Equity in Mathematics Education: Unions and Intersections of Feminist and Social Justice Literature

Laura Jacobsen Spielman

Abstract Traditional models of gender equity incorporating deficit frameworks and creating norms based on male experiences have been challenged by models emphasizing the social construction of gender and positing that women may come to know things in different ways from men. This paper draws on the latter form of feminist theory while treating gender equity in mathematics as intimately interconnected with equity issues by social class and ethnicity. I integrate feminist and social justice literature in mathematics education and argue that to secure a transformative, sustainable impact on equity, we must treat mathematics as an integral component of a larger system producing educated citizens. I argue the need for a mathematics education with tri-fold support for mathematical literacy, critical literacy, and community literacy. Respectively, emphases are on mathematics, social critique, and community relations and actions. Currently, the integration of these three literacies is extremely limited in mathematics.

Keywords Equity · Social Justice · Gender

Abbreviations

BLS	Bureau of Labor Statistics
NAEP	National Assessment of Educational Progress
NCTM	National Council of Teachers of Mathematics
NSF	National Science Foundation
SES	Socioeconomic status
WEF	World Economic Forum

L.J. Spielman (✉)
Radford University, Radford, VA, USA
e-mail: lspielman@radford.edu
url: http://www.radford.edu/lspielman

This chapter is a reprint of an article published in ZDM—The International Journal on Mathematics Education (2008) 40(4), 647–657. DOI 10.1007/s11858-008-0113-0.

H. Forgasz, F. Rivera (eds.), *Towards Equity in Mathematics Education*,
Advances in Mathematics Education,
DOI 10.1007/978-3-642-27702-3_5, © Springer-Verlag Berlin Heidelberg 2012

1 Introduction

"The public purpose of schooling in this nation—a nation founded on principles of freedom, justice and measures of happiness for all—is to educate the citizenry in understanding and abiding by these principles." (Goodlad 2004, pp. 14–17)

The question, "What is the purpose of schooling?," almost invariably leads to responses involving support for democratic ideals, or civic and global responsibility, or fairness and justice, or building moral character, or developing the whole person, or gaining knowledge useful for real life and for economic opportunity. Schools ideally help us to develop multiple forms of literacy—for personal growth, community livelihood, the workforce, and responsible citizenship. Yet historically and internationally, school mathematics is isolated from other subjects and from students' lives and interests outside of school. Mathematics is treated as independent from important social, political, and economic issues facing our communities and our world. This paper constructs unions and intersections between feminist and social justice literature in mathematics education. I make the case that to secure a transformative, sustainable impact on mathematics equity we must begin by promoting excellence and a challenging, inclusive mathematics curriculum for all students. But further, we must treat mathematics as an integral component of a larger social system producing educated citizens. Students must learn the relevance of mathematics for understanding and even remedying local, national, and global injustices—both gender related and otherwise.

We can rethink common sense in mathematics education when we revisit education's purpose and put principles such as "freedom, justice and measures of happiness for all" (Goodlad 2004, pp. 14–17) at the forefront. Drawing on Eric Gutstein's (2006) recommendations for mathematics curriculum, I use a broad range of existing research to argue the need for theoretical and practical frameworks in mathematics education that offer tri-fold support for students' mathematical literacy, critical literacy, and community literacy (described later). Respectively, emphases are on mathematics, social critique, and community relations and actions. Currently, the integration of these three literacies is extremely limited in mathematics.

This paper situates gender equity in mathematics within broader equity considerations both in the U.S., where I live, and across the globe. I first address gender equity in mathematics, then broaden the discussion to situate gender equity in mathematics within broader equity concerns, then shift and broaden discussion again by addressing the global picture of gender equity. This leads to specific suggestions for a new construction of mathematics education premised on these contextualizations, conceived as *mathematics education in the public interest*.

2 Gender Differences in Mathematics

Gender differences in mathematics achievement and attitudes are complex and changing over time. Since the early 1900s, a wide range of international research has reported gender inequities in mathematics, favoring males (e.g., Keitel 1998;

Leder 1992; Sriraman 2007). By about 1980, consistent findings from research on gender and mathematics showed that fewer females than males elected to study mathematics when it was optional in secondary schools; young women indicated mathematics as not particularly useful and tended to express less confidence in their ability to learn mathematics; mathematics was stereotyped as a male domain; and societal influences tended to suggest mathematical learning as not particularly appropriate for girls (Damarin 1995; Fennema 2000; Leder 1992).

Gender differences in mathematics have narrowed substantively over time and by some measures have even been eliminated. For example, in the U.S., sex differences in high school mathematics coursetaking no longer exist, and females earn approximately half (47%) of bachelor's degrees in mathematics [National Science Foundation (NSF), 2006]. In recent years, gender attention has increasingly shifted to include concerns about boys' educational needs and the problems boys experience (e.g., Forgasz and Leder 2001; Lingard et al. 2002; Weiner et al. 1997).

Interventions designed to address gender differences in mathematics have been classified by program type, time, school calendar, targeted population, education focus, strategy, elements of success, creation of new organizations, and teaching and learning strategies (Leder et al. 1996). Traditional models of gender equity created student norms based on male experiences and treated differences in personal characteristics as deficits on the part of females, or as the "girl problem" in mathematics (Campbell 1995). Deficit model assumptions that male behavior and outcomes are the desirable norm to which women should strive have underpinned previous policy, much research, and even many intervention programs (Forgasz and Leder 2001).

These traditional deficit models explaining gender differences in mathematics have been challenged by feminist models emphasizing the social construction of gender and positing that women may come to know things in different ways from men (e.g., Baxter Magolda 1992; Becker 1995; Belenky et al. 1986/1997; Brew 2001; Damarin 1995; Kaiser and Rogers 1995). Related interventions have sometimes attributed gender differences to pedagogical or assessment practices that are discriminatory toward females; others have explained inequities in mathematics in terms of the design, content, and structure of the mathematics curriculum (Goodell and Parker 2001).

3 Situating Gender Equity Within Broader Equity Concerns

Mathematics is "often regarded as the most abstract subject removed from responsibilities of cultural or social awareness" (Boaler and Staples 2005, p. 32). Mathematics has further been associated with the stratification of learning opportunities across race, ethnicity, gender, and social class. For example, Stinson (2004) referred to mathematics as "(re)produc[ing] and regulat[ing] racial, ethnic, gender, and class divisions" (p. 9). Among other nations, in the U.S., disparities and unequal access to mathematics course taking, achievement, and career fields remain a serious problem (Oakes et al. 2004; Secada 1992). Secada summarized:

> Along a broad range of indicators, from initial achievement in mathematics and course taking to postsecondary degrees and later careers in mathematics-related fields, disparities can be found between Whites and Asian Americans on the one hand and African Americans, Hispanics, and American Indians on the other; between males and females; among groups based on their English language proficiency; and among groups based on social class. (p. 623)

Referring to U.S. education as a whole, a 2007 report by the Jack Kent Cooke Foundation showed lower income students disproportionately fall out of the high-achieving group during elementary and high school, rarely rise into the ranks of high achievers during those periods, and far too infrequently ever graduate from college or go on to graduate school (Wyner et al. 2007, p. 4). Sirin (2005) conducted a meta-analysis on socioeconomic status [SES] and academic achievement in journal articles published between 1990 and 2000; results showed a medium to strong SES-achievement relation. According to the long-term National Assessment of Educational Progress [NAEP] assessments, White students continue to outperform Black and Hispanic students in both reading and mathematics (National Center for Education Statistics 2007).

Gender gaps in mathematics achievement and participation have closed over time but do still exist and are interconnected with differences by social class and race/ethnicity. In Australia, Lamb (1996, 1997) suggested social class differences in mathematics participation at the senior level of schooling were substantial for both girls and boys. He described girls as less likely than boys to take advanced mathematics, but suggested girls from professional family origins experienced far less of a gender gap in mathematics participation, confidence, and interest than girls from skilled manual backgrounds.

Interestingly, research intersecting gender with socioeconomic status does not always yield consistent findings. In the U.S., analyzing relationships among achievement and mathematical content, student proficiency and percentile levels, race, and socioeconomic status, the gender performance gap favoring males is generally small but did not diminish from 1990 to 2003 (McGraw et al. 2006). McGraw et al. reported gender gaps were most consistent for White, higher socio-economic groups of students, and were non-existent for Black students. Further, female students' mathematics attitudes and self-concepts continued to be more negative than those of male students. Female students were less likely than male students to indicate they like or believe they are good at mathematics; yet females had similar views to males about their beliefs about their level of understanding of what goes on in mathematics class.

4 Global Picture of Gender Equity

The issue of gender inequity in mathematics must be considered not only in connection with inequities by SES and race/ethnicity, but also in connection with cultures and with gender inequities in and outside of education as a whole (Rogers and Kaiser 1995). The World Economic Forum (WEF) conducted a study to assess the current

size of the gender gap internationally by measuring the extent to which women in 58 countries have achieved equality with men in five critical areas: economic participation, economic opportunity, political empowerment, educational attainment, and health and well-being (Lopez-Claros and Zahidi 2006). The U.S. ranked 17 among these countries with regard to gender gap rankings across these five measurable areas. The study concluded, "Even in light of heightened international awareness of gender issues, it is a disturbing reality that no country has yet managed to eliminate the gender gap" (p. 1).

Nordic countries lead the way in providing women with a quality of life almost equal to that of men (Lopez-Claros and Zahidi 2006). However, some other countries show wide variation, and some across all five dimensions. The WEF suggested *educational attainment* is "without doubt, the most fundamental prerequisite for empowering women in all spheres of society" (p. 5). Yet women represent more than two-thirds of the world's illiterate adults. According to the WEF, an obvious gender gap in education tends to appear early in most countries and on average to grow more severe with each year of education. The WEF makes a critical point that simply making literacy and education accessible to women will not be enough. To close the gender gap, the content of the curriculum and attitudes of teachers must also change so as not to reinforce prevalent stereotypes and injustices.

5 Reconstructing Mathematics: Mathematics Education in the Public Interest

"When we write a thesis or a paper, we learn that the first thing to do is to latch it on to the discipline at some point. This may be by showing how it is a problem within an existing theoretical and conceptual framework. The boundaries of inquiry are thus set within the framework of what is already established." (Smith 1974)

In 1974, sociologist Dorothy Smith questioned the taken-for-granted assumptions of traditional sociological thought—its methods, conceptual schemes, and theories. Smith began a longstanding effort to develop a sociology for women/people that takes issue with the disjunction that at times exists between women's lived experiences in the world and the theoretical schemes available to think about it. She explained:

> Our experience of the world is of one which is largely incomprehensible beyond the limits of what is known in a common sense. No amount of observation or face-to-face relations, no amount of analysis of commonsense knowledge of everyday life, will take us beyond our essential ignorance of how it is put together. (p. 13)

Smith argued that supplementing traditional male notions of sociology with components relevant to women's worlds, such as by addressing omitted and overlooked conversations, only serves to produce women's sociology as an addendum while still maintaining existing sociological thought and procedures and also extending their authority. Related arguments can be made regarding the transformation of mathematics education.

5.1 Setting New Goals in Mathematics Education

Putting aside deficit models popular in the past, current feminist perspectives generally posit the problem in mathematics is not with women's ability, but instead with mathematics as currently taught and constituted (Jacobs 1994; Kaiser and Rogers 1995). Feminist perspectives often suggest women tend to be *connected knowers* and men separate knowers (Belenky et al. 1986/1997; Becker 1995; Clinchy 1989; Gilligan 1982; Jacobs 1994). *Connected knowing* suggests knowledge is contextualized and built on personal or shared experiences; *separate knowing* suggests impersonal procedures and abstractions help establish truths.

Traditional approaches to mathematics instruction— stressing certainty, deduction, logic, argumentation, algorithms, structure, and formality—may be particularly incompatible with women's ways of learning (Becker 1995; Becker and Jacobs 2001; Jacobs and Becker 1997). To the extent girls perceive school mathematics and word problems as unrealistic or meaningless, school mathematics must not focus only on mathematical skills, but must also address problems in contexts that respect and develop self-confidence, awareness, and independence (Gellert et al. 2001). Gellert et al. argue that schools must foster students' ability to study and possibly change the local environment and to critique mathematical applications and the use to which mathematics and science are put in society.

Certain differences in reasoning and knowing patterns may exist between genders, depending on contexts (e.g., Galotti et al. 1999; Galotti et al. 2001; Knight et al. 1995). Feminist recommendations to mathematics educators typically encourage content and pedagogical change supporting *connected teaching*, where, for example, teachers and students problem solve and discover mathematics together in a supportive environment where alternate solution methods are encouraged (e.g., Becker 1995; Jacobs and Becker 1997). These recommendations have much in common with recommendations in the National Council of Teachers of Mathematics (NCTM) *Standards* (1989, 2000) guiding reform in the U.S. The *Standards* support instruction where students conjecture, test, and build mathematical arguments and also learn to value mathematics and to become confident in their ability to do mathematics.

More important than possible gendered differences in mathematics, however, is that many differences undoubtedly exist between individuals in mathematics in general. Any mathematics education aimed at reaching a broad audience must therefore accommodate the various individual, gendered, socioeconomic, racial/ethnic, cultural, and other differences, or otherwise risk excluding many learners. Given the important roles of mathematics in helping promote literacy and in opening doors to career possibilities, among other roles, exclusion of any individual or group is unacceptable. For this reason, mathematics education must necessarily transform its largely decontextualized and impersonal traditions. Goals to support equity and to diversify student interest and participation in mathematics must take center stage. These goals must also resonate with broader public interest goals to improve educational and social conditions both in the U.S. and abroad.

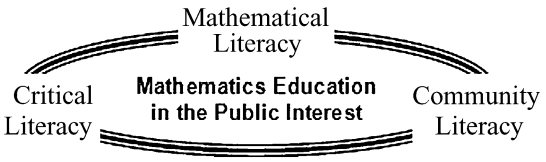

Fig. 1 Integrated literacies

Similar to Smith's development of a feminist sociology, we can argue that appending components of social justice (or other) theoretical or pedagogical viewpoints to certain accepted mathematics disciplinary constructions and assumptions might further sanction and privilege mainstream thought. To secure a transformative and sustainable impact on mathematics equity and bring additional new students into the world of mathematics, rather than appending "radical" concepts to the mainstream, we need to engage in "rethinking mathematics" (Gutstein and Peterson 2005). What would this new mathematics look like?

Mathematics educators and others have already done much to answer this question, paving the way for fundamental change. A range of issues contribute to inequities in mathematics education, including policy and social factors, curriculum choices and implementation, and institutional practices (Bishop and Forgasz 2007). For mathematics curriculum to help close gaps in achievement and participation—whether they are associated with gender, race/ethnicity, or social class—will require not only educating individuals with traditional mathematics knowledge, but also rewriting learning objectives to necessarily include feminist perspectives, culturally relevant content, and social justice emphases that help students understand and challenge dominant power relations.

A wide range of empirical and theoretical research introduced in the next several sections points to the urgent need for an integrated *mathematical literacy*, *critical literacy*, and *community literacy* to narrow the existing and perpetuating gaps in mathematics interest, participation, and achievement among different gender, racial/ethnic, and social class groups (see Fig. 1; Table 1 describes these forms of literacy). Respectively, these forms of literacy emphasize mathematics, social critique, and community relations and actions. Gutstein (2006) perhaps most closely identified and described the need for integrated literacies by proposing an exploratory orientation toward building mathematics curriculum with integrated components of community knowledge, critical knowledge, and classical knowledge. The 12 characteristics of the Connected, Equitable Mathematics Classroom proposed by Goodell and Parker (2001) also support similar emphases in the rethinking of mathematics.

Integrating these literacies will necessarily imply that mathematics curriculum and instruction be fundamentally redesigned with overlapping objectives that, for example: (1) incorporate feminist connected teaching approaches, (2) are more culturally responsive, (3) make use of individuals' and groups' funds of knowledge, (4) engage learners' more fully, more meaningfully, and more responsibly with their communities, and (5) explicitly aim to achieve social justice locally and globally. This may be a lot to ask of mathematics educators, but successful advocacy for positive social change requires also organizing and implementing revised structures and approaches in mathematics curriculum and instruction.

Table 1 Mathematical literacy, critical literacy, and community literacy

Mathematical literacy	*Mathematical literacy* suggests all students should be problem solvers who can communicate and reason mathematically; students should learn to value mathematics and have confidence in their ability to do mathematics. Instruction promoting mathematical literacy provides learners with cooperative opportunities for exploration, for problem solving and problem posing, and for using and justifying multiple solution methods in a supportive community of learners (cf., Becker 1995; Jacobs and Becker 1997; NCTM 1989, 2000)
Critical literacy	*Critical literacy* suggests students should learn to question "power relations, discourses, and identities in a world not yet finished, just, or humane. . . . [Critical literacy] connects the political and the personal, the public and the private, the global and the local, the economic and the pedagogical, for rethinking our lives and for promoting justice in place of inequity" (Shor 1999)
	Critical mathematical literacy concerns have to do with both mathematics research and practice, and include concerns for equity and social justice (Skovsmose 2004). Skovsmose suggested mathematics education can "contribute to the creation of a critical citizenship and support democratic ideals" (p. 1)
Community literacy	*Community literacy* engages students in the complex of social relations and actions to making and communicating meaning around issues of common concern throughout the community (Bishop and Bruce 2001). Premises include: • Individuals have and produce knowledge about their communities, including mathematical knowledge (e.g., Lave 1988; Moll and González 2004). This knowledge is integral to learning and must be valued and included in instruction • Teachers should incorporate culturally relevant curriculum to build on students' prior knowledge and experiences (e.g., Ladson-Billings 1995). "The goal of multicultural education is to teach students to know, to care, and to act to promote democracy in the public interest" (Banks 2006, p. 145) • Community service allows young people to deepen and demonstrate their learning while also becoming more civic minded (D. Hart et al. 2007; National Commission on Service Learning 2002)

Gutstein (2006) proposed building mathematics curriculum with integrated community knowledge, critical knowledge, and classical knowledge. MEPI's descriptions of literacy forms were informed by these classifications.

In making use of these overlapping ideas and reconstructing mathematics by starting from education's broader objectives and purposes to produce an educated citizenship, the need for mathematical literacy, critical literacy, and community literacy becomes "common sense." These forms of literacy overlap substantively. For example, Steen's (1997) description of quantitative literacy (including reading and reasoning, writing and calculating, problem solving and technology, practices and knowledge, and procedures and contexts), and his description of the economic and social consequences of innumeracy, contains certain elements of all three forms of literacy. I only distinguish these literacies to help clarify the aims of a mathematics education established to serve the public interest. Following justification of emphases on each of mathematical literacy, critical literacy, and community literacy, I describe how I view this combination as a useful merger of feminist and social justice perspectives.

5.2 Why Mathematical Literacy?

Regarding student learning, research has yielded largely positive support for reforms incorporating connected mathematics teaching and relatedly, NCTM *Standards*-based (1989, 2000) reforms. For example, evidence exists that connected teaching approaches can improve both success and attitudes in mathematics among young women (Becker 1996; Buerk 1996; Morrow 1996). Looking across genders, in an extensive, 3-year comparative study of two schools in England, Boaler (1998) suggested that students who receive project-based instruction learn more, and different mathematics than students receiving traditional skills-based instruction. Relatively consistent evidence also exists that students using reform-based curricula perform equally well on tests of mathematical skills and procedures as comparison students using traditional curricula, and perform better on tests involving mathematical concepts and problem solving (Schoenfeld 2002; Senk and Thompson 2003). Schoenfeld further explained, "Reform appears to work when it is implemented as part of a coherent systemic effort in which curriculum, assessment, and professional development are aligned. Not only do many more students do well, but the racial performance gap diminishes substantially" (p. 17). Also, both male students and female students in reform-based school programs in the U.S. outperformed their counterparts in traditional programs; and for female students, all performance differences by program were statistically significant (Riordan and Noyce 2001).

All students can learn, and must be supported to learn, challenging mathematics. Bob Moses, activist and founder of the *Algebra Project*, further argued mathematical literacy to be a civil right (Moses and Cobb 2001). Moses and Cobb argued mathematics education's role in the ongoing struggle for citizenship and equality for the poor and for people of color. They suggested as a floor for all middle school students that they be ready for the college preparatory sequence in high school, and for all high school students, that they be ready to engage in college curricula in mathematics and science.

Though many different conceptualizations of mathematics exist, including the one promoted in this paper, regardless of the definition used, access to challenging mathematics and emphases on problem solving are indeed civil rights. It is essential that all students develop mathematical literacy. In the U.S., the Bureau of Labor Statistics (BLS) projected differential growth of the labor force from 2002 to 2012, with much of the difference attributable to strong growth in mathematics and computer-science related occupations—occupations where women, African Americans, Hispanics, and other populations remain underrepresented (BLS 2004; NSF 2006). Outside of the workplace, the need for a strong understanding of mathematics is equally important. For example, Steen (1997) argued that in today's society, a strong tendency exists to reduce complex information to numbers, with these numbers also helping to shape public policy. He suggested citizens lacking strong quantitative reasoning skills are made increasingly vulnerable by the quantification of public policy issues.

5.3 Why Critical Literacy?

Goals to support equity in mathematics education are very important. Recommendations for how to achieve equity goals almost always include requirements for setting high expectations and providing strong support for all students (e.g., Moses and Cobb 2001; NCTM 2000). In the U.S., despite many strengths, reform documents such as the NCTM *Standards* (1989, 2000) do not go far enough. Gutstein (2006) indicated the *Standards* embody a relatively narrow perspective on equity, discussing equity in terms of opportunity to learn, but not critiquing societal inequities behind the lack of those opportunities for many segments of the population both in the U.S. and abroad. Apple (1992) similarly explained:

> One searches in vain among the specifics of what teachers should know for a substantive sense of social criticism and for a more detailed understanding of the complex and contradictory roles that mathematical knowledge may play in an unequal society. (p. 425)

Based on my dissertation research in one elementary teacher education program in the U.S., I argued that *Standards*-based teaching philosophies sometimes have limited, place-specific relevance in schools (Spielman 2006). Specifically, I argued the limited relevance unacceptably tended to favor middle-class White children and to marginalize urban or diverse schools and classrooms, or schools having more limited resources, as viable places to engage in teacher education program-recommended practices for good teaching.

A critical mathematical literacy is needed to help students—also citizens—to clarify issues, to understand the structure of society, and to justify or refute opinions (cf., Frankenstein 1989). Critical mathematical literacy increases learners' capacity to understand and also challenge oppressive social structures and power relations that perpetuate over time and across the globe. Paolo Freire's (1970/2004) work rejecting a class-based society and multiple forms of oppression provides guidance to views on critical literacy. Freire advocated problem-posing education, suggesting:

> In problem-posing education, people develop their power to perceive critically *the way they exist* in the world *with which* and *in which* they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation. (p. 83)

In a world where educational inequities and other inequities exist and persist, the treatment of school mathematics as abstract, as independent of students' lived experiences, and as independent of moral and social obligations is short-sighted. We can do better.

In recent years, an increasing number of mathematics educators have begun to ground mathematical investigations in meaningful personal and social contexts. A small group of teachers and researchers, primarily in the U.S., have begun to document students' experiences and learning from this process, as well as their own experiences and learning. Turner and Strawhun (2005) described New York City middle school students' experiences with mathematically investigating overcrowding at their school, concluding, "Not only did opportunities to engage in responsive action support students' sense of themselves as people who can and do make a difference, but using mathematics as a tool to support their actions challenged students' view of the discipline" (p. 86).

Any educator seeking equity and social justice must consider how mathematics is not only a tool to produce literate citizens who understand the discipline and its meanings and applications in sociocultural contexts, but also a powerful tool to identify and rectify injustices across the globe. As Gutstein and Peterson (2005) suggest, "Math has the power to help us understand and potentially change the world" (p. 5). Teaching in a middle school classroom in a diverse Chicago school, Gutstein's class included mathematical studies of the distribution of the world's wealth, possible racism in housing data and mortgage loans, and random drug testing (pp. 117–120). Based on his research, Gutstein (2007) suggested, "Students learned mathematics and began to develop sociopolitical awareness and see themselves as possible actors in society through using mathematics to understand social injustices" (p. 420).

Students must experience opportunities to be part of the change needed in this world by experiencing first-hand the many ways that mathematical knowledge makes us more informed, and more powerful, citizens. Particularly given disparities in educational and social opportunities and conditions across gender, race/ethnicity, and social class, an emphasis on critical literacy in the mathematics classroom is sorely needed. Examinations of how mathematical applications can be deliberately and explicitly used to challenge gender inequities such as those identified by the WEF (Lopez-Claros and Zahidi 2006), among other local, national, and global inequities, are likewise sorely needed.

5.4 Why Community Literacy?

People have and produce valuable knowledge about their communities and their lives. Studies on everyday cognition, in-school and out-of-school mathematics, and ethnomathematics are among those examining connections, and sometimes conflicts, between the school world and everyday and cultural practices (e.g., Civil 2002; D'Ambrosio 2006; Lave 1988; Nunes et al. 1993). A number of educators have developed teaching innovations that build on children's and their families' backgrounds and experiences. For example, Civil (2007) describes how in the Funds of Knowledge for Teaching project (González 1995; Moll 1992; Moll et al. 1992), efforts are made to build on cultural aspects of students' communities and to implement such innovations with an eye on the mathematics. A basic conjecture is that when educators view all learners as creators of knowledge and tap into their personal and community "funds of knowledge," this helps learners to produce important connections between school and non-school aspects of their lives (Moll and González 2004). Currently, mathematics curriculum too often has little personal or cultural relevance to children's lives outside of school. Gellert et al. (2001) explained the detrimental impact this can have:

> The culturally alienating effect of mathematics education in school is extremely destructive in nonindustrialized countries that have imported mathematics and science curricula.... People in developing countries may adopt, uncritically, Western thinking in mathematics

> and science and thereby abandon some of their cultural identity, or they may come to regard themselves as lacking in mathematical ability. (p. 63)

The need and transformative potential of a mathematics curriculum that connects with children's lived experiences and draws upon their existing personal and community-based knowledge and cultural practices has begun to be documented for its significance. In Lim's (2004) study of girls' experiences in learning school mathematics, the authoritative and competitive culture of the mathematics classroom was found to be a primary source of pervasive anxiety or self-alienation among participants. Lim suggested the teaching authority in mathematics classrooms rarely listens to or respects the voices of learners themselves; she offered that this classroom structure can threaten girls' feelings of self-worth and can undetermine their rights as individuals and their freedom to learn. Ladson-Billings (1997) argued the existence of a correspondence between the nature of school mathematics teaching and middle class norms. She explained that given how middle class culture demands "efficiency, consensus, abstraction, and rationality," the traditional teaching of mathematics with emphasis on "repetition; drill; convergent, right-answer thinking; and predictability" (p. 669) may be most compatible with experiences and understandings of one segment of society—most notably, White middle-class male students. Ladson-Billings suggested that different forms of cultural expression are neither reinforced nor represented in school mathematics. This must change.

Service learning in mathematics education may also be important. The National Commission on Service-Learning defined service-learning as "a teaching method that combines meaningful service to the community with curriculum-based learning" (2002, p. 3) and described the inextricable linkage between individuals' well being and the well being of their local, national, and worldwide communities. In a study of community service among high school students, using the National Educational Longitudinal Study database, both voluntary *and* school-required community service were strong predictors of adult voting and volunteering (D. Hart et al. 2007). Another study compared undergraduate preservice teachers participating in a literacy tutoring service-learning experience with preservice teachers engaged in self-selected and independently directed tutoring sessions. Service-learning was found to positively influence student academic achievement (S. Hart and King 2007). Hadlock's (2005) edited text further illustrated numerous ways that mathematics students and communities have benefited from service learning.

At Salome Ureña Middle Academies, situated in a low-income, working-class neighborhood of New York City, and with a primary population of first-or second-generation immigrants from the Dominican Republic, sixth-grade students learned mathematics by teaching 4- and 5-year olds and planning for their needs (Clinkscales and Zaslavsky 1997). This approach was based on a view that community service empowers students to be productive members of their community. Clinkscales and Zaslavsky explained that middle school students must be actively engaged to build a knowledge base, and that they must understand how academic experiences affect the quality of daily life. They reported that the sixth-graders developed confidence in presenting their ideas to the public, used mathematical terms

with increasing ease, and came to understand the connections among mathematics, the humanities, and the real world. Further, students gained experiences working with different age groups and with people in the community of diverse racial/ethnic backgrounds.

5.5 *Unions and Intersections of Feminist and Social Justice Literature*

In this paper, I have described many specific studies in feminist and social justice literature; still needed is a summary of how the proposal for integrated literacies represents the union and intersection of these knowledge bases. To begin, feminist recommendations for content and pedagogical change supporting connected teaching excel at promoting a mathematical literacy likely to support the learning of all students—female and male alike. Breaking from long-standing traditions in mathematics education, feminist connected teaching pedagogies stress student engagement, opportunities for firsthand experience, teacher/student dialogue, and a supportive learning environment (Becker and Jacobs 2001). These types of goals appropriately alter the confines of mathematics as a discipline. Another great strength of current feminist literature in mathematics education is that it stresses the significant role of shared experiences and cultural environments in shaping how we come to know things. This emphasis promotes certain components of community literacy, as the term is used in this paper.

Under-examined in feminist literature and in international mathematics education literature on the whole are critical literacy approaches to mathematics curriculum and instruction (Keitel 1998; Valero 2001). Explicit attempts in mathematics education curriculum to analyze issues such as poverty, or racism, or gender injustices, or capitalism and the global economy are sparse. Additional texts and resources such as *Relearning Mathematics* (Frankenstein 1989) and *Rethinking Mathematics* (Gutstein and Peterson 2005) are sorely needed, as is related research on the effectiveness of these materials and related instructional approaches. Although important, it is not enough for a broader audience of learners simply to learn mathematics better; we must also alter the global balance of power and resources to achieve lasting improvements in individuals' social, economic, political, and educational conditions worldwide. We must achieve a critical literacy, including a critical mathematical literacy, to actualize this goal.

Social justice literature comes in various forms that tend toward advocating one of either critical literacy or community literacy. Forms more supportive of critical literacy and citizen activism are exceptional at reframing mathematics in applications with transformative potential to understand and change society as we know it. A weakness of related literature is that it largely fails to temper its sometimes argumentative, or by some standards radical, recommendations with the personal and interpersonal feminist or multicultural recommendations that can help demonstrate the common-sense nature of the new version of mathematics being advanced.

Forms of social justice literature more supportive of community literacy demonstrate the significance of individuals' and communities' funds of knowledge in shaping all of what we experience. These forms are interconnected with and help to further situate connected teaching approaches in sociocultural contexts and democratic terms. Both forms overall are supportive of approaches to achieving mathematical literacy as advocated by feminist and NCTM *Standards*-based (1989, 2000) perspectives, though such approaches in social justice literature are typically couched within social justice applications rather than described for their possible inherent advantages. Neither feminist nor social justice literature tends to address possible advantages of service learning in mathematics to help achieve community literacy.

In describing unions and intersections, I aimed not to express all the nuances of various bodies of literature, but simply to help reveal the fruitful potential to integrate wide-ranging perspectives. As previously noted, authors such as Goodell and Parker (2001) and Gutstein (2006) have made similar recommendations. These recommendations help construct a narrative for thinking about for mathematics education in the public interest. However, the narrative is thus far incomplete.

Considerations for how to best implement reform are likely at least as important as the nature of the reforms themselves. For example, among other constraints, high stakes testing environments can and do undermine reform efforts, defining the framework of what is important in schools by controlling what is tested. It is advantageous for change to take shape through grassroots efforts that enlist support and involvement from individuals and communities. For example, the largely successful Algebra Project employs experiential strategies, ongoing teacher education, and grassroots community leadership to increase student achievement in math and prepare students to succeed in college-prep mathematics and science courses at the high school level. As Boaler (1998) described, even successful reform-based systems can be dismantled if they are not well understood or supported by parents. It will remain a challenge for future educators and community leaders to consider how to best organize and support grassroots efforts of the magnitude required to effect real change.

6 Summary

To promote gender, racial/ethnic, social class, and global equity, mathematics education needs fundamental change. However, the mathematics education community will be unable to produce the much-needed change by maintaining current structures and assumptions. Many mathematics educators and researchers have already set the stage and made the case for transformative, sustainable change. A space is produced for change in mathematics education, and emphases on multiple forms of literacies are easily legitimized, when we reconstruct mathematics through a lens of producing an educated and capable citizenship and when we come to understand the relevance of mathematics as a tool to learn about and even to remedy local, national, and global injustice—both gender related and otherwise. Together, we can reconstruct common sense in mathematics education by tearing down tired disciplinary boundaries and building up a new mathematics education in the public interest that can inspire hope and change.

References

Apple, M. W. (1992). Do the *Standards* go far enough? Power, policy, and practice in mathematics education. *Journal for Research in Mathematics Education*, *23*(5), 412–431.

Banks, J. A. (2006). Democracy, diversity, and social justice: Educating citizens for the public interest in a global age. In G. Ladson-Billings & W. F. Tate (Eds.), *Education research in the public interest: Social justice, action, and policy* (pp. 141–157). New York: Teachers College Press.

Baxter Magolda, M. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco: Jossey-Bass.

Becker, J. R. (1995). Women's ways of knowing in mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 163–174). London: Falmer Press.

Becker, J. R. (1996). Research on gender and mathematics: One feminist perspective. *Focus on Learning Problems in Mathematics*, *18*(1, 2, & 3), 19–25.

Becker, J. R., & Jacobs, J. E. (2001). Introduction. In W. G. Secada, J. E. Jacobs, J. R. Becker & G. F. Gilmer (Eds.), *Changing the faces of mathematics: Perspectives on gender* (pp. 1–7). Reston: NCTM.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986/1997). *Women's ways of knowing: The development of self, voice, and mind* (2nd ed.). New York: Basic Books.

Bishop, A. P., & Bruce, B. C. (2001). *Fostering community literacy*. International Conference on Researching Literacy. Gevirtz Graduate School of Education, University of California Santa Barbara, Santa Barbara, CA, USA.

Bishop, A. J., & Forgasz, H. J. (2007). Issues in access and equity in mathematics education. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 1145–1167). Charlotte: Information Age Publishing.

Boaler, J. (1998). *Experiencing school mathematics*. Philadelphia: Open University Press.

Boaler, J., & Staples, M. (2005). Transforming students' lives through an equitable mathematics approach: The case of Railside School. Retrieved June 20, 2005, from http://www.stanford.edu/~joboaler/pubs.html.

Brew, C. (2001). Women, mathematics, and epistemology: An integrated framework. *International Journal of Inclusive Education*, *5*(1), 15–32.

Buerk, D. (1996). Our open ears can open minds: Listening to women's metaphors for mathematics. *Focus on Learning Problems in Mathematics*, *18*(1, 2, & 3), 26–31.

Bureau of Labor Statistics (2004). *National industry-occupation employment projections 2002–2012*. Washington: U.S. Department of Labor.

Campbell, P. B. (1995). Redefining the "girl problem in mathematics". In W. G. Secada, E. Fennema & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 225–241). New York: Cambridge University Press.

Civil, M. (2002). Culture and mathematics: A community approach. *Journal of Intercultural Studies*, *23*(2), 133–148.

Civil, M. (2007). Building on community knowledge: An avenue to equity in mathematics education. In N. Nasir & P. Cobb (Eds.), *Improving access to mathematics: Diversity and equity in the classroom* (pp. 105–117). New York: Teachers College Press.

Clinchy, B. (1989). On critical thinking and connected knowing. *Liberal Education*, *75*(5), 14–19.

Clinkscales, G., & Zaslavsky, C. (1997). Integrating mathematics with community service. In J. Trentacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom: The gift of diversity, 1997 yearbook* (pp. 107–114). Reston: National Council of Teachers of Mathematics.

Damarin, S. K. (1995). Gender and mathematics from a feminist standpoint. In W. G. Secada, E. Fennema & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 242–257). New York: Cambridge University Press.

D'Ambrosio, U. (2006). The program Ethnomathematics: A theoretical basis of the dynamics of intra-cultural encounters. *Journal of Mathematics and Culture, 1*(1). Retrieved November 12, 2007, from http://www.ccd.rpi.edu/Eglash/nasgem/jmc/issue_1_1.html.

Fennema, E. (2000). *Gender and mathematics: What is known and what do I wish was known?* Paper presented at the 5th Annual Forum of the National Institute for Science Education, Detroit, MI, USA.

Forgasz, H., & Leder, G. (2001). "A + for girls, B for boys": Changing perspectives on gender equity and mathematics. In B. Atweh, H. Forgasz & B. Nebres (Eds.), *Sociocultural research on mathematics education* (pp. 347–366). Mahwah: Erlbaum.

Frankenstein, M. (1989). *Relearning mathematics: A different third R—radical maths*. London: Free Association Books.

Freire, P. (1970/2004). *Pedagogy of the oppressed* (30th Anniversary ed.). New York: Continuum.

Galotti, K. M., Clinchy, B. M., Ainsworth, K. H., Lavin, B., & Mansfield, A. F. (1999). A new way of assessing ways of knowing: The attitudes toward thinking and learning survey (ATTLS). *Sex Roles*, *40*(9/10), 745–766.

Galotti, K. M., Drebus, D. W., & Reimer, R. L. (2001). Ways of knowing as learning styles: Learning MAGIC with a partner. *Sex Roles*, *44*(7/8), 419–436.

Gellert, U., Jablonka, E., & Keitel, C. (2001). Mathematical literacy and common sense in mathematics education. In B. Atweh, H. Forgasz & B. Nebres (Eds.), *Sociocultural research on mathematics education* (pp. 57–73). Mahwah: Erlbaum.

Gilligan, C. (1982). *In a different voice: Psychology theory and women's development*. Cambridge: Harvard University Press.

González, N. (1995). Educational innovation: Learning from households. *Practicing Anthropology*, *17*(3), 3–24.

Goodell, J. E., & Parker, L. H. (2001). Creating a connected, equitable mathematics classroom: Facilitating gender equity. In B. Atweh, H. Forgasz & B. Nebres (Eds.), *Sociocultural research on mathematics education* (pp. 411–431). Mahwah: Erlbaum.

Goodlad, J. (2004). Fulfilling the public purpose of schooling. *School Administrator*, *61*(5), 14–17. Retrieved November 17, 2007, from http://findarticles.com/p/articles/mi_m0JSD/is_5_61/ai_n6046265.

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. New York: Routledge.

Gutstein, E. (2007). "And that's just how it starts": Teaching mathematics and developing student agency. *Teachers College Record*, *109*(2), 420–448.

Gutstein, E., & Peterson, B. (Eds.) (2005). *Rethinking mathematics: Teaching social justice by the numbers*. Milwaukee: Rethinking Schools.

Hadlock, C. R. (Ed.) (2005). *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences*. Washington: The Mathematical Association of America.

Hart, D., Donnelly, T. M., Youniss, J., & Atkins, R. (2007). High school community service as a predictor of adult voting and volunteering. *American Educational Research Journal*, *44*(1), 197–219.

Hart, S. M., & King, J. R. (2007). Service learning and literacy tutoring: Academic impact on pre-service teachers. *Teaching and Teacher Education*, *23*(4), 323–338.

Jacobs, J. E. (1994). Feminist pedagogy and mathematics. *ZDM*, *26*(1), 12–17.

Jacobs, J. E., & Becker, J. R. (1997). Creating a gender-equitable multicultural classroom using feminist pedagogy. In J. Trentacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom: The gift of diversity, 1997 yearbook* (pp. 107–114). Reston: National Council of Teachers of Mathematics.

Kaiser, G., & Rogers, P. (1995). Introduction: Equity in mathematics education. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 1–10). New York: Routledge Falmer.

Keitel, C. (Ed.). (1998). *Social justice and mathematics education: Gender, class, ethnicity and the politics of schooling*. Berlin: Freie Universität.

Knight, K. M., Elfenbein, M. H., & Messina, J. A. (1995). A preliminary scale to measure connected and separate knowing: The knowing styles inventory. *Sex Roles*, *33*(7/8), 499–513.

Ladson-Billings, G. (1997). It doesn't add up: African American students' mathematics achievement. *Journal for Research in Mathematics Education*, *28*, 697–708.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, *32*(3), 465–491.

Lamb, S. (1996). Gender differences in mathematics participation in Australian schools: Some relationships with social class and school policy. *British Educational Research Journal*, *22*(2), 223–240.

Lamb, S. (1997). Gender differences in mathematics participation. *Educational Studies*, *23*(1), 105–126.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. New York: Cambridge University Press.

Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 597–622). New York: Macmillan.

Leder, G. C., Forgasz, H. J., & Solar, C. (1996). Research and intervention programs in mathematics education: A gendered issue. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick & C. Laborde (Eds.), *International handbook of mathematics education* (pp. 945–985). Dordrecht: Kluwer.

Lim, J. H. (2004). Girls' experiences in learning school mathematics. *Focus on Learning Problems in Mathematics*, *26*(1), 43–60.

Lingard, B., Martino, W., Mills, M., & Bahr, M. (2002). *Addressing the educational needs of boys*. Research report submitted to the Australian Government Commonwealth Department of Education, Science, and Training, Canberra City, Australia. Retrieved November 2, 2007, from http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/addressing_educational_needs_of_boys.htm.

Lopez-Claros, A., & Zahidi, S. (2006). *Women's empowerment: Measuring the global gender gap*. Geneva, Switzerland: World Economic Forum.

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

Moll, L. C. (1992). Bilingual classrooms and community analysis: Some recent trends. *Educational Researcher*, *21*(2), 20–24.

Moll, L., Amanti, C., Neff, D., & González, N. (1992). Funds of knowledge for teaching: A qualitative approach to developing strategic connections between homes and classrooms. *Theory into Practice*, *31*(2), 132–141.

Moll, L. C., & González, N. (2004). A funds-of-knowledge approach to multicultural education. In J. A. Banks & C. A. Banks (Eds.), *Handbook of research on multicultural education* (2nd ed., pp. 699–715). San Francisco: Jossey Bass.

Morrow, C. (1996). Women and mathematics: Avenues of connection. *Focus on Learning Problems in Mathematics*, *18*(1, 2, & 3), 4–18.

Moses, R. P., & Cobb, C. E. (2001). *Radical equations: Civil rights from Mississippi to the algebra project*. Boston: Beacon Press.

National Center for Education Statistics (2007). *Status and trends in the education of racial and ethnic minorities*. NCES 2007–039: U.S. Department of Education. Retrieved November 2, 2007, from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2007039.

National Commission on Service-Learning (2002). *Learning in deed: The power of service-learning for American schools*. Battle Creek: W. K. Kellogg Foundation.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics*. Reston: Author.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston: Author.

National Science Foundation (2006). *Science and engineering indicators*. Arlington: Author. Retrieved October 12, 2007, from http://www.nsf.gov/statistics/seind06/.

Nunes, T., Schliemann, A., & Carraher, D. (1993). *Street mathematics and school mathematics*. New York: Cambridge University Press.

Oakes, J., Joseph, R., & Muir, K. (2004). Access and achievement in mathematics and science. In J. A. Banks & C. A. M. Banks (Eds.), *Handbook of research on multicultural education* (2nd ed., pp. 69–90). New York: Jossey-Bass.

Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards-based mathematics curricula on student achievement in Massachusetts. *Journal for Research in Mathematics Education*, *32*(4), 368–398.

Rogers, P., & Kaiser, G. (Eds.) (1995). *Equity in mathematics education: Influences of feminism and culture*. New York: Routledge Falmer.

Schoenfeld, A. H. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher*, *31*(1), 13–25.

Secada, W. G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 623–660). New York: Macmillan.

Senk, S. L., & Thompson, D. R. (Eds.) (2003). *Standards-based school mathematics curricula: What are they? What do students learn?* Mahwah: Erlbaum.

Shor, I. (1999). What is critical literacy? *Journal of Pedagogy, Pluralism, and Practice, 4*(1). Retrieved November 12, 2007, from http://www.lesley.edu/journals/jppp/4/shor.html.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417–453.

Skovsmose, O. (2004). Critical mathematics education for the future. Unpublished manuscript, Aalborg University. Retrieved April 14, 2007, from http://www.learning.aau.dk/en/department/staff/ole_skovsmose.htm.

Smith, D. E. (1974). Women's perspective as a radical critique of sociology. *Sociological Inquiry*, *44*(1), 7–13.

Spielman, L. J. (2006). *Preservice teachers' characterizations of the relationships between teacher education program components: Program meanings and relevance and socio-political school geographies*. Blacksburg: Virginia Polytechnic Institute and State University, Unpublished doctoral dissertation.

Sriraman, B. (Ed.). (2007). *International perspectives on social justice in mathematics education*. Charlotte: Information Age Publishing.

Steen, L. A. (Ed.). (1997). *Why numbers count: Quantitative literacy for tomorrow's America*. New York: College Entrance Examination Board.

Stinson, D. W. (2004). Mathematics as 'gate keeper'(?): Three theoretical perspectives that aim toward empowering all children with a key to the gate. *The Mathematics Educator*, *14*(1), 8–18.

Turner, E. E., & Strawhun, B. T. F. (2005). With math, it's like you have more defense. In E. Gutstein & B. Peterson (Eds.), *Rethinking mathematics: Teaching social justice by the numbers* (pp. 81–87). Milwaukee: Rethinking Schools.

Valero, P. (2001). Review of the book social justice and mathematics education: Gender, class, ethnicity and the politics of schooling. *ZDM*, *33*(6), 187–191.

Weiner, G., Arnot, M., & David, M. (1997). Is the future female? Female success, male disadvantage, and changing gender patterns in education. In A. H. Halsey, P. Brown, H. Lauder & A. Stuart Wells (Eds.), *Education, economy, culture, and society*. Oxford: Oxford University Press.

Wyner, J. S., Bridgeland, J. M., & Diiulio, J. J. (2007). *Achievement trap: How America is failing millions of high-achieving students from lower-income families*. Lansdowne: Jack Kent Cooke Foundation.