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Unpacking the Male Superiority Myth and Masculinization of Mathematics at the Intersections: A Review of Research on Gender in Mathematics Education

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Gender research in mathematics education has experienced methodological and theoretical shifts over the past 45 years. Although achievement studies have used assessment tools to explore and subsequently challenge the assumption of male superiority on mathematics assessments, research on participation has unpacked these studies' sex-based achievement comparisons by exploring the masculinization of mathematics through qualitative methods. This article offers a review of gender research in mathematics education with analysis of its findings as well as conceptual and empirical contributions. Current understanding of mathematics as a gendered space, however, can be further broadened through intersectional analyses of gender and its interplay with other identities (e.g., race or ethnicity, class). Implications for future gender research, particularly the adoption of intersectionality theory, are raised to inform more nuanced analyses.

Keywords: Achievement; Identity; Intersectionality; Participation

Past educational research on issues of gender and sex has largely fallen short in providing clear, theoretically grounded definitions of adopted terminology. Glasser and Smith (2008) highlighted “the pattern of unclear, conflated, and even synonymous use of the terms” (p. 343) *gender* and *sex* observed in educational research, and they called for future scholars' increased clarity in their conceptualizations of gender. Mathematics education research is no exception, as noted in its by-and-large problematic use of gender to describe sex differences or differences in mathematics achievement and participation according to students' biological sex, namely, being female or male (Damarin & Erchick, 2010). This conceptual drawback in not distinguishing between gender and sex, according to Damarin and Erchick (2010), is particularly troubling for the future of mathematics education research because its “difference-as-deficit” (p. 320) views perpetuate a long-standing myth of male superiority on mathematics assessments that disallows agency among women and other marginalized groups as well as dismiss the complexities of gender as a social construct.

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In light of such limited considerations for within-group variation among women and men in mathematics, researchers exploring gender in mathematics education have refined their methodologies by supplementing quantitative analyses of mathematics achievement differences with qualitative data on students' mathematical attitudes, persistence, and experiences in school mathematics. Some of these more contextualized analyses allow for considerations of gender as conceptualized in queer theory (Butler, 1990, 2004)—namely, a dynamic social construct performed differently across contexts and individuals. Butler (1990) defined this performativity of gender as a “*stylized repetition of acts*,” or dynamic performances that are constrained by “a set of meanings already socially established” (p. 191), that perpetuates gender as a heteronormative binary construct. Gender, therefore, emerges from individuals' negotiations of social norms and discourses structured by sexism, heterosexism, and other systems of power in mathematics education and society more broadly. In mathematics education, for example, narratives of women's underachievement and underrepresentation in mathematics contribute to the masculinization of the domain that unfairly holds students to men's higher levels of achievement and participation as a measure of success (Boaler, 1997). Scholars exploring mathematics participation with more localized and sociocultural analyses of gender, therefore, have detailed mathematics as a masculinized domain (as opposed to one of male superiority) in which students discursively negotiate their identities and practices with gendered norms and experiences in their mathematics education.

In this literature review, I synthesize gender research in mathematics education that offers different theoretical perspectives and methodological approaches to better understand the gendering of mathematics that impacts opportunities for learning and succeeding in mathematics. The purpose of this review is to present a critical analysis that highlights various studies' respective contributions and methodological limitations to inform subsequent research on gender in mathematics education. More specifically, this analysis takes stock of advances in the study of gender within the field of mathematics education to shed light on the extent to which research studies have distinguished between sex and gender in their theoretical perspectives and methodologies. This review of research provides the field with insights for designing future studies that allow for considerations of gender as socially constructed and thus attend to within-group variation in gendered patterns of mathematics achievement and experiences that have gone largely underexplored in mathematics education. Furthermore, I argue that intersectionality theory¹ (Crenshaw, 1991) from Black feminist thought (Collins, 1993, 2000; hooks, 1981; Moraga & Anzaldúa, 1981), complemented with insights from extant research on gender in mathematics education, allows for more nuanced analyses of gender at

¹ Intersectionality theory was introduced by Crenshaw's (1991) legal analysis of the forms of societal oppression that Black women experience at intersections of race and gender. As opposed to traditional understanding of identity premised on the lumping of static social classifications, Crenshaw's intersectionality theory offers a perspective premised on the dynamic interplay and mutual constitution of race or ethnicity, class, gender, sexuality, and other identities.

different intersections with race or ethnicity, class, sexuality, and other socially constructed identities.

As per recommendations to clearly define terms in educational research (Damarin & Erchick, 2010; Glasser & Smith, 2008), some insight on the terminology adopted in this review regarding gender and race is in order. My analysis of the literature draws on poststructuralist and queer theories (Butler, 1990, 2004; Wilchins, 2004) in defining gender as discursive productions that vary across individuals and are subject to change in different contexts. This conceptualization informs my use of the terms *women* or *men* and *girls* or *boys* when discussing gender and the terms *females* or *males* when discussing sex throughout the review. However, when reviewing extant research in mathematics education, I maintain the authors' original choice of terms unless stated otherwise. Drawing on Ladson-Billings and Tate (1995), I define *race* as a social construct that intersects with property rights to capture the societal inequities (including education) in the United States for people of color. When discussing gender research outside of the United States, I adopt the term *ethnicity*, which is more appropriate than *race* for considerations of cultural diversity within different nations. I use these adopted definitions of gender and race, in turn, to argue for the future adoption of intersectional analyses of gender in mathematics education research.

Method

I caution readers that this review does not include every publication on gender in mathematics education. A diligent attempt was made to pursue a comprehensive analysis of key publications that made notable contributions and advanced explorations of gender in the field. This was completed through three rounds of filtering extant research on issues of sex and gender in mathematics education. First, a general search using Google Scholar was completed. The search terms used were “sex mathematics,” “gender mathematics,” “sex maths,”² and “gender maths.” I filtered through the first 400 results of each Google Scholar search (sorted by relevance) to focus only on peer-reviewed journal articles, edited book chapters, and handbook chapters that reported on empirical research studies in which issues of sex and gender in mathematics education were the central focus. More specifically, reviews of research, metasyntheses, and theoretical pieces that introduced models and frameworks were not included in these filtered search results. Second, I further filtered this subset of publications by focusing on peer-reviewed articles published in the top 100 journals across the fields of education, mathematics (with a focus on education), and gender studies according to SCImago Lab's (n.d.) Journal & Country Rank as of 2014. Last, I filtered these remaining peer-reviewed articles published in top journals as well as the edited book chapters and handbook chapters on the basis of the number of times each publication had

² In British English, the term *maths* is interchangeable with *math* or *mathematics* in North American English. For consistency, the review will continue to use the term *mathematics* unless it is used in direct quotes from the reviewed literature.

been cited. The publication years for these filtered results spanned almost 40 years, so I staggered the citation number criterion for consideration in the review per decade to account appropriately for varying amounts of time to be cited: 100 or more citations for research published in the 1970s, 65 or more in the 1980s, 50 or more in the 1990s, 20 or more in the 2000s, and 10 or more in the 2010s. These staggered values were selected to capture the higher range of citation numbers per decade to be as inclusive as possible of publications with a broad scholarly impact since their respective time of publication. A total of 56 studies met this staggered citation criterion and thus constituted the literature for the review, which included studies published in 49 journal articles, three edited book chapters, and one handbook chapter.³

Drawing on Weaver-Hightower's (2003) literature review methodology, I analyzed this body of literature with regard to conceptual and methodological approaches to studying gender. This resulted in the identification of two broad categories of studies: research focused on student achievement and research that examined aspects of student participation in mathematics. The *achievement* literature included research studies that pursued sex-based comparisons between females' and males' mathematics learning outcomes across different assessments and their relationships with task completion processes (e.g., spatial reasoning, strategy use) or psychosocial influences (e.g., attitudes, parental and teacher expectations). A total of 26 studies published in peer-reviewed journal articles were included in the achievement category. The *participation* literature included studies that examined patterns of students' persistence in mathematics (e.g., course enrollment, postsecondary degree, and career pursuits), interactions with their teachers, student engagement in mathematics classrooms, and negotiations of their identities and practices in mathematics from either a sex- or gender-based lens of analysis. A total of 30 studies presented in 23 journal articles, three book chapters, and one handbook chapter were included in the participation category. Of these participation studies, 21 studies pursued a sex-based analysis, and nine studies pursued a gender-based analysis. A *sex-based* analysis characterizes participation studies in which findings were interpreted using a binary (female or male) conceptualization of gender. In participation studies with a *gender-based* analysis, findings were interpreted using a conceptualization of gender as socially constructed.

The Appendix (available online at <http://www.nctm.org/jrme>) includes a listing of each reviewed publication, organized in chronological order within each of the two categories: the achievement and participation perspectives on the study of gender in mathematics education. Also included for each publication are the number of scholarly citations on Google Scholar as of January 2016, study context, analytical focus, and participant profile. The reader is encouraged to refer to the Appendix for this supplementary information. No publications were deliberately excluded from the review on the basis of their conceptual development,

³ The handbook chapter (Forgasz & Leder, 2001) reviewed four of the authors' prior studies on gender in mathematics education.

methodological approach, or political stance. Therefore, the achievement and participation categories make up a grounded scheme to thematically organize the literature for the purposes of this review. It should also be noted that achievement and participation studies discussed in detail in the following sections were purposefully selected as representative studies because they made explicit the characteristics of the two categories and influenced the fields of mathematics education and education more broadly, as shown by the numbers of citations. Thus, these representative studies highlighted from the entire review of the literature are used to trace the intellectual development of gender as an area of focus in mathematics education research.

Review of Literature

I present a review of the research studies in the achievement and participation categories that both highlights and critiques their respective contributions to the study of gender in mathematics education. More specifically, I examine the theorization of gender as well as the adopted data collection and analysis techniques across the two bodies of literature. Variation in the conceptualization and empirical study of gender within these research perspectives is also considered. I then present an analysis of how theoretical and methodological use of intersectionality theory (Crenshaw, 1991) complements the achievement and participation perspectives to allow for more nuanced analyses of gender in mathematics education.

Achievement

Research on gender in mathematics education can be interpreted through the lens of achievement and characterized primarily by comparisons of females' and males' mathematics learning outcomes and task performance. Several achievement studies conceptualized gender and sex as the same construct and did not take into consideration intersex and gender nonconforming people, thus reifying the idea that there are two distinct biological groups of people. Participants' sex or "gender," therefore, was treated as a variable in quantitative analyses to document "sex(-related) differences" in mathematics achievement (Brandon, Newton, & Hammond, 1987; Ethington & Wolfle, 1986; Fennema & Sherman, 1977, 1978; Wainer & Steinberg, 1992) or "gender differences" (Birenbaum & Nasser, 2006; Fennema, Carpenter, Jacobs, Franke, & Levi, 1998; Hanna, 1989) in mathematics achievement and task performance. Such investigations for the underlying causes of sex-based differential achievement were largely motivated by the long-standing yet problematic myth of male superiority on mathematics assessments (Fennema, 1979). Thus, the achievement studies used evidence of sex-based differences to draw causal inferences for mathematics education regarding sex and achievement.

I grouped the achievement studies into two strands. The first strand pursued quantitative analyses of mathematics achievement differences according to sex through the use of various assessment instruments, such as standardized tests (e.g., Brandon et al., 1987; Wainer & Steinberg, 1992), as well as scores from international and national mathematics assessments (e.g., Hanna, 1989; Penner & Paret, 2008;

Robinson & Lubienski, 2011). One subset of this strand also considered sociocultural factors (e.g., culture, ethnicity, and socioeconomic status [SES]), psychosocial influences, and their relationships with sex-based differences in mathematics achievement (Ai, 2002; Birenbaum & Nasser, 2006; Brandon et al., 1987; Ethington, 1992; Ethington & Wolfle, 1984, 1986; Hanna, 1989; Lubienski, Robinson, Crane, & Ganley, 2013; McGraw, Lubienski, & Strutchens, 2006). The other subset of studies in this strand also attended to sociocultural and psychosocial factors but appropriately termed their units of analysis “gender differences” (Ai, 2002; Birenbaum & Nasser, 2006; Ethington, 1992; Hanna, 1989; Lubienski et al., 2013) or “gender gaps” (McGraw et al., 2006; Robinson & Lubienski, 2011).

The second strand is composed of achievement studies that quantitatively examined achievement differences between sexes in relation to internal influences. One subset of studies examined cognitive processes, such as spatial reasoning and strategy use during task performance (Bielinski & Davison, 1998; Carr, Jessup, & Fuller, 1999; Carr, Steiner, Kyser, & Biddlecomb, 2008; Davis & Carr, 2001; Fennema et al., 1998; Fennema & Sherman, 1978; Fennema & Tartre, 1985; Ferrini-Mundy, 1987; Guay & McDaniel, 1977). Another subset attended to the relationships between mathematical attitudes and achievement or task performance (Battista, 1990; Fennema & Sherman, 1977; Marsh, 1989; Stage & Kloosterman, 1995; Tartre & Fennema, 1995). Some achievement studies in this strand supplemented qualitative methodologies of student and teacher interviews with quantitative analyses of sex-based differences in mathematics task performance (Battista, 1990; Fennema et al., 1998; Fennema & Tartre, 1985).

It is important to note that only a small subset of achievement studies across the two strands used the term *gender* in their sex-based analyses despite lacking any sociocultural or psychosocial considerations (e.g., Bielinski & Davison, 1998; Penner & Paret, 2008). In the following sections, I examine how the theorization of gender as synonymous with sex in achievement studies resulted in mostly quantitative searches for underlying causes of female–male disparities in mathematics achievement and task performance. I highlight how the emergence of such sex differences in the upper grade levels motivated future researchers to unpack these quantitative findings in relation to contextual factors including sociocultural and psychological influences. To accomplish this, I draw on research studies from Fennema and Sherman (1977, 1978), Hanna (1989), and Fennema, Carpenter, Jacobs, Franke, and Levi (1998)—one study per subset of the achievement strands—to trace the development of theoretical perspectives and empirical approaches to studying gender in mathematics education from the achievement perspective.

Problematising male superiority on mathematics assessments. Fennema and Sherman (1977, 1978) observed negligible sex differences in mathematics achievement among students in the early grades and, when controlling for prior mathematics knowledge, among high school students. These findings challenged the myth of male superiority on mathematics assessments that largely motivated

the detailing of sex-based differences across achievement studies (Fennema, 1979). In addition, sex-based disparities in mathematics achievement and student interest were found to significantly widen in upper grade levels, with males outperforming their female counterparts on assessments with more difficult mathematics content (namely, requiring spatial visualization skills) and more frequently enrolling in advanced mathematics courses (Fennema & Sherman, 1977, 1978). Such consistent findings contributed evidence to deficit views of females in mathematics that were challenged in subsequent gender equity scholarship, such as Campbell's (1995) efforts to redefine "the 'girl problem in mathematics.'"

These findings, furthermore, motivated future achievement studies to explore the extent to which mathematics task performance processes (e.g., spatial reasoning, problem solving), psychosocial factors (e.g., mathematical attitudes, teacher and parental expectations), and contextual influences (e.g., cultural norms, curricula, instruction) serve as gendering mechanisms that give rise to sex-based achievement differences (Davis & Carr, 2001; Ethington & Wolfle, 1984, 1986; Hanna, 1989). Fennema and Sherman (1978) wrote, "The spotty nature of the findings of superior mathematics achievement by males, which was always found in conjunction with a host of less favorable attitudes by females, suggests that important negative influences may exist within the schools themselves" (p. 202). Thus, Fennema and Sherman (1977, 1978) set the stage for challenging the myth of male superiority on mathematics assessments by calling for sociocultural considerations of achievement in light of variation across schools, individuals, and other contextual factors that may influence student performance.

Brandon, Newton, and Hammond (1987), for example, found that Hawaiian public school girls outperformed their boy peers on a norm-referenced state mathematics test—a finding that countered the narrative of male superiority. An analysis across four ethnic groups (Caucasians, Filipinos, Hawaiians, and Japanese) captured how girls' and boys' achievement differences according to sex were the smallest among Caucasians in Hawaii. Findings from the Brandon et al. (1987) study identified variation in achievement across ethnic–sex subgroups and, thus, pointed to the importance of considering the "influence of sociocultural factors on sex differences in mathematics" (p. 439), including culture and ethnicity.

Using a cross-cultural lens of analysis absent in prior achievement studies, Hanna (1989) similarly problematized narratives of females' deficiencies in mathematics by examining 70,000 eighth-grade students' mathematics assessment score differences across 20 countries. When country and country-by-sex variables were factored in, a two-way multivariate analysis on achievement was found to be statistically significant. Hanna used this finding to address how mathematics achievement differences according to sex can vary internationally because of cultural influences on curriculum development and social norms.

Such sociocultural considerations were also taken up in more recent achievement studies like Birenbaum and Nasser's (2006) analysis of "ethnic and gender differences" between Arab and Jewish girls' and boys' mathematics dispositions and performance on an Israeli national mathematics test. Findings from the study

noted that Arab boys omitted more test items than Arab girls; the girls also reported receiving less help from others and being held to higher academic expectations. This gendered trend was described as an “achievement-enhancing pattern” (Birenbaum & Nasser, 2006, p. 36) that reflected the stronger emphasis placed on academic success among Arab girls than Arab boys in Israel. Birenbaum and Nasser’s analysis, therefore, captures the insights that can be gained from making meaning of gendered patterns of mathematics achievement and task performance in relation to student participants’ educational contexts shaped by cultural norms and other sociocultural influences.

Thus, the studies by Brandon et al. (1987), Hanna (1989), and Birenbaum and Nasser (2006) point to the minimal consideration of within-group variation among females and males in prior achievement research. Findings from the Brandon et al. (1987) and Birenbaum and Nasser (2006) studies raise questions for future research on how acculturation, ethnicity, and school factors (e.g., curricula, instruction) may shape differential patterns of mathematics achievement among females and males. The interaction between students’ sex and country of origin in Hanna’s (1989) work offers more nuanced explanations of sex-based mathematics achievement differences that would not have been possible with sex as the only variable in the analysis. Although these studies highlighted the variation in sex-based achievement trends that can be gleaned by attending to the interplay of sex or “gender” with participants’ racial or ethnic, cultural, and class identities, the studies largely focused on sex because of the challenges of gaining insights into more nuanced dimensions of gender through assessment instruments and large-scale studies, both of which lend themselves more to quantitative analyses. Such nuanced considerations of gender were taken up in studies that supplemented quantitative analyses of achievement with qualitative methodologies, such as interviews, to explore cognitive and social influences on mathematics task performance (Carr et al., 1999; Fennema et al., 1998).

A cognitive turn in gender research. With mathematics task performance as the unit of analysis, Fennema et al. (1998) took up the myth of male superiority on mathematics assessments for further analysis in their longitudinal study of “gender differences” between girls’ and boys’ problem solving. They reaffirmed prior achievement findings through a noted year-to-year absence of early female–male differences in mathematics assessment performance. These researchers, however, went further and argued that “gender differences” in more advanced mathematics can be explained by females’ and males’ distinct problem-solving approaches—namely, males used abstract strategies more frequently than females, which led to their greater success with complex problem-solving tasks. Although the extrapolation that these problem-solving strategies are exclusively adopted by either females or males is worth further exploration in terms of what mechanisms produced such sex-based differences, the findings of this research were insightful in raising initial considerations of gendered performances in doing mathematics.

Whereas preceding studies focused on differences in test scores, the Fennema et al. (1998) longitudinal study served as a turning point in the achievement literature with its considerations of mathematics learning and task performance processes. These researchers used a problem-solving assessment aligned with participants' school mathematics curricula as well as a series of cognitive interviews to probe students' problem-solving strategy use. In contrast to the standardized tests used in prior achievement studies, the researcher-developed assessment and interviews were methodological affordances that not only took participants' mathematics content familiarity into account but also allowed for explorations of mathematical reasoning and strategy development over 3 years.

The Fennema et al. (1998) study did introduce learning perspectives to the research on gender in mathematics education, but other scholars have noted how the lack of insights about participants' mathematics learning environments (e.g., classrooms) remained an analytical drawback (Boaler, 2002c; Hyde & Jaffee, 1998; Sowder, 1998). More specifically, Boaler (2002c) argued that Fennema et al. (1998) offered minimal detail about the mathematics teaching and learning practices to further situate the nature of students' classroom experiences, thus "position[ing] gender as a characteristic of groups of people rather than as a situated response" (p. 139).

From a social and feminist psychological perspective, Hyde and Jaffee's (1998) solicited critique of the Fennema et al. (1998) study also asserted the need for mathematics classroom observations to consider how individual females and males responded similarly and differently to the mathematics. More specifically, Hyde and Jaffee (1998) argued that the young children in the Fennema et al. (1998) study may have associated invented algorithms with masculine traits of independence and confidence, whereas standard algorithms were associated with feminine traits of compliance and meekness. Such gendered associations with problem-solving strategies, according to Hyde and Jaffee (1998), may be reified through teacher-student interactions in public spaces of mathematics classrooms in which students may feel pressure to conform to gendered expectations of problem-solving behaviors that shape teachers' instruction. Thus, Hyde and Jaffee (1998) pointed to classroom observations as a methodological approach to gain insight into the gendering of problem-solving strategies that can further explain the Fennema et al. (1998) study's findings of female-male differences in strategy use.

In alignment with Boaler's (2002c) and Hyde and Jaffee's (1998) critiques, Fennema (2000) later acknowledged these limitations and described how such studies on "gender differences" often presented an incomplete picture that overlooked complex variation in individuals' learning experiences, including the gendered socialization of mathematics classrooms. For example, it was left implicit how findings from the Fennema et al. (1998) study generalize from its predominantly White participant population. A more diverse sampling in future studies building on the methodology from the Fennema et al. (1998) study would allow for considerations at intersections of sex, race or ethnicity, and class with the possibility of finding variation among female and male participants' mathematics achievement and task performance. These reflections on the Fennema et al. (1998) study and

other achievement studies further challenged the discourse myth of male superiority and shed light on nuances of social contexts and identities that need to be actively considered in future research on gender.

Research implications from an achievement perspective. For over 30 years, achievement studies experienced major methodological shifts that provided promising templates for more nuanced explorations of gendered mathematics inequities in future research. Boaler (2002c) wrote,

An important responsibility of gender researchers in the future will be to build upon our predecessors' work and search for explanations of the differences they found, not within the nature of girls, but within the interactions that produce gendered responses. (p. 139)

The two strands of achievement studies reviewed here raised considerations for future research in exploring the connections between students' achievement and persistence in mathematics, as well as how cognitive, psychosocial, and institutional influences in school mathematics (e.g., tracking, curricula, classroom norms) contribute to the gendered nature of these connections (Ethington, 1992; Fennema & Sherman, 1977, 1978; Hanna, 1989). In addition, studies in the second strand, including the Fennema et al. (1998) study, supplemented quantitative achievement findings with qualitative methodologies (e.g., cognitive interviews) that allowed for considerations of learning as well as insights into gendered performances of doing mathematics that broadened empirical approaches to studying gender.

Reflecting on studies about gender in mathematics education prior to Hanna's (1989) study, Fennema (2000) described how the field was in need of more complex lenses of analysis that attend to the influence of other identities and social contexts that result in differential mathematics achievement among females and males: "The US, as many other countries, is a highly heterogeneous society, made up of many layers, divisions, and cultures. The pattern of female differences in mathematics varies across these layers and must be considered" (Research from 1970–1990 section, para. 13). It is, therefore, critical that researchers carefully attend to mathematics learning contexts and the interplay of students' multiple identities (including race or ethnicity, culture, class, gender, and sexuality) to establish a more nuanced understanding of variation in mathematics achievement. A subset of achievement studies attended to these contextual and sociocultural factors through cross-cultural analyses of students' mathematics test performance (Birenbaum & Nasser, 2006; Brandon et al., 1987; Hanna, 1989). These studies highlighted social complexities resulting in differential academic outcomes and mathematics task performance that can be better understood by examining within-group variation among female and male participants.

In general, however, achievement studies have conceptual and methodological limitations, particularly with their analytical focus on female–male differences and decontextualized analyses of assessment performance. Boaler (1997) critiqued implications from achievement research as inequitably contributing to the

masculinization of norms for mathematics success. More specifically, she argued that discourses of girls' weaker mathematics performance are unfairly suggestive of "ways in which girls should change, ways in which they should become less anxious, more confident; in essence, more *masculine* [emphasis added]" (p. 285). This aligns with critiques of the Fennema et al. (1998) study that called for the coupling of task performance with classroom observation data to explore how patterns in students' problem-solving strategy use may have been shaped by gendered socialization in mathematics classrooms rather than sex-based differences in mathematical reasoning (Boaler, 2002c; Fennema, 2000; Hyde & Jaffee, 1998).

With possible connections between mathematics achievement and gendered values of engagement in mathematics, researchers faced the task of exploring whether gendered inequities rested in the masculinization of mathematics as opposed to assumptions of male superiority on mathematics assessments. Calls for more individualized and situated analyses of students' mathematics experiences resulted in conceptual and methodological shifts in research to explore gender from a different perspective—that of participation rather than achievement.

Participation

In this section of the review, the research literature is explored from a participation perspective using two subcategories based on their conceptualizations of gender: sex-based studies and gender-based studies.

Sex-based participation studies pursued analyses and interpreted findings using a binary conceptualization of gender that resulted in the reporting of differences between females and males in mathematics. One strand of sex-based participation studies detailed differences in students' mathematical attitudes and course enrollment, perceptions of mathematical ability, and views of mathematics as a "gendered domain"⁴ that were analyzed out of context and reported according to the sex of the participants (Armstrong, 1981; Benbow & Stanley, 1982; Bornholt, Goodnow, & Cooney, 1994; Brandell & Staberg, 2008; Casey, Nuttall, & Pezaris, 2001; Dick & Rallis, 1991; Eccles et al., 1985; Forgasz, Leder, & Barkatsas, 1998; Forgasz, Leder, & Kloosterman, 2004; Pallas & Alexander, 1983; Pedro, Wolleat, Fennema, & Becker, 1981; Seegers & Boekaerts, 1996; Sherman & Fennema, 1977; Wolleat, Pedro, Becker, & Fennema, 1980). The other strand similarly reported on female–male differences but attended to the classroom context in relation to

⁴ The phrase "gendered domain" was adopted by Forgasz et al. (2004) in the naming of their Mathematics as a Gendered Domain instrument, one of two scales that they developed to overcome design limitations of the Fennema and Sherman (1976) Mathematics as a Male Domain Scale. Despite the intentional renaming of the original instrument to attend to external influences (e.g., classroom factors, peers) that complicate the notion of mathematics as a male domain, the instrument consisted of 48 Likert-scale items of girls–boys and women–men comparisons in different mathematics-related situations, which were then used to measure "gender differences" (p. 406) in female and male respondents' attitudes toward mathematics as a male, female, and gender-neutral domain. Thus, this instrument conceptualized gender as a binary and was adopted in the Forgasz et al. (2004) and Brandell and Staberg (2008) studies to pursue sex-based analyses of participants' perceptions of mathematics as a gendered domain.

teacher–student interactions, teacher beliefs of students’ mathematical ability, and students’ engagement with activities and instruction (Becker, 1981; Boaler, 1997; Fennema, Peterson, Carpenter, & Lubinski, 1990; Hart, 1989; Peterson & Fennema, 1985; Tiedemann, 2000, 2002).

Gender-based participation studies adopted nonbinary conceptualizations of gender to document variation in students’ views and experiences in mathematics. One strand of gender-based participation studies documented individual variation in students’ mathematical attitudes and gendered experiences through field observations, self-report data (e.g., surveys, interviews), or both (Barnes, 2000; Forgasz, 1998; Leder & Forgasz, 1997; Shapka & Keating, 2003; Vale & Leder, 2004). This strand of gender-based participation studies attended to potentially gendered influences, such as collaborative learning (Barnes, 2000), a single-sex curriculum (Shapka & Keating, 2003), and technology use (Vale & Leder, 2004). The other strand used narrative inquiry to examine variation in how students made meaning of their mathematics experiences in and out of the classroom in relation to their gender identities (Mendick, 2003, 2005a, 2005b; Solomon, 2012). The review of literature from the sex-based participation perspective begins with studies that pointed to sociocultural influences and student experiences, particularly in mathematics classrooms, to better understand gendered trends in mathematics participation.

Sex-based participation out of context: Pointing to sociocultural and experiential influences. In the 1970s and early 1980s, studies in the sex-based participation literature documented few differences between females’ and males’ attitudes that contributed to their persistence in mathematics (Benbow & Stanley, 1982; Sherman & Fennema, 1977). This brought forth arguments for the influence of socialization and how students’ experiences could be used to better explain differences between females’ and males’ mathematics achievement and participation. Pallas and Alexander (1983), for example, contended “that it is premature to reject socialization and experiential explanations for the male–female gap in levels of quantitative performance” (p. 165).

As for socialization, sex-based participation studies attended to how females’ lower levels of confidence in mathematics and attributions of their mathematics success to effort rather than ability affected their persistence (Casey et al., 2001; Dick & Rallis, 1991; Eccles et al., 1985; Pedro et al., 1981; Seegers & Boekaerts, 1996; Wolleat et al., 1980). Scholars studying participation factors using a sex-based lens highlighted how such sociocultural factors shaped perceptions of mathematics as a gendered (i.e., male) domain that in turn negatively affected females’ mathematics task performance and persistence (Bornholt et al., 1994; Brandell & Staberg, 2008; Forgasz et al., 1998; Forgasz et al., 2004).

Other sex-based participation studies shed light on the extent to which access to mathematics coursework can impact achievement differences between females and males (Armstrong, 1981; Pallas & Alexander, 1983). At a more local level of analysis, the sex-based participation literature pointed to the importance of

examining students' experiences in mathematics education (including in classrooms) to inform ways of broadening opportunities for females in mathematics achievement and participation (Bornholt et al., 1994; Casey et al., 2001; Pallas & Alexander, 1983). Bornholt, Goodnow, and Cooney (1994), for example, asserted that in order to better understand gendered influences on mathematics participation, future researchers must attend to individual experiences (including perceptions of one's mathematical ability) as well as the social constructions of groups (e.g., females) across mathematics spaces.

Sex-based participation in context: Gendering sociomathematical norms.

Sex-based participation studies on mathematics classroom experiences aligned with Boaler and Greeno's (2000) framing of participation as the social and personal negotiations of meaning that shape individuals' identities and practices in mathematics. In this framing, mathematics classrooms are figured worlds (Holland, Lachiotte, Skinner, & Cain, 1998) in which students' participation is subject to peers' and teachers' gendered interpretations that in turn shape their mathematics and socially constructed identities (Barnes, 2000; Esmonde & Langer-Osuna, 2013).

This strand of sex-based participation studies, therefore, explored how students' participation across different mathematics learning contexts led to gendered experiences in their pursuits of academic success. These studies considered various units of analysis across mathematics classrooms, including teacher–student interactions (Becker, 1981; Hart, 1989), teachers' beliefs about mathematical ability (Fennema et al., 1990; Tiedemann, 2000, 2002), and student engagement (Boaler, 1997; Peterson & Fennema, 1985). Despite an analytic shift that considered contextual influences on gendered inequities, the analysis of data in these sex-based participation studies used a binary conceptualization of gender that was similarly adopted in achievement studies. This section explores insights from three sex-based participation studies—one per unit of analysis listed above—that highlight how teacher–student interactions, teacher beliefs, and student engagement contributed to the gendering of sociomathematical norms.⁵ In particular, I argue that the Becker (1981), Fennema, Peterson, Carpenter, and Lubinski (1990), and Boaler (1997, 2002b) studies detailed the establishment of gendered hierarchies of ability that influenced students' participation and negotiations of mathematics success in the classroom.

Teacher–student interactions. Using an adaptation of the Brophy-Good Teacher-Child Dyadic Interaction System (Brophy & Good, 1969) instrument for high school classrooms and participant observations, Becker (1981) examined 10

⁵ Yackel and Cobb (1996) define *sociomathematical norms* as the “normative understandings of what counts as mathematically different, mathematically sophisticated, mathematically efficient, and mathematically elegant in a classroom” (p. 461). These norms, in turn, are relationally produced and negotiated to establish interpretations of who is “intellectually autonomous in mathematics” (p. 458).

predominantly White ninth- and 10th-grade geometry classrooms (50% female) in urban–suburban and rural high schools to document mathematics teachers’ sex-based differential treatment of students. Quantitative findings showed that teachers more frequently initiated contact (both formal and informal) with and extended academic encouragement to male students than female students. Such sex-based treatment from teachers, as Becker (1981) argued, is a possible explanation for why most of the female students became increasingly quiet and passive throughout the length of the study. Becker (1981) went on to hypothesize how these differential teacher–student interactions were reflections of teachers’ sex-based academic expectations aligned with stereotypes about females being less mathematically able than males. As a result, female and male students’ respective classroom behaviors may have been responses to the differential treatment that, in turn, maintained teachers’ academic expectations and structured a learning environment that “sex-typed mathematics as male” (p. 50).

Becker (1981) captured how mathematics teachers’ differential interactions with female and male students were implicit ways of communicating their beliefs about females having lower mathematical ability and interest than males. This shaped teachers’ as well as students’ perceptions of appropriate behaviors in the mathematics classroom according to sex, with females being passively engaged (e.g., keeping quiet) and males taking on active roles (e.g., asking questions, calling out answers). Thus, Becker’s (1981) analysis offers insight into how both teachers and students made meaning of sex-based, differential treatment resulting in the gendering of sociomathematical norms across the geometry classrooms with females having less opportunity to actively engage in learning mathematics.

Although Becker (1981) alluded to how unpacking sex-based classroom interactions is one way to inform change in mathematics, which serves “as a critical filter that keeps many women out of a variety of careers” (Sells, 1976, as cited in Becker, 1981, p. 40), especially Black women, the influence of the observed differential treatment on Black females and other students of color was left implicit in the analysis across the predominantly White geometry classrooms. This variation is important to consider in Becker’s (1981) analysis of the urban–suburban and rural mathematics classrooms as “complete sociocultural system[s]” (p. 41) in which the interplay of gendered as well as racialized and classed discourses shapes teachers’ beliefs of student ability and thus affords differential opportunities for engagement at intersections of students’ identities.

Teacher beliefs about students’ mathematical ability. In a study involving 38 first-grade teachers (all female) across 24 schools, Fennema et al. (1990) closely attended to teacher beliefs about mathematical ability according to sex. The scholars raised concerns about how differential teacher beliefs about females’ and males’ mathematical ability may lead to inequitable opportunities for success in the classroom. When asked to name the two most successful students in their class, teachers identified males as their first choice 79% of the time and their second choice 58% of the time. The teachers showed a higher frequency of inaccurately

choosing males compared with females on the basis of scores on a researcher-developed mathematics test. Teachers largely attributed the chosen males' success to ability, whereas chosen female students' success was attributed to either individual effort or ability. The teachers gave the chosen males higher ratings for the following traits compared with their choices for most successful females: competitive, enjoys mathematics, independent, logical, persistent with mathematics, and willing to volunteer answers. These differential and inaccurate perceptions of mathematics success brought Fennema et al. (1990) to question how teacher beliefs may produce inequitable patterns of student acknowledgment that lead to sex-based achievement differences documented in the literature.

Findings from the Fennema et al. (1990) study served as a starting point for the consideration of how teacher beliefs and school structures play a role in the gendering as well as the racializing of sociomathematical norms associated with mathematics success, particularly in the United States. It is noteworthy that several of the traits used to characterize the most successful students, including independence, persistence, and willingness to volunteer, are what Fennema and Peterson (1985) referred to as *autonomous learning behaviors* (ALB) that "serve as mediators between internal/external influences and mathematics performance" (p. 309), particularly on tasks resulting in sex-based differences. The value that the first-grade teachers in the Fennema et al. (1990) study placed on ALB potentially marginalized students who were less independent, persistent, and vocal. It should be noted how these ALB described in the Fennema et al. (1990) study directly aligned with cultural values of independence and persistence among White, middle-class men in the United States (Moore, 2008). Although this is left implicit in the study, Fennema et al. (1990) provided an opportunity to note ways in which Whiteness intersects with issues of gender. As a result, students in the study had to unfairly subscribe to the valued classroom norms with inherent cultural and gender biases leading to inequitable opportunities for being perceived as successful in mathematics.

Students' engagement with activities and instruction. Shifting from a classroom- to a school-level analysis, Boaler (1997, 2002b) shared insights from a 3-year ethnographic study that compared advanced females' and males' mathematics classroom experiences in two nonselective, comprehensive schools in England (analogous to public high schools in the United States)—Amber Hill and Phoenix Park. Both schools primarily enrolled White, working-class students between the ages of 13 and 16; the schools differed, however, in terms of their social class settings and engagement with mathematics instruction. Amber Hill was situated in an affluent area with greater job accessibility, whereas Phoenix Park was in a working-class neighborhood with students' families living in public housing. Amber Hill used traditional mathematics teaching methods that focused mainly on procedures, and Phoenix Park structured its mathematics instruction with more reform-oriented, discussion-based interventions, including various projects. Females experienced less academic struggle and enjoyed mathematics more in

Phoenix Park, whereas males were observed to have similarly positive mathematics experiences in Amber Hill. Analogous to the observed sex-related differences in problem-solving strategies use in the Fennema et al. (1998) study, Boaler (1997) attributed differences in participants' mathematics engagement to the alignment between the schools' pedagogical approaches and students' sex-based mathematics learning styles—namely, females' "quest for understanding" (p. 292) to make sense of the taught mathematics and males "playing the 'school mathematics game'" (p. 292) focused on efficiency and algorithmic approaches to completing mathematics tasks.

Boaler (2002b) used interview and observation data to detail how the females and males adopted strategic moves in negotiating their mathematics learning practices and the two schools' mathematics curricular structures. Phoenix Park males, in particular, were described as "play[ing] the game" (Boaler, 1997, p. 298) by overlooking their minimal conceptual understanding of school mathematics and focusing on quickly getting correct answers to remain mathematically successful. However, Amber Hill females dwelled on their inability to build conceptual meanings of the mathematics, lagged behind males academically, and were described as feeling powerless to change their school's mathematics teaching approaches. This variation in the female and male cohorts' adoption of effective coping strategies can inform future research that highlights the importance of detailing individual students' negotiations of mathematics success with regard to their socially constructed identities, including gender, and mathematics learning contexts.

It is worthwhile to consider how the Amber Hill and Phoenix Park students' working-class backgrounds intersected with their gendered engagement in mathematics. For example, in a follow-up study 8 years later, Boaler and Selling (2017) noted how former Phoenix Park students reflected on school mathematics being directly applicable to their work situations after graduation. Females' focus on conceptual understanding of mathematics, therefore, conflicted with Phoenix Park's vocational vision of success, which, in turn, explains their male peers' success by "playing the game" of school mathematics. Although such interrelationships of gender and class were left implicit in Boaler's (2002b) analysis, she later looked back on her findings and questioned how future research could attend to intersections of gender and other socially constructed identities in mathematics: "How do identities of race, class, and gender intersect with those of mathematics?" (Boaler, 2002a, p. 47).

Summary. Although these three sex-based participation studies approached the analysis and interpretation of data using a conceptualization of gender as a female–male binary, their findings allude to how mathematics can be a gendered experience through students' negotiations of mathematics success with contextual factors, such as classroom interactions, teacher beliefs, curricula, and instruction, that had been largely unexplored in the achievement literature. Thus, sex-based participation studies shifted the object of analysis in research on gender away from individuals'

mathematics achievement and toward gendered “coproductions” (Boaler, 2002c, p. 128) of success between students and their mathematics learning environments. These sex-based participation studies also illustrate how mathematics is a space in which students constantly negotiate their learning practices as well as their respective positions along a gendered, racial, and classed hierarchy of mathematical ability (Martin, 2009). Moreover, as noted with respect to Fennema’s (2000) and Boaler’s (Boaler & Selling, 2017) reflections on their past research, participation studies began to raise the possibility of integrating analyses of gender with issues of race or ethnicity and class, although the studies discussed here did not take this up explicitly.

Gender-based participation: Doing mathematics = doing gender = doing masculinity. The gender-based participation studies that I reviewed conceptualize gender as a social construct performed differently across contexts and individuals (Butler 1990, 2004). Such conceptualizations defined “gender difference” as being dynamic, relational, and situational—that is, more than a static measure of achievement and participation as typically reported in achievement and sex-based participation studies respectively (Mendick, 2006). Walshaw (2001), for instance, took up Butler’s (1990) critique of Foucauldian thought on its “problematic indifference to sexual difference” (Butler, 1990, p. x) to present a poststructural retheorization of gender in mathematics education. More specifically, Walshaw (2001) discussed how “gender is the social organization of sexual differences” (Weedon, 1987, 1999; as cited in Walshaw, 2001, p. 473) that is constantly in flux and negotiated with practices and discourses across mathematics spaces. Furthermore, the gender-based participation studies that I review here explored the masculinization of mathematics through narrative and situated accounts of students’ experiences with the subject (Barnes, 2000; Mendick, 2003, 2005a, 2005b, 2006; Shapka & Keating, 2003; Solomon, 2012; Vale & Leder, 2004). As Esmonde (2011) wrote, “Mathematics classrooms can be the site of gender struggles between boys and girls, certainly, but also between *various forms of masculinity* [emphasis added]” (p. 30). Thus, although observations in gender-based participation studies allowed researchers to examine how gender was relationally produced through mathematics classroom interactions, interviews provided personal insights on the extent to which gender played a role in how students made meaning of their mathematics experiences.

The gender-based participation perspective adopted a poststructuralist lens of analysis to understand how mathematics success is discursively and relationally produced as a source of power (Damarin, 2000; Esmonde & Langer-Osuna, 2013; Mendick, 2005a, 2005b, 2006). Damarin (2000) wrote, “The discourse of mathematics as a key to power has been central (if often unstated) to thinking about gender and mathematics” (p. 78). By expanding on sex-based participation studies, the poststructuralist analyses across gender-based participation studies explored individual students’ strategic moves and narratives of experience to better understand how they positioned themselves along the gendered hierarchy of

mathematics success. Mathematics has been documented as a power-laden and masculinized academic domain (Esmonde, 2011; Esmonde & Langer-Osuna, 2013; Mendick, 2006). Gender-based participation studies, in particular, highlighted how individuals experience the “double-edgedness of power” (Mendick, 2006, p. 20)—namely, Foucault’s (1990) notion of “where there is power, there is resistance” (p. 95)—resulting in different forms of gendered negotiation of mathematical competence. In the paragraphs that follow, I describe the Barnes (2000) and Mendick (2006) studies to elaborate the gender-based participation perspective.

Constructions of varying masculinities in mathematics classrooms. Barnes (2000) conducted an ethnographic study in an advanced high school calculus classroom in Australia to explore how student subgroups engaged with varying discourses of masculinity during collaborative learning opportunities. To accomplish this, Barnes (2000) looked across videotaped lessons, individual student interviews, focus groups, field notes, and work samples “to investigate the interaction of student gender, the social construction of mathematical competence, and ways in which mathematics is valued” (p. 145). The major finding from the study was the discursive production of two subgroups of boys in the calculus classroom (Mates and Technophiles) whose classroom learning behaviors greatly differed. Barnes (2000) described how the Mates and Technophiles performed patterned forms of masculinity in being mathematically successful by tapping into social and intellectual capital, respectively. The Mates used their recognized athleticism and extracurricular involvement to approach mathematics with a sense of coolness, whereas the Technophiles embodied a “rational form of masculinity” (Barnes, 2000, p. 163) maintained through exclusionary problem-solving behaviors and academic praise from their teacher. In contrast to Boaler’s (1997, 2002b) sex-based separation of mathematics learning approaches across two schools, Barnes (2000) employed a more nuanced analysis to detail gendered variation of doing mathematics among boys in a single mathematics classroom.

With poststructuralist considerations for gendered power dynamics, Barnes (2000) identified the Mates as being “closest to the stereotype of hegemonic masculinity” (p. 145) in the classroom. In other words, the Mates expressed the more dominant form of masculinity based on societal standards for men and their gender roles compared with the Technophiles. The power in the Mates’ masculinized scripts of mathematics engagement is observed in the marginalization experienced by the Technophiles and other calculus classmates. Girl classmates, for example, were treated as the Mates’ mathematics “helpers or assistants,” which they regularly tolerated and even excused. The Technophiles’ subordinate forms of masculinity as the stereotypical nerds of the classroom often brought them to be ignored by their peers, including the Mates, except when acknowledged by the calculus teacher. In alignment with the Foucauldian dialectic of power and resistance, the classroom’s social outcasts, the Technophiles, used their attributed intellectual superiority as a gendered form of academic resistance to subsequently reject their

less mathematically competent classmates (including girls, even though the girls were similarly apt and engaged) and any of their problem-solving contributions.

These masculinizing discourses of doing mathematics, therefore, structured a gendered hierarchy of mathematical ability that differentially positioned both individual girls and individual boys in the calculus classroom. In alignment with Boaler's (2002b) analysis of students' negotiations of mathematics success with the nature of mathematics teaching, it is important to consider how the Mates, Technophiles, and other calculus students negotiated the calculus classroom's gendered discourses of mathematics success. Barnes (2000) discussed how Mates often found themselves at the juncture of these commonly conflicting discourses and had to engage in "delicate balancing act[s]" (p. 164) to protect their Mate identities while meeting the teacher's academic expectations. This illustrates how mathematics classrooms serve as "spaces of authoring" (Holland et al., 1998, p. 272) in which students constantly engage in "forms of authoring" (Boaler & Greeno, 2000, p. 173)—in this case, negotiating discourses of mathematics success with their gender identities.

Making meaning of mathematics experiences and negotiating gender identities. In efforts to make meaning of men's disproportionate representation in the mathematics field, Mendick (2003, 2005a, 2005b, 2006) presented results from a multisite ethnographic study that explored British college students' choices in pursuing mathematics coursework. Mendick (2003, 2005a, 2005b, 2006) looked across 43 individual student interviews and 3 weeks of classroom observations. Her analysis, however, focused on the interview data. The three colleges considered in Mendick's (2003, 2005a, 2005b, 2006) study varied across student demographics, including an inner-city comprehensive school with a working-class population, a selective school with middle-class students, and a school with foreign nontraditional college students. Using thematic narrative analysis of the interview data, Mendick (2006) highlighted how men more readily opted into studying mathematics for career development and saw themselves as mathematicians compared with women; this was true across the colleges. Another noteworthy finding was that only women viewed studying mathematics as a way of "proving something to themselves" (Mendick, 2006, p. 87). Mendick (2003) posited that these different interpretations of students' mathematical pursuits are explained by the idea that "in choosing maths they [students] are simultaneously doing gender" (p. 170).

Similar to Barnes's (2000) classroom discourse analysis, Mendick (2003, 2005a, 2005b, 2006) examined the masculinizing influences of doing mathematics by interviewing students about past experiences and perceptions of mathematics with a focus on gendered patterns of meaning making. With the study's relational view of gender that explored femininities and masculinities among the women and men participants, these interviews provided Mendick (2006) with a glimpse into individual students' *gender identity projects*⁶ in mathematics, including those of women, a population minimally discussed in Barnes's (2000) study. Interviews, in

other words, served as the college students' spaces of authoring in which they engaged in *identity work* (Mendick, 2005a) by negotiating various discourses related to gender and mathematics. Mendick (2005a) discussed how "gendered discourses of rationality" (p. 203), in particular, brought mathematical ability to be socially acknowledged as a masculine attribute that, in turn, caused women to struggle in identifying themselves as being "good at maths."

Participants described their respective positions within this gendered binary of "good at maths" or "not good at maths," resulting in femininity and masculinity projects of mathematics identity. Some men shared beliefs about the natural separation of mathematicians like themselves and nonmathematicians, which was analogous to the Technophiles' exclusionary behaviors in Barnes's (2000) classroom observations. Other men adopted views of pursuing mathematics as "hard work" for future professional advancement as opposed to the "effortless achievement" described by their mathematician-identifying peers. This second group of men, therefore, engaged in "a new mode of school student masculinity" (Mendick, 2006, p. 73), which was similar to the Mates' views of mathematics as a career credential; however, the limited use of observations in Mendick's (2006) analysis does not provide situated insights into how this masculinized discourse manifested itself across mathematics and college campus spaces. It is noteworthy that the men's reflections either asserted being "good at maths" or described their efforts at mathematics success without any claims of being "not good at maths," an assertion raised by some of the women participants.

By choosing mathematics, women and men participants encountered the double-edgedness of power and thus negotiated their gender identities with masculinized discourses in mathematics, resulting in both empowerment and tensions in their gender identity projects (Mendick, 2006). Three men reflected on pursuing mathematics as a challenging academic subject in efforts to "prove something to others." For example, Michael perceived mathematics success as a way to validate his academic ability and respond to racial discourses about African Caribbean men like himself. Michael's reflection, however, was the only instance of the intersection of ethnicity and gender that was noted in Mendick's (2006) analysis. Other men perceived as successful in mathematics discursively resisted losing their established sense of masculinity vis-à-vis mathematics through discussions that separated themselves from nonmathematicians and characterized themselves as being hard-working rather than naturally talented. Thus, hard work for future professional advancement characterized hegemonic masculinity in this context, whereas the "socially incompetent mathematicians" (Mendick, 2005a, p. 214) and nonmathematicians were the subordinate masculinities. This is analogous to the maintenance of different masculinities in Barnes's (2000) classroom evidenced in

⁶ Mendick (2005b) views gender as an ongoing "project . . . that is achieved in interaction with others" (p. 235). Gender identity projects in her work, therefore, refer to individuals' negotiations of gender identities and discourses of mathematics as a masculinized space that are encountered and reified through interpersonal interactions.

the separations between the Mates and Technophiles and between the Technophiles and the remainder of the class. Students in both studies found themselves at intersections of conflictingly gendered discourses and thus were tasked to negotiate hard work with others' perceptions of their innate mathematical ability.

In addition, Mendick's (2006) conceptualization of gender coupled with her poststructuralist analysis allowed for the consideration of gender *transgressions* (Davies, 1989), particularly in women participants' discursive negotiations of their gender identities with the masculinized notion of being "good at maths." This is a conceptual advance on Boaler's (1997, 2002b) and Barnes's (2000) participation work by broadening analytical opportunities for not only how women and men do mathematics similarly but also how gendered binaries of success in mathematics are challenged in individuals' constructions of mathematics identities. For many women in Mendick's (2003, 2005a, 2005b, 2006) work, choosing mathematics was a way to "prove something to themselves," which led to varying forms of gendered resistance and tensions specific to their feminine identities in a masculinized field. More specifically, successful women in college mathematics shared strategic moves in "using maths to do masculinity" (Mendick, 2006, p. 82) while viewing masculinity as inaccessible to them as women. In addition, Mendick (2006) described some other successful college women as attempting to be "the ideal neoliberal subject" (p. 95) by discounting the idea that their female and feminine identities were associated with their mathematical ability. Thus, Mendick's (2003, 2005a, 2005b, 2006) more complex and localized analysis of individual women's and individual men's narratives on pursuing college mathematics considered individual experiences of empowerment and marginalization that are often lost in the homogenizing binary groupings (e.g., male–female, boy–girl) across the achievement and sex-based participation studies.

Research implications from a participation perspective. Overall, participation studies advanced approaches in conceptualizing and methodologically exploring gender issues in mathematics education. Sex-based participation studies provided the field with a better understanding of how contextual influences, such as teacher beliefs, curricular structures, and instruction, shaped schools and classrooms as gendered spaces for learning mathematics. Thus, these studies unpacked the quantitative findings from achievement studies on female–male mathematics test score and task performance differences by considering the gendered coproductions between students and their mathematics learning contexts. Conceptualizing gender as socially constructed, gender-based participation studies expanded on such explorations of gendered coproductions through interviews and observations to detail how students negotiated their classroom practices and identities with gendered discourses of mathematics success. Such analyses of mathematics as a masculinized space allowed for considerations of variation across individuals, among groups of women and groups of men, in their discursive positionings along the gendered and racialized hierarchy of mathematical ability (Esmonde & Langer-Osuna, 2013; Martin, 2009). This was a conceptual and methodological advance

from the sex-based participation perspective's analyses of female–male differences by considering individuals' differentially gendered ways of doing and making meaning of mathematics.

Despite such progress, limited consideration was given to how race or ethnicity, class, and other socially constructed identities intersected with gendered trends in mathematics achievement and participation as well as individual student experiences in mathematics. Becker (1981) and Fennema et al. (1990) discussed how school structures and teachers' personal biases may serve as systematic influences on student achievement. However, the researchers left unexplored across their analyses the variation of teachers' interactions with students and ratings of students' mathematics success particularly at intersections of gender, race, and class. This is important to note considering the fact that research has documented how low-income students of color in urban schools have limited access to high-quality mathematics teaching and supportive teacher–student relationships (Jerome, Hamre, & Pianta, 2009; Ladson-Billings, 1997; Lubienski, 2002; Pianta & Stuhlman, 2004). Similarly, findings from Boaler's (1997, 2002b) ethnographic study explored gendered patterns of mathematics engagement among White working-class students in two schools located in socioeconomically different areas in England. Boaler (2002b) noted sex-based differences including “*a quest for understanding*” for females and “playing a kind of school mathematics game” for males (p. 139). However, what remains implicit in Boaler's (2002b) analysis is how such sex-based differences are manifestations of how social class intersects with gender to shape students' strategies for success in mathematics classrooms with either an academic or a vocational focus.

Mendick (2006) adopted a relational model of gender that claimed to “explore how inequalities of class and race/ethnicity interact with gender” (p. 11) when college students pursue mathematics. However, ethnicity is explicitly discussed only once when Mendick is considering one African Caribbean student's reflections on how his mathematics success served as a response to others' views of poor mathematical ability among students of color. As a result, an explicit intersectional analysis of gender and race or ethnicity is missing from this and other narrative analyses presented in Mendick's (2003, 2005a, 2005b, 2006) work. Although Mendick (2006) acknowledged that these other social dimensions were not the primary focus of her analysis, they are important considerations for future research that examines students' gendered mathematics experiences, with gender conceptualized as a social construct that is raced, ethnic, classed, sexed, and so forth. Thus, there remains much analytical space in the research literature to critically examine how intersections of gender and other vectors of identity further explain students' achievement, engagement, and identities in mathematics.

Whiteness, furthermore, is excluded across the sex-based and gender-based participation studies' analyses of mathematics practices and identities. Intersectional analyses across the participation studies would allow for the exploration of racialized and ethnic influences on mathematics experiences of White individuals (Sue, 2004). Without such a conceptualization of race and ethnicity in the

participation literature, however, White students' mathematics experiences were not deemed racialized (Battey & Leyva, 2016). An example of such theoretical considerations of White students as raceless was evidenced in Boaler's (2002b) assertion that White females and males constructed their mathematics identities as "unproductive gender responses" (p. 153) to classroom environments similar to the unproductive racialized responses among students from different cultural backgrounds. As a result, this drawback across the participation studies rendered Whiteness and privilege invisible and racially neutral in their respective analyses.

It should also be noted that much of the participation research reviewed here was completed outside of the United States. For example, Barnes's (2000) calculus classroom ethnographic study took place in Australia, and Boaler's (1997, 2002b) and Mendick's (2003, 2005a, 2006) studies took place in various school sites in England. Social norms of race or ethnicity and gender vary across international contexts, as noted in Hanna's (1989) cross-cultural international study; thus, insights from these participation studies may not directly translate across different geographic locations. Much remains to be explored about individual students' gendered mathematics experiences in the Americas and how this compares with extant findings in participation research from other nations. In addition, many of the studies did not theorize how the social and cultural norms of local contexts related to their findings as the Brandon et al. (1987), Hanna (1989), and Birenbaum and Nasser (2006) studies did in their analyses. Understanding the impact of geographic and social context is a space for future gender research in mathematics education.

A Call for Intersectional Analyses of Gender in Mathematics Education Research

A Framing of Intersectionality Theory

Intersectionality theory (Crenshaw, 1991) is an interdisciplinary framework that explores the nuanced interplay of various social constructs (e.g., gender, race, class, sexuality) and its productions or reproductions of distinct forms of marginalization at intersections of multiple systems of oppression. Crenshaw (1991) discussed how emergent patterns of intersectional disempowerment are not necessarily intentionally imposed but arise from the intermingling of different sources of marginalization. Collins (1993) extended this theorization by highlighting how such intersectional forms of oppression vary across individuals and social contexts.

Moreover, intersectionality theory bypasses the limitations of identity politics that ignores individual differences and deems social groups as homogeneous entities. It instead recognizes the existence of intragroup differences in power and privilege, allowing marginalized subgroups to differentially negotiate their identities in these hierarchical social relations and establish empowering coalitions (i.e., women of color, queer people of color). Intersectionality, thus, reconceptualizes the notion of identity from a lumping of static categories to a mutually constitutive interplay of dynamic social constructs including gender (Crenshaw, 1991).

Intersectional Analyses in Mathematics Education Research

Despite shifts in the conceptualization and empirical study of gender in mathematics education, intersections of gender with other dimensions of students' identities generally remain minimally explored in analyses across achievement and participation studies. Damarin and Erchick (2010) wrote, "If mathematics education research is to promote equity for girls and women within multiple racial and ethnic groups, similar attention to the intersection of clearly defined constructs, including gender, is required" (p. 312). Either race or gender, for example, has traditionally been adopted as the unit of analysis in extant research to understand social forms of marginalization among African Americans, Latin@s,⁷ and women in mathematics (Berry, 2008; Boaler, 1997, 2002b; Damarin, 2000; Fennema et al., 1998; Martin, 2000; Mendick, 2003, 2005a, 2006; Moschkovich, 2013; Stinson, 2008; Terry, 2010). However, research that focuses on a single construct of identity potentially leaves implicit the analysis of variation across individuals' negotiations of gendered as well as racialized, classed, sexed, and other social norms and discourses of mathematics success. Scholars are, therefore, calling for a more complex understanding of students' gendered mathematics experiences, particularly at multiple intersections with other socially constructed identities (Campbell, 1989; Damarin & Erchick, 2010; Esmonde, 2011; Esmonde, Brodie, Dookie, & Takeuchi, 2009; Lim, 2008b; Martin, 2009; Reyes & Stanic, 1988).

Although intersectional analyses offer a promising way to gain a more nuanced understanding of students' mathematics achievement and experiences, they have yet to be done effectively from both methodological and conceptual standpoints in much of the extant research on gender in mathematics education and the equity literature more broadly. Esmonde (2011) identified one of the common pitfalls in past researchers' use of intersectional analyses as making faulty subgroup comparisons, such as assuming similarities between girls and boys with different racial backgrounds. Studies using critical race theory (CRT), however, pursue sampling of participants in ways appropriately informed by intersectionality to examine narratives of mathematics experience among student populations traditionally marginalized in mathematics (e.g., Berry's, 2008, and Terry's, 2010, studies on African American males). Although intersectionality is one of the tenets of the CRT framework in educational research used to examine how racism intersects with other forms of oppression (e.g., sexism, classism), CRT studies in mathematics education attend to race and sex separately in their analyses; thus, considerations of their intersections are left implicit (e.g., McGee & Martin, 2011; Terry, 2010).

In addition, CRT studies adopt conceptualizations of gender as a female–male binary that limit considerations of mathematics as a racially masculinized space that shapes differentially gendered forms of racial oppression for participants,

⁷ Drawing on Gutiérrez (2013), the term *Latin@* decenters the patriarchal nature of the Spanish language that traditionally groups Latin American women and men into a single descriptor (Latino) denoting only men. The @ symbol allows for gender inclusivity among individuals from Latin America compared with the either-or form (Latina/o) that implies a gender binary.

including African Americans and Latin@s. Terry (2010), for example, acknowledged the need for such intersectional analyses in future CRT studies on African Americans in mathematics framed in “a broader theoretical discussion of constructed academic identities vis-à-vis Black masculinity” (p. 96). However, a common misinterpretation in exploring these intersections is consideration of social oppression as additive or compounded instead of related and interconnected (e.g., notions of being “multiply oppressed” or in “double jeopardy”).

Despite the challenges associated with intersectional analyses, we can build on the advances in studying gender across the research reviewed here to design future studies that explicitly attend to the intersectionality of students’ experiences and thus capture variation in gendered trends of mathematics achievement and participation. Studies in the first strand of the achievement literature that examined sociocultural influences in particular were arguably intersectional in their analyses as they attended to how culture, ethnicity, and SES intersected with sex in detailing within-group variation of mathematics achievement among females and males (Birenbaum & Nasser, 2006; Brandon et al., 1987; Hanna, 1989; Lubienski et al., 2013; McGraw et al., 2006). However, researchers in the achievement literature who used large data sets understandably had to limit their analyses to a conceptualization of gender as a female–male binary; thus, the intersectionality of participants’ mathematics experiences to further explain within-group variation of achievement went unexplored. Therefore, I argue that future research should draw on intersectionality theory coupled with a conceptualization of gender as socially constructed to gain a more nuanced understanding of mathematics achievement and participation as functions of the interplay between individuals’ gender and other identities, such as race or ethnicity, class, language, and sexuality.

To illustrate the promise of such intersectional analyses, I present a second and more focused review of research on gender in mathematics education that either framed the analyses using Crenshaw’s (1991) intersectionality theory or focused on specific intersections without necessarily drawing on intersectionality theory. These studies were purposefully selected using criteria analogous to that adopted in the search, selection, and classification of research in the first review. More specifically, a Google Scholar search (sorted by relevance) using a combination of the terms “intersectionality (and intersections),” “mathematics (and maths),” and “gender (and sex)” was completed in January 2016.

Only empirical research studies that pursued such intersectional analyses of gender in mathematics education were considered from the first 400 results of each search. These studies were published in peer-reviewed journals spanning education, gender studies, and mathematics education as well as edited book chapters. This resulted in 14 research studies, including those completed by Lubienski et al. (2013) and McGraw et al. (2006) that also met the selection criteria for the broader review of gender research in mathematics education presented earlier. No citation number or journal rank criterion was applied to broaden opportunities for the consideration of intersectional research on gender in mathematics education.

I used the achievement and participation categories from the first review to classify the 14 research studies on the basis of their respective units of analysis and conceptualizations of gender. Three studies were grouped under the achievement category in light of their analyses of mathematics achievement differences according to sex at intersections with race (Capraro, Young, Lewis, Yetkiner, & Woods, 2009), SES (Lubienski et al., 2013), or both (McGraw et al., 2006). Riegle-Crumb and her colleague's intersectional analyses (Riegle-Crumb, 2006; Riegle-Crumb & Humphries, 2012) were classified as sex-based participation studies. Their quantitative analyses examined teacher perceptions of mathematical ability and students' mathematics course-taking patterns, focusing especially on intersections of students' sex and race or ethnicity. The use of large-scale national data sets across these achievement and sex-based participation studies' intersectional analyses understandably limited the researchers' conceptualizations of gender to participants' selection of their biological sex on surveys.

The remaining nine intersectional studies were classified as gender-based participation studies. These studies used interviews, classroom observations, and self-report data (e.g., questionnaires, written reflections) to detail students' mathematics experiences and construction of identities at intersections of gender, culture, race or ethnicity, class, age, and sexuality. One strand of these gender-based participation studies focused on how students made meaning of their experiences in navigating mathematics spaces (e.g., classrooms, problem-solving workshops, cooperative group work) at different intersections (Esmonde et al., 2009; Lim, 2008c; Oppland-Cordell, 2013; Oppland-Cordell & Martin, 2015). Another strand of these intersectional studies examined students' reflections on negotiating their socially constructed identities with discourses of ability and opportunities to pursue mathematics (Hernandez-Martinez et al., 2008; Lim, 2008a; Mendick, 2008; Siivonen, 2013; Williams et al., 2009). It is noteworthy that the gender-based participation category has the largest number of studies and thus captures the progress being made in mathematics education research in studying gender as a social construct shaped by other identities.

The following sections present findings from a subset of these intersectional research studies that explicitly attended to intersections of sex or gender with other socially constructed identities in relation to how they shaped students' mathematics achievement and participation. I focus on the McGraw et al. (2006), Riegle-Crumb and Humphries (2012), and Esmonde, Brodie, Dookie, and Takeuchi (2009) studies—one study per category of intersectional research outlined above—because they respectively illustrate how intersectional analyses extended insights on gender from the achievement, sex-based participation, and gender-based participation research reviewed earlier. Additionally, these intersectional studies have arguably had a broad impact: Two studies were published in top journals in mathematics education and gender studies respectively, and one study had the most number of citations among intersectional studies in the strand that detailed mathematics spaces. In looking across these intersectional studies, I apply insights from the previously reviewed research, including the conceptualization and

empirical study of gender as a social construct, to raise implications for future research directions on gender in mathematics education.

Rethinking “gender gaps” in mathematics achievement at intersections of race and class. McGraw et al. (2006) examined gaps in mathematics achievement and affect data from the National Assessment of Educational Progress for fourth-, eighth-, and 12th-grade students, with a particular focus on sex and variation at intersections with race or ethnicity (Black, Hispanic, and White) and SES. At intersections of race and sex, McGraw et al. (2006) noted statistically significant “gender gaps” favoring males only among White and Hispanic students in fourth and eighth grades. They also observed an opposite and statistically significant achievement difference with Black females outperforming their Black male counterparts in geometry and data analysis. These findings have implications for institutional change to broaden marginalized students’ access to advanced mathematics and to offer empirical evidence that challenges gendered and racial discourses of mathematical ability. Despite the limitation of a binary conceptualization of gender, the analysis presented in the McGraw et al. (2006) study was an advancement from the achievement literature reviewed earlier because of its use of an intersectional lens to detail differentially gendered patterns of mathematics achievement across race–sex subgroups of students. Furthermore, this informed future intersectional research attending to students’ gendered coproductions of mathematics success with psychosocial and contextual influences at intersections with race or ethnicity, culture, class, and other socially constructed identities (e.g., Lim, 2008a; Lubienski et al., 2013). Thus, this was also an advancement from sex-based and gender-based participation studies, which left such variation of gendered experiences at different intersections of identity implicit in their analyses.

Documenting patterns in teacher perceptions of students’ mathematical ability at race–sex intersections. Turning the analytical focus to the mathematics classroom context, Riegle-Crumb and Humphries (2012) adopted intersectionality theory to analyze teacher bias in their perceptions of students’ mathematical ability. Riegle-Crumb and Humphries (2012) examined data for a nationally representative sample of 15,000 U.S. high school sophomore students from the Education Longitudinal Study of 2002 to document the extent to which gendered stereotypes shaped these perceptions. The researchers observed that the saliency of gendered stereotypes varied across mathematics course levels. They found that teachers were more likely to think that mathematics was “too difficult” for White females than for White males in more advanced courses. This finding was consistent across average-level courses in which teachers, according to Riegle-Crumb and Humphries, may have relied more on student status shaped by gendered stereotypes than achievement to assess mathematical ability. Teachers were less likely to view mathematics as being “too difficult” for Black females compared with White males in more advanced courses despite the underrepresentation of students of color in

these classes. Riegle-Crumb and Humphries argued that narratives of low achievement among Black and Hispanic students may have explained away any gendered perceptions of mathematical ability for females of color minimally observed in their study.

This study was an advancement from the sex-based participation literature reviewed earlier because it provided insights in rethinking gendered mathematics achievement and participation gaps by detailing the differential influence of teacher bias across different race–sex subgroups. Furthermore, Riegle-Crumb and Humphries's (2012) finding on the varying saliency of gendered stereotypes across course levels illustrates how contexts, including mathematics classrooms, shape the discourses of mathematical ability that students must navigate. Much like the McGraw et al. (2006) study, Riegle-Crumb and Humphries (2012) called for situated and qualitative analyses to better understand these intersectional complexities of experience among women of color and other race–sex subgroups across mathematics classrooms.

Detailing mathematics classrooms and group work as gendered and racialized spaces. Adopting an intersectional analysis of gender as being socially constructed in mathematics classrooms, Esmonde et al. (2009) presented findings from an interview case study of two students' cooperative group work experiences in an urban, reform-oriented U.S. high school mathematics class. Two girls were the focus of this analysis: Candie (a 10th-grade lesbian and African American girl) and Willow (a ninth-grade bisexual and biracial girl). The scholars documented three emergent themes of gendered and racialized influences on the students' cooperative group work experiences, including interactional styles, mathematical understanding, and friendship patterns. Esmonde et al. (2009) noted that high school students, outside of these group work contexts, openly discussed issues of racial underrepresentation across higher level mathematics courses, boys' stronger mathematical ability compared with that of girls, and the correlation of school achievement with social class. Although these discussions did not find their way explicitly into group work, the researchers argued that they may have implicitly shaped group work interactions, such as White students (particularly boys) often dominating discussions. A similar dynamic was observed with students' homogeneous friendships in terms of race and class, with students reporting that they worked better with peers who looked like them. Esmonde et al. (2009), therefore, questioned the inclusivity of heterogeneous group work, with students of color and White girls finding themselves consistently marginalized in these contexts. Findings from their intersectional analysis of student marginalization supported the researchers' description of "mathematics classrooms as sites for power struggles that are often related to their social identities" (Esmonde et al., 2009, p. 39).

This intersectional analysis offered qualitative, situated accounts of students' mathematics experiences to glean more nuanced insights of contextual influences at intersections of race, class, and sexuality. The conceptualization of gender as

socially constructed allowed for detailing variation between Candie's and Willow's group work experiences as two queer-identifying girls in the same mathematics classroom. In particular, the varying saliency of either their racial or gender–sexuality identity in the classroom offered insight into how the girls negotiated their mathematics *practice-linked identities* (Esmonde et al., 2009) and socially constructed identities similarly and differently. This is an advancement from the gender-based participation literature reviewed earlier, which focused solely on gender in detailing how students made meaning of mathematics experiences. Furthermore, the analytical focus on two queer girls' experiences allowed for considerations of gender–sexuality intersections, which were left implicit or unexplored in the previously reviewed research. This is an important next step in mathematics education research in light of the institutional genderism and heteronormativity documented in mathematics and mathematics-intensive fields like engineering (Cech & Waidzunas, 2011; Esmonde, 2011; Yoder & Mattheis, 2016).

Looking across these three studies, we can see that there remains a need for mathematics education research that conceptualizes and examines gender as a social construct to make meaning of mathematics achievement and participation at different intersections of identity. McGraw et al. (2006) highlighted the importance of exploring within-group differences to avoid reverting back to the oversimplified discourse of male superiority on mathematics assessments and perpetuating the “‘gap-gazing’ fetish” (Gutiérrez, 2008) in mathematics education. In order to unpack gendered disparities in mathematics achievement and participation documented in the research literature, Riegle-Crumb has argued that future research must complement quantitative analyses with qualitative methodologies (e.g., interviews, classroom observations) to shed light on contextual factors that differentially shape the intersectionality of mathematics experiences and thus impact achievement and participation (Riegle-Crumb & Humphries, 2012; Riegle-Crumb, King, Grodsky, & Muller, 2012). As illustrated in the study by Esmonde et al. (2009), the coupling of intersectionality theory with a conceptualization of gender as a social construct allows for exploration of similarities and differences among students in relation to achievement and negotiations of mathematics success at intersections of gender with other socially constructed identities.

Discussion

In this review of research, I have presented two perspectives of studying gender in mathematics education—namely, achievement and participation—premised on researchers' conceptualizations of gender and methodological approaches to their studies. Achievement studies generally used quantitative analyses from large-scale studies to challenge the long-standing myth of male superiority on mathematics assessments and to call for considerations of contextual factors to further explain gendered achievement disparities. In response, a subset of participation studies adopted qualitative methodologies (e.g., interviews, classroom observations) to

obtain more contextual insights on sex-based and gender-based variation across students' learning approaches and experiences in mathematics.

Significant progress is evidenced in recent studies' conceptual distinctions of gender and sex unlike that observed in achievement and sex-based participation research. In addition, theorizations of gender as a dynamic and socially constructed identity in the gender-based participation literature offered a more nuanced understanding of mathematics as a gendered and, more specifically, White and heteronormatively masculinized space leading to within-group variation in achievement and educational experiences across subgroups of women and men. A limited number of research studies have adopted this intersectional conceptualization of gender; thus, there remains much analytical space to examine gender as a social construct and how this differentially affects students' mathematics achievement and experiences.

I argue that complementing situated analyses of gender with intersectionality theory allows for more nuanced insights on students' experiences at multiple intersections of gender and other socially constructed identities, including race or ethnicity, culture, class, and sexuality. Race or ethnicity and sexuality were largely absent in achievement and participation studies' sex- and gender-based analyses of assessment performance and experiences in mathematics. Whiteness is a social construct that intersects with gender and other identities and in turn shapes different mathematics experiences among White individuals, including those in the achievement and participation studies (Battey, 2013; Battey & Leyva, 2016; Sue, 2004). Similarly, sexuality intersects with gender identities in light of how systems of heterosexism and heteronormativity structure social norms that marginalize gender-nonconforming populations, including members of the LGBTQ+ (lesbian, gay, bisexual, trans*, queer or questioning, and other) community (Butler, 1990; Esmonde, 2011). However, such intersectional considerations of mathematics achievement and participation shaped by Whiteness and sexuality were left implicit in the analyses of the achievement and participation studies that I reviewed.

The invisibility of Whiteness and sexuality, as well as the need for explorations of gender as a social construct, began to be addressed by studies' intersectional analyses of mathematics achievement and participation vis-à-vis quantitative and qualitative analyses (e.g., Esmonde et al., 2009; McGraw et al., 2006; Riegler-Crumb & Humphries, 2012). These analyses advanced research on gender by highlighting within-group variation in mathematics achievement and experiences and thus problematized White, heteronormatively masculinized discourses of mathematical ability.

It is, therefore, critical that scholars examine the influences of different contexts on students' mathematics achievement and experiences at intersections of gender and other socially constructed identities. Although the majority of achievement and sex-based participation studies that I reviewed were conducted in the United States, insights from the gender-based participation perspective came from research completed in Australia, Canada, and the United Kingdom. Thus, much remains to be explored in the United States and other nations on the extent to which the

masculinization of mathematics differentially impacts students' achievement and participation.

In addition, future research on gender in mathematics education must closely consider the different levels of influence that simultaneously shape students' mathematics achievement and identities institutionally (e.g., school curricula, public policies), interpersonally (e.g., peer influences, teacher and family expectations), and ideologically (e.g., stereotypes, cultural norms). This provides a three-tiered analytical framework for future research to examine relationships between achievement data and qualitative insights on mathematics experiences at different intersections of identity (Leyva, 2016). Such study designs allow for detailing the interconnectedness of mathematics achievement and participation with an intersectional lens of analysis on gender operating at and across these three levels. This will shed light on variation in students' strategies for negotiating mathematics success with their gender and other identities that in turn problematizes marginalizing narratives of mathematical ability ascribed to entire social groups.

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An Appendix, providing a listing of all publications reviewed for this article along with additional information about each, is available online at <http://www.nctm.org/jrme>. More4U content is available to NCTM members only.

**Unpacking the
Male Superiority Myth
and Masculinization
of Mathematics
at the Intersections:
A Review of Research
on Gender in
Mathematics Education**

Appendix

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APPENDIX

Table A1
Reviewed Publications for Achievement and Participation Perspectives

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
Achievement	Fennema & Sherman (1977)*	1,002	<i>American Educational Research Journal (AERJ)</i>	4 predominantly White high schools across U.S.	Sex differences in test scores and Fennema-Sherman Mathematics Attitude (FSMA) Scales	589 females and 644 males
	Guay & McDaniel (1977)	120	<i>Journal for Research in Mathematics Education (JRME)</i>	U.S. elementary schools	Sex differences in 4 researcher-developed tests on spatial ability	90 children between the ages of 14 and 16
	Fennema & Sherman (1978)*	552	<i>JRME</i>	Predominantly White, middle-class middle schools in Madison, Wisconsin	Sex differences in problem solving, vocabulary, spatial ability, and FSMA Test	1,320 sixth- to eighth-grade students representative of top 85% in math achievement
	Ethington & Wolfe (1984)	91	<i>JRME</i>	U.S.	Covariance-structures model of mathematics achievement and resulting sex differences	13,200 high school sophomore and senior student participants (7,115 females and 6,085 males) in NCES longitudinal study, High School and Beyond
Participation	Fennema & Tartre (1985)	162	<i>JRME</i>	4 middle schools in Madison, Wisconsin	Sex differences in use of spatial visualization and mathematical problem solving performance	36 females and 33 males interviewed annually between sixth and eighth grades
	Ethington & Wolfe (1986)	78	<i>AERJ</i>	U.S.	Sex differences in latent-construct causal model for processes of mathematics achievement	16,555 respondents (8,912 females and 7,643 males) in NCES longitudinal study, High School and Beyond
	Brandon, Newton, & Hammond (1987)*	70	<i>AERJ</i>	4 public schools in Hawaii	Sex differences in norm-referenced mathematics achievement test performance across 4 grade levels	4 major ethnic groups (Caucasians, Filipinos, Hawaiians, and Japanese); 7,926 student participants (3,912 females and 4,014 males) in 1982 and 8,582 (4,155 females and 4,427 males) in 1983

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Ferrini-Mundy (1987)	86	<i>JRME</i>	Medium-sized state university in the U.S.	Sex differences in spatial training on calculus achievement, spatial visualization ability, and use of visualization in problem solving	334 students (167 females and 167 males) preregistered for first- semester calculus
	Hanna (1989)*	66	<i>Educational Studies in Mathematics (ESM)</i>	20 countries between 1982 and 1983	“Gender differences” in test scores from Second International Mathematics Study (SIMS)	37,043 females and 37,410 males in eighth grade
	Marsh (1989)	185	<i>AERJ</i>	1,015 high schools in the U.S.	Sex differences in development of academic constructs of achievement, attitudes, and course selection in mathematics	14,825 respondents in a second follow-up to High School and Beyond study
	Battista (1990)	257	<i>JRME</i>	Middle-class, Midwestern community in the U.S.	“Gender differences” in geometry performance (achievement and problem solving) with consideration of teacher effects	148 high school geometry students (53 females and 75 males)
	Examples (* denotes representative studies highlighted in review)					
Perspective	Ethington (1992)	77	<i>JRME</i>	U.S.	“Gender differences” in mathematics achievement using psychosocial model	746 eighth-grade student participants in SIMS
	Wainer & Steinberg (1992)	141	<i>Harvard Educational Research</i>	51 U.S. colleges and universities	Sex differences in Scholastic Aptitude Test (SAT) Mathematics performance	46,920 students (21,028 females and 25,892 males) matched by the same grade in first-year college mathematics course
	Stage & Kloosterman (1995)	111	<i>The Journal of Higher Education</i>	Public research university in Midwestern U.S.	“Gender differences” in beliefs and achievement in remedial college-level mathematics classroom	236 students (95 females and 141 males) enrolled in college remedial algebra course
	Taritre & Fennema (1995)	86	<i>ESM</i>	4 middle schools (Grades 6–8) in Midwestern U.S.	“Gendered differences” in relationships between mathematics achievement and cognitive and affective variables	60 students (32 females and 28 males) tested across eighth, 10th, and 12th grades

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Bielinksi & Davison (1998)	52	<i>AERJ</i>	U.S.	“Gender differences” in item difficulty interactions on basic skills, multiple-choice tests	10,321 eighth-grade students
	Fennema, Carpenter, Jacobs, Franke, & Levi (1998)*	250	<i>Educational Researcher</i>	3 elementary schools in U.S.: <ul style="list-style-type: none"> Rural, predominantly White with 4% free or reduced lunch Predominantly White with 26% free or reduced lunch Predominantly White with 8% free or reduced lunch 	“Gender differences” in mathematics strategy use on researcher-developed problem solving test	38 females and 44 males (89% White, 11% free or reduced lunch)
	Cart, Jessup, & Fuller (1999)	87	<i>JRME</i>	2 schools (10 first-grade classrooms) in suburban Atlanta and 3 schools (13 first-grade classrooms) in small towns in Georgia, U.S.	Parent and teacher influences on “gender differences” in first-grade students’ mathematics strategy use	92 children; 2 females and 2 males per classroom across 23 first-grade classrooms (21% African American, 74% Caucasian, 4% other groups [mainly Asian])
Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Davis & Carr (2001)	46	<i>Learning and Individual Differences (LID)</i>	2 suburban elementary schools (5 classrooms) in the U.S.	“Gender differences” in fluence on mathematics strategy use	84 first-grade students (42 females and 42 males); 51% White, 15.2 % African American, 5.4% Asian, 8.7% Hispanic, and 8.7% multiracial
	Al (2002)	82	<i>Mathematical Thinking and Learning (MTL)</i>	Randomly selected 52 public schools in the U.S. (Longitudinal Study of American Youth)	“Gender differences” in growth in mathematics achievement related to psychosocial influences (e.g., mathematical attitudes, self-esteem, parental encouragement, teacher expectations, peer influences)	Nationally representative sample of 3,116 students traced between Grades 7 through 10
	Birenbaum & Nasser (2006)	35	<i>Learning and Instruction</i>	Israel	Ethnic and “gender differences” in mathematics achievement (National Assessment Test in Mathematics) and dispositions (attitudes, parental expectations, effort, and help)	Nationally representative sample of 2,332 eighth-grade students: 1,585 Jewish (824 girls and 761 boys) and 747 Arab (344 girls and 403 boys)

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Armstrong (1981)	204	<i>JRME</i>	Women in Mathematics Project (WMP, Education Commission of the States) and 1977– 1978 NAEP mathematics assessment	Sex-based comparisons of achievement scores to document persistence of differences when controlling for mathematics course taking	452 13-year-old and 1,788 17-year-old WMP respondents; 75 000 students for NAEP (including 9-year-olds, 13-year-olds, and 17-year-olds)
	Becker (1981)*	265	<i>JRME</i>	3 U.S. high schools: <ul style="list-style-type: none"> • 2 schools in an urban–suburban area with well-educated and relatively affluent population • 1 school in a rural area near city located 50 miles from large metropolitan area 	Sex differences in mathematics teacher treatment using Brophy-Good Teacher- Child Dyadic Interaction System	10 high school geometry teachers (7 females, 3 males)
	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
Perspective	Pedro, Wolleat, Fennema, & Becker (1981)	121	<i>AEJ</i>	9 high schools across urban, suburban, and rural communities in 2 midwestern U.S. states (3 urban schools with 11–37% non-White students; other schools were predominantly White)	Sex-based variation in attributions and attitudes in election of mathematics courses	633 female and 572 male students enrolled in high school algebra and geometry
	Benbow & Stanley (1982)	217	<i>AEJ</i>	Maryland schools in the U.S.	Persistence of sex difference in mathematical reasoning ability in relation to achievement and participation	2,188 student participants (61% male) in the Study of Mathematically Precocious Youth
	Pallas & Alexander (1983)	233	<i>AEJ</i>	24 public high schools across 15 U.S. communities	Relationship of sex difference in quantitative SAT performance and high school mathematics coursework pattern	6,119 students from ETS Study of Academic Prediction and Growth

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley (1985)	116	<i>Women and mathematics: Balancing the equation</i> [Book chapter]	Not specified	Sex differences in mathematics course enrollment decisions related to self-perceptions, task perceptions, and socializing influences	339 students in Grades 5–11 in Year 1 and control group of 329 in Year 2
	Peterson & Fennema (1985)	231	<i>AERJ</i>	15 schools in a rural area or small towns near large U.S. cities; predominantly White and middle class	Sex differences in low and high NAEP item performance as well as (non-)engagement in classroom activities (competitive, cooperative, social, off-task)	6 randomly-selected females and 6 randomly-selected males across 36 fourth-grade mathematics classes (3 female teachers, 33 male teachers)
	Hart (1989)	97	<i>JRME</i>	Spring 1980 in the U.S.	Sex differences in mathematics teacher–student interactions across confidence levels using modified Brophy–Good Dyadic Observation System	93 seventh-grade mathematics students (20 high-confidence females, 25 low-confidence females, 24 high-confidence males, 24 low-confidence males); 6 teachers with 5–10 target students in each class

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Fennema, Peterson, Carpenter, & Lubinski (1990)*	231	<i>ESM</i>	24 U.S. elementary schools	Sex differences in teachers' attributions and beliefs of student mathematical ability	38 first-grade, female teachers; 314 females and 368 males
	Dick & Rallis (1991)	225	<i>JRME</i>	9 high schools with socioeconomic variation in Rhode Island	“Gender differences” in perceived factors and influences on academic and career choices (including a focus on students academically well prepared in mathematics and science)	2,213 high school seniors (1,124 women and 1,089 men)
	Bornholt, Goodnow, & Cooney (1994)	86	<i>AERJ</i>	Coeducational government high school in Sydney, Australia	Influence of “gender stereotypes” on “gender differences” in perceptions of mathematics achievement	663 students followed across first 4 years of high school
	Seegers & Boekaerts (1996)	127	<i>JRME</i>	20 middle-class schools in urban region of Leiden, the Netherlands	“Gender-related differences” in mathematics performance in relation to self-referenced cognitions and task-specific appraisals	96 girls and 90 boys between 11 and 12 years old

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Forgasz, Leder, & Kloosterman (2004)	61	<i>MTL</i>	Victoria, Australia; urban independent school as well as middle and high schools in Midwestern U.S. rural district	Sex and country differences in perceptions of mathematics as a gendered domain via Mathematics as a Gendered Domain and Who and Mathematics instruments	Approximately 400 female and 400 male students in Grades 7–10 in Australia; 61 females and 62 males in Midwestern urban school in U.S.; 200 females and 184 males in rural middle and high schools in U.S.
	Brandell & Staberg (2008)	45	<i>G&E</i>	17 compulsory schools (2 classrooms) and 6 upper secondary schools (4 classrooms) across 3 regions of Sweden	Perceptions of mathematics as a female, male, or gender-neutral domain	1,300 students (15- or 17-year-olds)
Gender-Based	Barnes (2000)*	20	<i>Multiple perspectives on mathematics teaching and learning</i> [Edited book chapter]	Independent coeducational school in Australia	Gendered collaborative learning experiences in accelerated mathematics class	22 students aged between 15–16 years old in accelerated Year 10 mathematics class

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Forgasz & Leder (2001)	24	<i>Sociocultural research on mathematics education: An international perspective</i> [Handbook chapter]	Australia	Students' motivations and experiences as gendered influences on tertiary mathematics studies	21 mature-age (over 21 years old) participants enrolled in mainstream postsecondary mathematics courses
	Three studies: • Forgasz (1998)		<i>Australian Association for Research in Education</i> [Conference paper presentation]	Australia	• Gendered patterns of cognitive and affective engagement with mathematics as predictors of future mathematics involvement	• 5 seventh-grade students (3 girls and 2 boys)
	• Leder & Forgasz (1997)		<i>The Australian Educational Researcher</i>	Australia		

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	<ul style="list-style-type: none"> Not specified in handbook chapter 			<ul style="list-style-type: none"> Outer suburban government primary school in middle-class area in Australia 	<ul style="list-style-type: none"> Students' attitudes toward gender in and out of the classroom and any influences from school community members (e.g., parents, teachers) 	<ul style="list-style-type: none"> 8 fourth-grade students, 7 sixth-grade students, 6 teachers, and 4 parents
	Mendick (2003)	21	<i>Which way social justice in mathematics education?</i> [Edited book chapter]	3 postsecondary schools in England: <ul style="list-style-type: none"> Ethnically diverse, working class (Grafton) Ethnically diverse, middle class with academic curriculum (Westerburg) International, nontraditional student population with vocational, part-time curriculum (Sunnydale) 	Gendered experiences with postsecondary mathematics subject choice	43 postsecondary students aged between 16 and 19 pursuing mathematics

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Shapka & Keating (2003)	100	<i>AERJ</i>	2 public high schools in Ontario, Canada: target school with single-sex program and control school with coeducational program	Effects of single-sex mathematics and science classes on girls' achievement, course enrollment, mathematical attitudes, and engagement and performance in coeducational program	786 students (85 girls in all-girl classes, 319 girls and 382 boys in coeducational program) from middle- to upper-middle-class White families living in suburban area
	Vale & Leder (2004)	87	<i>ESM</i>	Lower- to middle-class coeducational secondary school in metropolitan area of Melbourne, Australia	Gendered variation in girls' and boys' perceptions of computer use in mathematics classes	49 eighth- and ninth-grade students (17 girls and 32 boys)

Perspective	Examples (* denotes representative studies highlighted in review)	Number of Citations	Source	Context	Analytical Focus	Study Participants
	Mendick (2005a)	125	<i>G&E</i>	<p>3 postsecondary schools in England:</p> <ul style="list-style-type: none"> Ethnically diverse, working class (Grafton) Ethnically diverse, middle class with academic curriculum (Westerburg) International, nontraditional student population with vocational, part-time curriculum (Sunnydale) 	Gendered experiences with postsecondary mathematics subject choice	43 postsecondary students aged between 16 and 19 pursuing mathematics
	Solomon (2012)	20	<i>ESM</i>	United Kingdom (U.K.)	Narratives of success for creating identities of the “female self” in mathematics	Two undergraduate women studying mathematics at two different U.K. universities