. *Applied Developmental Science, 9*(1), 14–30.

Steele, J. R., Reisz, L., Williams, A., & Kawakami, K. (2007). Women in mathematics: Examining the hidden barriers that gender stereotypes can impose. In R. J. Burke & M. C. Mattis (Eds.), *Women and minorities in science, technology, engineering and mathematics: Upping the numbers* (pp. 159–183). Northampton, MA: Edward Elgar.

Steinke, J. (2005). Cultural representations of gender and science: Portrayals of female scientists and engineers in popular films. *Science Communication, 27*(1), 27–63.

Stevens, T., Wang, K., Olivárez, A., & Hamman, D. (2007). Use of self-perspectives and their sources to predict the mathematics enrollment intentions of girls and boys. *Sex Roles, 56*(5–6), 351–363.

Stromquist, N. P. (2007). Gender equity education globally. In S. S. Klein et al. (Eds.), *Handbook for achieving gender equity through education* (2nd ed., pp. 33–42). Mahwah, NJ: Erlbaum.

U.S. Bureau of Labor Statistics. (2009a). *May 2008 national occupational employment and wage estimates: United States*. http://www.bls.gov/oes/current/oes_nat.htm. Accessed 21 Aug 2009.

U.S. Bureau of Labor Statistics. (2009b). *Highlights of women's earnings in 2008* (Report 1017). Washington, DC: U.S. Department of Labor. http://www.bls.gov/cps/cpswom2008.pdf.

U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau. (2008). *Women's Health USA 2008*. Rockville, MD: U.S. Department of Health and Human Services.

Watt, H. M. G., Eccles, J. S., & Durik, A. M. (2006). The leaky mathematics pipeline for girls: A motivational analysis of high school enrolments in Australia and the USA. *Equal Opportunities International, 25*(8), 642–659.

Wiest, L. R. (2010). Out-of-school-time (OST) programs as mathematics support for females. In H. J. Forgasz, J. R. Becker, K.-H. Lee, & O. B. Steinthorsdottir (Eds.), *International perspectives on gender and mathematics education* (pp.55–86). Charlotte, NC: Information Age Publishing.

Yan, W., & Lin, Q. (2005). Parent involvement and mathematics achievement: Contrast across racial and ethnic groups. *The Journal of Educational Research, 99*(2), 116–127.