

**Recommendations for Teachers and Researchers:
Supporting Female Learners of Secondary Mathematics:
A Review of Literature**

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Abstract

This literature review is intended to collect recommendations for practices in secondary education that promote gender equity in math and science. A brief overview of the history of gender and gender equity in mathematics, science and related fields will be provided, along with an examination of current aspects of gender equity in science and math that remain to be addressed. Recommendations for practices of secondary mathematics teachers that promote gender equity will be given with reference to practice theory and situated learning.

Keywords: *mathematics education, gender equity, gender in education, practice theory, situated learning*

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Chapter 1

Introduction

Much of our modern world relies on mathematics and science. Mathematicians use incredibly large prime factors to create encryptions for online communications that we rely on every day. Electrical engineers design the circuits that power the computers making those online communications. Microbiologists and chemists create medicines and products that help us live longer and more productive lives. Civil engineers provide us with infrastructure for transportation and services. Mathematics and science are two of the key tools that the workforce uses to continually innovate in our increasingly technological world. In addition to the benefits that we gain from the fruits of scientists' and mathematicians' labors, we also gain a strong economy (Bilimoria & Liang, 2012). No one can deny the importance of math and science in our daily lives, and that math and science fluency should be goals of the educational system.

However, innovation does not stem only from the tools used; rather, it stems from a combination of the tools and the people who use them. Each engineer, each mathematician, each developer will use their unique insight born of their life experience to wield their mathematic and scientific tools to solve problems in different ways, and to serve different audiences with disparate needs. In this context, diversity becomes an intellectual asset to the economy. By this logic, equal access to careers in the fields of science, technology, engineering, and math (STEM) should also be a goal of education, and of policy and practice in those fields. Yet, throughout the twentieth century (and

continuing into the twenty-first), there have been consistently low rates of women studying and working in STEM fields. While the rates have fluctuated within individual STEM fields, and while the locations of greatest disparity in participation rates in the STEM pipeline (the path from student to a career in STEM) have changed over the years, there remains a trend of low participation of women in STEM (Eisenhart & Finkel, 1998), as we will see in the discussion of the history of gender equity in science and math that follows.

A discussion of the history of narratives on gender inequity in STEM disciplines serves to inform the current recommendations that are made for teachers of female learners of secondary mathematics. While the aforementioned gap has been ever-present, the ways that social scientists and theorists have framed the phenomenon has changed over the years, culminating with the ideas of social construction and practice theory. In response the recommended courses of action have changed to reflect the day's understanding of gender inequity.

Despite the changes in gender equity issues over the last fifty years, secondary school is still identified as an area where mathematics students, females in particular, are likely to disengage with mathematics. This paper's focus is to examine ways that secondary educators can promote gender equity in mathematics. However, some critiques of and approaches to teaching other STEM disciplines will be discussed, as many of the issues that are brought to bear against these disciplines also apply to mathematics.

Furthermore, inequity is systemic whether it is based on gender, race, class, or any other characteristic. It is a product of the society as a whole rather than a product of the marginalized group. To combat the systemic nature of inequity, other groups must be included in efforts to promote marginalized groups. Accordingly, the strategies discussed in this paper are not limited to those that target female learners of mathematics to the exclusion of other populations in the secondary classroom.

The organization of this paper is shown in Figure 1. We move from a discussion of math and science in general, to a discussion of research done in mathematics education, and finally into practices of the secondary mathematics classroom. The rationale for beginning with a discussion of the history of (gender in) math and science at large is so that the discussions of research and practice may be made with attention to the trends in those fields. Similarly, recommendations for practice in the classroom are founded upon the mathematics education research discussed in the second portion of the paper. The paper concludes with implications for further research in gender equity and mathematics education.

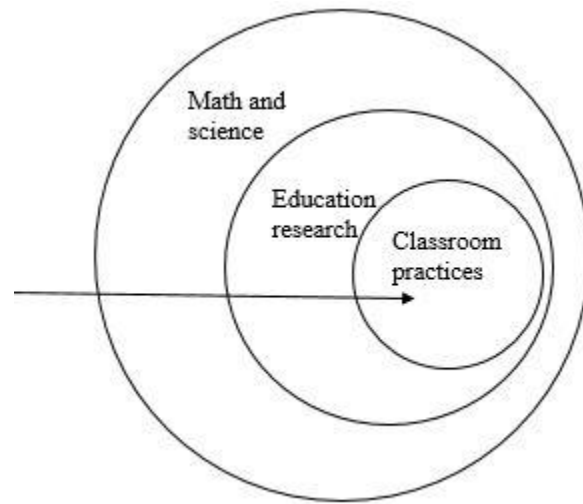


Figure 1. Organization of topics in this paper

Chapter 2

A Brief History of Gender in Math and Science

Let us open our discussion of the history of gender inequity in math and science in the early years of the twentieth century. It is no secret that the first part of the twentieth century saw society in general governed by restrictive gender roles where men were expected to be the breadwinners and women were expected to stay home and care for the children. Schiebinger (1999) references the Scientific Revolution of the seventeenth and eighteenth centuries for establishing this pattern in the scientific community as well:

“Scientific institutions – universities, academies, and industries – were structured upon the assumption that scientists would be men with wives at home to care for them and their families. The smooth working of the professional world in many ways depended on the unacknowledged contributions of wives who fed, clothed, and cared for their professional husbands, providing well-run homes and ready support to further the men’s careers (Schiebinger, 1999, p. 29).”

This wasn’t always a practical expectation given a family’s economic circumstances, but it was the ideal middle-class model to which families were expected to aspire.

While women in science and math were not unheard of during these years, they were rare and often overlooked or only grudgingly recognized by the institutions that they were a part of. To illustrate, consider two of the most eminent women in science and math in the early part of the twentieth century, Marie Curie and Emmy Noether. Marie Curie, despite winning two Nobel prizes (one for Physics in 1903, of which she

received a quarter, the remaining parts being allocated to her husband [one quarter] and to Henri Becquerel [half]; and one for Chemistry in 1911) was denied membership to the French Académie des Sciences in 1911 (Skwarzec, 2011). Her ascension to a professorship at the Sorbonne was only made possible through the untimely death of her husband; the university opted to give Marie the position that they had just created for her husband rather than eliminate it (Skwarzec, 2011).

Emmy Noether, a brilliant German algebraist, earned her doctorate at Erlangen in 1908 and was elected to many honorary mathematics societies. After receiving her doctorate, she had remained at Erlangen, where her father was a professor, and oversaw dissertations, but in capacity that carried no faculty position or pay (Silverberg, 2001). McLarty says, “By age 30 in 1912 she was known to and respected by most of the important mathematicians in Germany, and she was well into what anyone would have called a successful career as a mathematician, except, of course, that she had neither title nor salary. (2011, p. 102).” Noether would eventually be given a place on the faculty of Göttingen (a position traditionally closed to women) after a four-year struggle and only with the help of mathematicians and fellow faculty members Klein and Hilbert. Until her appointment, she was forced to lecture under Hilbert’s name (Silverberg, 2001).

These early forays of women into science and math follow the pattern that Schiebinger establishes of women using their family connections to male scientists and mathematicians to gain access to academic institutions and prestige. As well, these women were usually cast as helpers and aides to the ‘real’ scientists and mathematicians. During the 1920s and 30s, more women made their way into mathematics and the

sciences as institutions of learning gradually relaxed their prohibitions against women as students and faculty members, though rates of women as faculty remained a tiny fraction of those that attained mathematics or science degrees (Schiebinger, 1999). This changed briefly during the forties when many men were drawn away to war. With a large portion of the leading scientific and mathematical minds of the day working on projects for the war effort, women were allowed to step in and fill almost half of teaching positions at academic institutions (Schiebinger, 1999). However, when the war ended, the women were pushed out of those positions and the men reinstated. Low rates of female participation in math and science continued on into the 1960s and 1970s, when the women's liberation movement and the federal Equal Employment Opportunity Act of 1972 sought to explicitly promote gender equity in the professional world (Schiebinger, 1999).

It is worth noting that this pattern of low participation by women in math and science did not hold across national borders at this point. Eisenhart (1998) says that the Soviet Union possessed a high number of female engineers during the Cold War, and Americans used this as evidence that women could largely be successful as scientists; however, at the same time, they pointed out that Soviet women scientists were ugly and unfeminine by Western standards. They also insinuated that "women's preparation in science and engineering should be used only in case of dire national emergency (Eisenhart & Finkel, 1998, p. 32)."

Thus, a decision was made to keep women out of science and math despite evidence that they could succeed in order to allow Americans to continue to conform to

our manufactured culture. Women were cast as “delicate, emotional, unobtrusive and noncompetitive (Eisenhart & Finkel, 1998, p. 30),” while science was supposed to be “rigorous, rational, impersonal, and competitive (p. 30).” Science now was characterized in direct opposition to women; to be a woman scientist was to compromise your membership in one of those categories. Either your science was inferior because of your womanhood, or your womanhood was sacrificed at the altar of science.

Initiatives to Promote Gender Equity in Science and Math

After the Cold War and the Equal Opportunity Employment Act of 1972, recruitment efforts in science and math increased drastically (Schiebinger, 1999). The U.S. government funded programs to draw women in to math and science and to uphold the language of the EOE Act, which called for protection of applicants and employees “from discrimination... on the basis of race, color, religion, sex (including pregnancy), or national origin (EEOC, 2009).” The EOE Act also “prohibits sex discrimination in the payment of wages to women and men performing substantially equal work (EEOC, 2009),” because as we’ve seen previously, even women who are making major contributions to the field have been credited only as aides and paid far less than what their work merited.

Among the efforts made, there were several that attempted to draw attention to the fact that female learners were disengaging with mathematics at the secondary school level in particular. However, these efforts led to a common conception of female learners being fundamentally different from males in ways that accounted for their maladaptation to math and science. Boaler holds that while the initiatives in the 1970s

and 1980s served to raise awareness of trends pertaining to gender in education, they also portrayed “anxiety and underachievement as stable characteristics... of girls, rather than co-productions of people, society, and environment (2002, p. 129).” This reduction of a group of people to a set of defining personality traits or preferences is referred to as *essentialism*. Boaler argues that essentialism of girls (and boys) “has been a characteristic of many gender analyses and that these may have served to sustain, rather than eradicate, inequities in schools (2002, p. 128).”

After years of teaching strategies designed to minimize the gender gap by giving equal treatment to students of both genders, we have arrived at what is upheld as a *gender neutral discourse* of math and science (Eisenhart & Finkel, 1998). A gender neutral discourse is used to signify a set of standards that determine what is viewed as good work and success in the field, independent of the person that produced the work. However, Eisenhart and Finkel maintain that this is an illusion; the gender neutral discourse privileged the behaviors of white males in its creation of standards for success. Despite the strides that have been taken towards gender equity in math and science, women who do not adopt white male patterns of behavior are still marginalized.

Current Gender Equity Issues in Math and Science

Current manifestations of the discussion on gender inequity in math and science have eschewed the gender neutral politics that characterized earlier discussions and have instead embraced a more nuanced position on the interplay of gender, society, and the nature of science.

Gender as a Social Construction First, a distinction is to be made between gender and sex: *sex* is biological, a set of physical and chemical characteristics hardwired into the body via genetics; *gender* is a much more fluid signifier that allows a person to identify with archetypal roles in their society (or, alternately, to actively combat these roles). Here in present-day America, we are accustomed to two sexes (male, female) and two corresponding genders (men, women), though throughout our history and the world, there have been alternate configurations (Stryker, 2008). (A note: sexuality is different from gender identity/expression and for the sake of brevity will not be discussed here.) This is becoming less dichotomous, however, as we see the emergence of people who are intersex and transsexual or who identify as transgender or genderqueer into the public eye. (See the highly publicized transition of Tom Gabel of punk band Against Me! to Laura Jane Grace.) Simultaneously, we see the emergence of the idea that gender is a social construction.

Susan Stryker, a leading scholar and historian on the LGBTQI community/ies, says that “No one is born a woman or a man – rather, as the saying goes, ‘one becomes one’ through a complex process of socialization (2008, p. 11).” Gender is a performative aspect of our persons, exhibited by:

“...bodily action such as how we use our voices, cross our legs, hold our heads, wear our clothes, dance around the room, throw a ball, walk in high heels. These are things that each of us learns to do during the course of our lives by watching and mirroring others *with whom we identify*, as well as being subtly (or not so subtly) disciplined by other members of our society (particularly by our families)

when we perform the ‘wrong’ thing or perform the ‘right’ thing poorly (Stryker, p. 12; emphasis added).”

The important point of this for the purposes of gender inequity in education is that gender and sex are independent; that sex does not determine gender, but that culture and the politics of power do.

In the early days of the conversation about the place of women in academia and the work force, so-called biological differences were used to justify the marginalization of women (Fausto-Sterling, 1992). Brain structures and hormones were cited as having differential effects on cognition, making men and women suited for different types of tasks and careers, and thus differing levels of cultural and financial capital. This eventually morphed into a conversation about gender rather than sex, but the same essentialist frameworks that Boaler rails against persisted: women *are* more emotional, *women* are insecure, etc. This list of (negative) characteristics was a thing that was applied to *all* women, and was purported to be a fundamental part of their identity and personality that determined their prospects in the professional world.

With gender being instead a social construction, we get to side-step the problematic process of putting women in another metaphorical box based on their gender, and instead get to examine the society that creates these women through their lived experiences.

Practice Theory This idea of gender as a social construct falls under *practice theory*, the study of “the generation of meaning systems by people as they participate in everyday, local activities (or ‘social practices’) and on the way these meaning systems

connect people to broader patterns of social reproduction or change (Eisenhart & Finkel 1998, p. 43).” In particular, I’d like to examine the offshoot of practice theory pioneered by Lave and Wenger (1991) called situated learning that Eisenhart and Finkel use in their discussion of successful women scientists. Situated learning holds that knowledge and identity spring from the activities people participate in and how they participate in them.

In accordance with this, one constructs an identity for oneself as a mathematician or a scientist by engaging in the activities that mathematicians and scientists do. This seems fairly straightforward, right? However, this idea becomes more problematic when we remember that math and science are communities of practice that engage in collaboration and other types of peer interaction, much of which is made possible through the social networks that emerge in and between institutions. Yet the mathematic and scientific institutions are overwhelmingly male and proceed according to male social norms (Huyer and Westholm, 2007).

This has the effect of alienating women and blocking them from participating in meaningful collaborations and valuable projects, as Herzig’s 2004 qualitative investigation into female doctoral mathematics students’ working relationships with their faculty and advisors shows. Eisenhart and Finkel continue, “If women’s participation in constructive tasks, social relationships, and networks in science and engineering is blocked, which many have suggested it is, then women will not gain access to the forms of social involvement that increase their expertise (1998, p. 8).” It appears that in addition to working to promote women’s interest in STEM fields, there is work also to be

done in promoting more tolerance among the existing informal social networks that influence much of the work being pursued.

The Myth of Science as Isolated from Culture Finally, we must recognize that science is not independent of culture. Science and the philosophy of science in the mid-twentieth century took great pride in asserting itself as rational and impartial, unaffected by the cultural concerns of the day (Kourany, 2010). Yet how many times throughout history were scientific findings used to justify the oppression of various groups and preserve the status quo? There was the aforementioned case of using biological grounds to justify marginalizing women; similar tactics have been used repeatedly to oppress those of different racial backgrounds, of different sexualities, of different social classes.

Furthermore, cultural concerns determine what takes priority in science. Funding, resources, and manpower are allocated to projects and research that are deemed important by that culture; other projects are abandoned (Kournay, 2010). Dominant ways of thinking will influence the line of questioning that drives the research as well as what constitutes acceptable risks to populations during or as a result of research. In the middle of the twentieth century, the U.S. Public Health Service thought that knowingly infecting almost 400 black men with syphilis without their consent, and offering them no treatment, was an acceptable risk (Tuskagee, 1999). Today, this would never be viewed as an acceptable risk. It is also worth mentioning again that the dominant groups heavily influence what successful science looks like, or what being a successful scientist looks

like. For many years, this was behaving in ways that conformed to the prototypical white male experience (Eisenhart & Finkel, 1999).

In essence, we are not to exclude science, math, technology, or other fields from critical review because they profess to operate on a basis of ‘rational, methodical, and impartial thought’. As a product of society, they are imbued with society’s values and should be subject to the same scrutiny.

Chapter 3

Research in Mathematics Education

Now that the preceding section has laid a groundwork of understanding about the larger contexts in which mathematics education takes place, let us then turn to a discussion of some of the research that has been done on mathematics education, and its subsequent relation to gender equity in mathematics.

As discussed previously, many efforts were made in the latter half of the twentieth century to increase the number of women and other minorities who chose to pursue mathematics, both in their education and their professions. Most of these efforts used a particular line of reasoning to entice the audience: continuing to learn math opens up new curricular and career options, usually in prestigious and lucrative fields. Yet, as Denith (2008) notes in her interviews with female AP Calculus students, and as the ‘leaky pipeline’ model discussed by Huyer and Westholm (2007) suggests, this argument is not successful in *retaining* women and minorities in math. The students that Denith interviews are open about how important AP Calculus is to their chances of getting into a good college. Yes, they view math as important, but largely in the sense that it keeps them competitive, not because of the value of math or mathematical practices. Once access is granted to these realms, mathematics is abandoned. In this scenario, math becomes a means to an end – that end, of course, being power or cultural capital.

Damarin’s 2000 piece “The mathematically able as a marked category” further dissects this maxim that mathematical ability is power, and then contrasts that idea with the idea that mathematicians and the mathematically able are marked as deviant. The

struggle between these two conflicting narratives is largely responsible for the continued failure to interest minorities in the field, Damarin claims. Her research shows that within academia, mathematical ability is represented as power – not only as economic power, but also as personal power (the ability to access and understand the world). But, in the rest of our lives, we're bombarded with pop culture images of mathematicians as an 'other'.

We've all heard the words “nerd, weirdo, or geek (p. 75)” used to describe math and the people who embrace it. While there has been a trend developing over the past decade that seeks to celebrate the 'nerdy' in pop culture, the products of this still paint mathematicians (and scientists) as a class apart from normally functioning human adults, as people who are “incompetent (and even dangerous) in daily affairs (p. 78).” Consider, as examples, Syfy's series *Eureka*, where an enclave of brilliant but bumbling government scientists would have blown up the world several times over if it weren't for the relatively uneducated but 'functional' everyman sheriff; or CBS's hit *The Big Bang Theory*, whose success is largely attributable to playing the character of Sheldon (a theoretical physicist) and his hyper-logical approach to life for laughs. Damarin, quoting Nelkin (1986) says, “scientists (particularly males) are portrayed as 'socially removed, apart from, and above most normal human occupations' (p. 75).”

This phenomenon becomes particularly relevant in mathematics education, where Gattuso (1994) found that when students who didn't like math talked about their mathematics teachers, they used this model:

“Math teacher = rational = robot = non-human (p. 99).”

Somehow being a mathematical person marks you as less human than everyone else. Thus failing at mathematics makes a student ‘one of us;’ it’s touted as a humanizing experience. Damarin (2000) goes so far as to say that:

“failure in mathematics is not an occasion of embarrassment; these students (often with the support of parents, peers, and sometimes guidance counselors and other teachers) refer to the inability to do mathematics with a certain pride (p. 78).”

When I worked in a fabric shop during my undergraduate years, I frequently interacted with *educators* who laughed off their inability to calculate yardages with the cliché of “I’m just not a math person.” The idea that mathematical ability is determined by some feature of our bodies (brains, genetics, etc.), and the subsequent pride in not having that feature are deeply ingrained in our society.

How then does this stigmatization of the mathematically able relate to gender equity in mathematics? Damarin argues that, “Members of two marked categories typically find themselves at the margins of each, their membership in one category marking them as deviant within the other (p. 73).” This means that women and girls who embrace mathematics become doubly marked – as female and as mathematically able – and experience a disconnect from both of those groups as well as from the unmarked whole. But unlike other marked groups, the mathematically able don’t come together to celebrate their difference (Damarin 2000). Instead, they remain isolated from each other and lack a sense of comradery. These women set themselves apart as different by choosing math, yet most of the efforts to recruit females to mathematics are aimed at an age group where being seen as different is a major social concern and something to be

avoided. Is it any surprise that recruitment efforts based on math as power fail in the face of these conceptions of mathematicians in popular culture?

Another important development in mathematics education research as it pertains to gender equity is *women's ways of knowing* (Boaler, 2000). This refers to a set of learning and doing styles that appear to make the study of mathematics more fulfilling for women. In the interest of not falling prey to the essentialism that pervades much discussion on gender equity, I find it important to mention that Boaler's research has shown that pedagogy that embraces women's ways of knowing enriches mathematics and makes pursuing mathematics more fulfilling for both genders. While I personally would prefer not to use the term "women's ways of knowing" in the context of mathematics education because I feel that it semantically separates women learners from unmarked male learners and could be used to continue to marginalize them, I at present have no reasonable substitute.

However, I can talk about what Boaler identifies as two of the major components of women's ways of knowing: the idea of *connected knowing* as borrowed from Clinchy (1996) and Tarule (1996), and the development of *connected understanding*. She defines connected knowing as a type of knowing

"in which the individual considers her knowledge as primarily being constructed in interaction with other people (either directly, in conversation, or indirectly, through interacting with texts or other representations of others' knowledge and thinking), in a process that depends on understanding others' experiences, perspectives, and reasoning,

and incorporates this understanding into the individual's knowing and understanding (p. 174)."

Classrooms that promote a connected knowing model of mathematics are frequently discussion-based classrooms where meaning is negotiated amongst the students and teachers. Connected understanding, on the other hand, is used to refer to a deep, conceptual understanding of the mathematical content and its relation to other mathematical concepts.

The idea of connected knowing, Boaler argues, is essential to the development of a mathematically able identity. Due to the dialogical nature of the connected knowing processes, students cultivate a sense of agency in their mathematical learning. They, as individual people, are involved in the acquiring, understanding, and application of mathematics. Furthermore, as learners with agency, their identity as a mathematically able person does not develop in contrast to the type of person and learner that students often aspire to be – “creative, verbal, and humane (p. 179).” Many learners exposed to mathematics in a *received knowing* environment, where knowledge is handed down from an outside, authoritative source, view math as a procedural exercise involving no free thought, and reject it on the basis of its incompatibility with their identity as creative thinkers. Unfortunately, it seems that many students (Boaler 2002, 2000; Herzig 2004) regard higher level mathematics as precisely this cold and detached received knowing environment.

Similarly, pedagogy that makes a space for connected understanding promotes more positive attitudes towards math in students. (At the risk of being redundant – it also

means that students actually understand what they're doing and why, and thus should be a pedagogical goal in and of itself, irrespective of equity issues.) It seems that environments with connected knowing and connected understanding improve most students' attitudes towards math, but these two elements seem particularly effective in engaging female learners. In fact, the female doctoral students interviewed in Herzig's 2004 study implied that the procedural, disconnected approach used in their classes was one of the factors that made them consider leaving the program at some point (the other major factor being a perceived feeling of lack of care and mentorship from the faculty). Boaler and Greeno's 2000 study did find that some students in received knowing environments preferred mathematics precisely *because* of its lock-step procedures and lack of free thought; however, this way of doing mathematics is not reflective of the way that mathematicians or other professionals who use math in the field are required to think.

So, given our cultural perception of mathematicians as deviant and the demonstrated lack of interest in mathematics due to its perceived nature (that is, procedural and robotic), built on a societal foundation where women are particularly susceptible to these concerns, how do we promote the interest of women and other minorities in mathematics? Or, as Fennema (1998) asks, are we doing a disservice to females by pursuing the study of gender differences and inequity in mathematics education, rather than honoring women's choices to focus on other aspects of life?

Chapter 4

Recommendations for Teachers of Female Learners of Mathematics

As teachers of secondary mathematics, we need to be sensitive to the above points in our efforts to promote gender equity in mathematics, both in our classrooms and beyond.

Several recommendations for educators can be taken from the above discussions, with varying scopes.

First, make time (and a safe space) for the mathematics classroom to work on connected knowing. Specific examples include using discussion and exploration based methods to ‘build’ mathematical meaning, engaging in critiques and explications of texts, and collaborative projects. Such activities help students develop agency in their learning of mathematics and help them develop identities of mathematical ability that do not violate their aspired self-image of creative and human individuals. They are also more reflective of professional mathematical work. This more nuanced approach is also useful for promoting deep, connected understanding by encouraging students to voice mathematical insights to their peers.

Attempting to alter the ways of knowing in your classroom may seem like a daunting task, but gradual inclusion of elements that allow students to practice agency and to interact in an interpretive manner with the material and with their peers can build this environment without overwhelming either the teacher or the students. However, in considering some of the patterns that have been seen in classroom interactions (Eisenhart & Finkle 1998, Fennema 1997), such as males being called on more frequently or females being more reluctant to share abstract invented strategies for fear of lack of

clarity, it becomes apparent that there will need to be some set of ground rules and expectations for how students will interact with each other. Some students will need coaching on learning to value input from many quarters and coming in many forms, and some students will need coaching on contributing honestly – that is, including false starts and setbacks in their presentations.

Second, promote math as a creative endeavor in which mathematicians (both professionals and amateurs, like students) become emotionally invested. Humanize the experience of successful mathematicians – the frustration they felt when they followed a false lead, the joy they felt when they finally reached understanding in a new topic. Make a space in your classroom to talk about how mathematics fit into the lives of the mathematicians whose works students are learning; this could be in a professional sense (how did this work affect the career opportunities they were offered?) or in a more personal sense (how did Pascal transition from a mathematical prodigy to a Christian philosopher?). Let students know that being nervous about presenting something new is a normal feeling. Part of this can be accomplished by modeling your thought process for solving something for your students, and by acknowledging your mistakes. Welcome mathematical creativity in the classroom – unconventional solutions and connections to other areas of life should be celebrated. This humanizing element can serve to counter in small ways this pernicious pop culture portrayal of mathematicians and the mathematically able as robotic and inhuman, and in short, something that students – particularly girls – don't want to identify as.

Third, be aware of the culture in which you are operating. The previous discussions have illuminated the gendered history of the math and science fields at large, and the ways in which that history has been absorbed into the current gender-neutral discourse of the fields. Currently, success in math or science means adopting many behaviors of the prototypical white male (Eisenhart & Finkle, 1998); yet a rejection of essentialism in the discourse of gender equity means rejecting the idea that the low rate of women in math and science is due to flaws inherent to women that need to be corrected. While I believe it is clear that the burden of change lies here with the mathematic and scientific communities, this is an enormous undertaking unlikely to be resolved anytime in the near future; but, I also believe it unethical to leave the girls who *are* interested in math and science totally unprepared for success in those fields in the meantime. It is in this dilemma that I find Ambrose, Levi, and Fennema's pragmatic-idealistic continuum (1997) to be very useful for making choices in the classroom. At one end of the spectrum, there are choices for action that represent the current reality of the mathematics field and a responsibility to prepare students for that environment (i.e., changing the students), and at the other end, there are choices that represent efforts to change the environment of the mathematical and scientific professions. Using a thought tool like this, classroom teachers can reflect on how the pedagogical decisions they make affect their students and the mathematics community, and can more accurately align their efforts in a way that they feel best serves the futures of their students.

Chapter 5

Implications for Research on Female Learners in Secondary Mathematics

Existing research on female mathematics learners tells us that pedagogies that promote women's ways of knowing in the classroom boost the interest of female learners. However, most of these studies investigate feelings of interest and persistence in the short term. There seems to be a shortage of longitudinal studies that follow female learners through these encouraging environments into collegiate and professional mathematics environments (or not), where persistence rates can again be examined. Are positive mathematically able identities forged at the secondary level able to affect the persistence of women in math and science at a professional level? Or, once women's ways of knowing are legitimized to these learners in the classroom, must they continue to be recognized and used in the field to retain women?

Clearly, acceptance of women's ways of knowing in math and science should be an ethical goal; but one of the easiest ways to promote that goal seems to be having more women (or male allies conversant in these ways of knowing) in the field. To that end, more research on the specific behaviors of male learners and of males in the professional field that either legitimize or discredit women's ways of knowing can be useful. However, care should be taken in these studies to emphasize that women's ways of knowing, that is, connected knowing and deep conceptual understanding, benefit everyone of all genders in an academic and professional environment, and that efforts to promote them do not represent an attempt to delegitimize men or 'soften' or 'water down' mathematics and science.

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Vita

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