How Can Secondary Teachers Assist in Achieving Equity in Mathematics-Related Careers?

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Purpose

The 1990s brought about a peak of research in gender equity studies in mathematics education. Since then, the number of studies has declined, perhaps because of gains in more equitable mathematics achievement by gender. According to NCES, the National Assessment of Educational Progress (NAEP) scores for 17-year old males and females in 2012 are equitable. In addition, as of 2009, high school males and females are taking advanced mathematics courses, such as calculus, at an equitable rate. (NCES, 2013) However, I argue that studies investigating gender and equity in mathematics education are still needed and relevant, specifically studies considering gender with respect to ethnicity and culture.

Achievement is not the only important measure of equity. Students' perceptions of, attitudes towards, and beliefs about mathematics are also important for self-confidence and interest in mathematics. The affective domain may be where gains in gender equity can still be made. Potentially, more positive attitudes towards mathematics, higher self-confidence levels, and more role models for females and underrepresented minorities could create more interest in mathematics; however, it is unclear how these can be achieved. Some studies have identified perceived factors that have contributed to some adult women's (Anderson, 2001, Stage & Maple, 1996) and adult African American males' (Cluster, 2012) success in mathematics. Others investigated high school and college students' reasons given for choosing or not choosing to continue with mathematics or to choose mathematics-related careers (Brown, Brown, & Bibby, 2008; Piatek-Jimenez, 2008; Watt, 2005). Although there are many factors that contribute to

one's choice of career or interest in a subject (parents, peers, media, culture, etc.), not many of them are in the control of mathematics teachers. So how can we as mathematics teachers and educators contribute to the equity of the field of mathematics and mathematics related careers?

Changing the perceptions of mathematics and mathematics related careers through instruction may have an impact. Some studies have shown that the type of instruction (lecture, inquiry- based, problem-based, etc.) students receive can influence students' perceptions of mathematics (Boaler & Staples, 2008; Clarke, Breed, & Fraser, 2004; Laursen, Hassi, Kogan, & Weston, 2014). By reviewing the literature regarding students' choices for pursuing or not pursing mathematics, how some have succeeded in mathematics, and the influence of instruction on students' perceptions of mathematics, we may be able to hypothesize ways of contributing to the equity of the field of mathematics (or related fields) and identify what future studies could investigate to better achieve this goal.

High School Students' Mathematical Preferences

Some studies have focused on high school students' decisions to take more mathematics courses, while others have considered why some students have decided not to continue their mathematics education. Brown, et al. (2008) surveyed about 1500 16-year old students (both males and females) in the UK who were predicted to earn A*- C on the General Certificate of Secondary Education (GCSE exam). On an open-ended questionnaire, students indicated why they did or did not plan on continuing with their mathematics education. The results were coded and the following reasons for not continuing with mathematics were obtained: 1) mathematics is too difficult; 2) they did not enjoy it or like it; 3) mathematics is boring; 4) mathematics is not needed for their future degree or career; 5) mathematics is not useful in life; and 6) preference of other courses. Brown, et al. also considered theses categories based on student performance. One

somewhat startling result was that 47% of students who were receiving an A in mathematics still viewed mathematics as too difficult. Furthermore, female students were more likely to claim mathematics is too difficult (66% of responses from females and only 37% of responses from males) and lack of enjoyment (35% of responses from females and 24% of responses from males). It may be easy for one to argue that there are just other courses that students would prefer; however, the percentage of justifications in this category was small in comparison, making up only 2% and 3% of responses from males and females, respectively. This shows more than lack of interest in mathematics; it shows that students' perceive mathematics as too hard or that it will become too hard at more advanced levels, even for those who have succeed in the past. These perceptions were influenced by peers, siblings, and even some teachers. (Brown, et al., 2008).

Although the general perception in the U.K. is that mathematics is a difficult subject and deters some from choosing mathematics, it is also the reason why some feel compelled to continue with it. Heather Mendick (2005a, 2005b) interviewed 43 students who choose to continue their mathematics education. After coding her data, she obtained five categories for participant given justifications: 1) for enjoyment; 2) for chosen career and for enjoyment; 3) for chosen career and not for enjoyment; 4) to prove something to others'; 5) to prove something to themselves. Only three students, all of whom were female, felt they needed to prove something to themselves. The most male-dominated group (with eight total student responses), 'to prove something to others,' only contained responses from two females (Mendick, 2005b). Both the categories 'to prove something to themselves' and 'to prove something to others' contained responses that demonstrated the perception that mathematics is difficult and that by choosing to do mathematics, they can show that they are capable of taking on this challenge. Through the use

of narrative, Mendick tells the stories of three males (2005a) and four females (two females in her 2005a article and two in her 2005b article). She uses these stories to argue that for the girls in her study, "doing mathematics is doing masculinity" (Mendick, 2005b, p. 237). Through the lens of her alternative post-structural approach, Mendick (2005b) describes how the females in her study have had to balance a feminine identity in their daily lives developed from being biologically female with the masculinity of mathematics in order to succeed. Mendick (2005a) states that for the students in her study,

> 'real mathematics' is different from other subjects; it is certain and rational; 'real mathematicians' are different from other people; they combine the flattering character of geniuses and heroes with the unflattering character of 'nerds'. These discourses are oppositional and gendered; they inscribe mathematics as masculine, and so it is more difficult for girls and women to feel talented at and comfortable with mathematics and so to choose it and to do well at it (pp. 217).

From Mendick's (2005a, 2005b) and Brown, et al.'s studies, we can see that, at least in the U.K., teen-aged students tend to view mathematics as a difficult subject which males are more likely to pursue and for different reasons than females. It may be that the level of difficulty of mathematics in the U.K. may be emphasize due to structure of their schooling system, where students are expected to be stronger students in mathematics if they choose to continue beyond compulsory education. This begs the question, do these same views hold in other Western-culture societies?

It appears that the emphasis on difficulty may not be as prominent for students in Australia. Watt (2005) interviewed 60 strategically selected (based on mathematics performance and perceived mathematics talent) 9th-graders, 30 males and 30 females, about their future career

choices. Only two of these students mentioned the level of difficulty of mathematics. One of these students had perceptions of mathematics being too difficult (a girl), but the other wanted a math-related career because they believed the job would be easy (a boy). Thus, difficulty does not seem to be the emphasis these students in Australia, although it is important to note that these are select students are from an upper middle-class area in Sydney. Then, what is important for these students? Of the 60 participants in the study, 12 planned on pursuing a math-related career, of which twice as many were boys (8). Interestingly, girls with high perceived talent in combination with high performance (3) were more likely than comparable boys (1) to plan on pursing a math-related career. Most often, students chose a career in which they viewed mathematics to be instrumental, not because they enjoyed or were interested in mathematics. The later was offered as a reason for only one of the 60 participants. The second most common reason, 'being good at mathematics,' was given by four students (three boys and one girl), all of whom had high perceived mathematics talent (Watt, 2005).

Watt (2005) also investigated students' reasoning for not wanting to pursue math-related careers, for which there were 26 such students (the remaining students responded 'maybe'). Of these 26 students, 17 responses indicated that they simply had other interests, though this was more likely true for girls (12 responses), than boys (5 responses). Most of the other career interests for girls were desirable for their 'creative' aspects. For ten other students, math-related careers were undesirable because they had low perceptions of their ability (5 students) or disliked mathematics (5 students).

These three studies have somewhat different outcomes for the relatively same age groups of students. Students in the U.K. seem to have strong perceptions of mathematics as being difficult or challenging, which shows in their reasons for choosing careers in mathematics or

deciding whether or not to continue with their mathematics education (Brown, et.al, 2008; Mendick, 2005a, 2005b). In the Australian study, most students did not show a strong liking or disliking for mathematics. For some, it was simply a means to an end. For others, it just wasn't as interesting as other subjects (Watt, 2005). These differences could be due to the cultural perceptions of mathematics, the schooling systems in these countries, the selected participants, the theoretical lenses through which the researchers analyzed that data, or combinations of all or some of these.

Though some specific results are inconsistent, all three studies demonstrate that students' perceptions of mathematics and of themselves are significant influencing factors in students' choosing mathematics courses or related careers, whether or not the students are aware of it. For some, the view of mathematics as being difficult pushed them away, while others took it as a personal challenge. Some students perceived mathematics as lacking creativity, and thus chose a career requiring more creativity. For these students, perceptions of themselves as being creative did not align with their perceptions of mathematics. Mendick (2005a, 200b) explicitly uses an identity-related lens to interpret her interviews and argue that mathematics is gendered in a way that makes it easier for males to succeed, in part, because they are not conflicted to fulfill another role of gender in order to participate in mathematics. Since student perceptions of mathematics are formed partially by their experiences in mathematics classrooms, mathematics teachers have some influence on how students perceive mathematics, or at very least how mathematics is presented, which could impact students perceptions of mathematics.

Notably, I have not included any studies from the U.S. thus far. The study I wanted to include that was conducted in the U.S. was published in 1991, and therefore, may not be representative of today's high school students' choices for choosing to study mathematics or

enter a mathematics-related career. In addition, in the U.S. students are now required to take mathematics in high school through algebra II, and may not make a decision about taking more mathematics course until college. Thus, U.S. students will be represented in the next section as college level students.

Higher Education, Careers, and Mathematics Preferences

Though high school students may have some ideas as to what field they would like to study or what career they want, those may change over time. In college, students are still looking to the future but have to make decisions about courses and programs that will likely lead to a career. For those in graduate level programs, these decisions have become somewhat solidified, giving researchers the opportunity to analyze participants' reasoning for choices that have already been made, as opposed to what one intends. In this sense, researchers may learn about what influences and factors contributed to one's career choice.

One of these researchers, Piatek-Jimenez (2008), conducted interviews with five female mathematics majors enrolled in a college mathematics course intended to help students transition from concrete to abstract mathematics. The instructor of this course emphasized learning the culture of mathematics (learning to become a mathematician) as well as content. The interviews focused on students' perspectives of mathematicians and of themselves as mathematicians and were thus analyzed through an identity perspective. She found that these women had certain beliefs about mathematicians with which they did not identify. Only one of these five women was considering becoming a mathematician (others wanted to be mathematics teacher, to work for the CIA, or do something that allowed focus on family) and even then, she was not confident in her abilities to do so. Piatek-Jimenez (2008) concludes that "another possible reason that women choose not to pursue careers in mathematics may be because of their beliefs about what it

entails to be a mathematician" (p. 643). Thus, not only do students' perceptions of mathematics influence their career decisions, but their perceptions of mathematics careers and mathematicians do as well.

Piatek-Jimenez's approach was similar to that of Stage and Maple's (1996), who also utilized an identity perspective. They investigated why seven white-middle class women who were enrolled in graduate programs in mathematics decided to leave. All these women enjoyed mathematics, but ultimately decided that it did not entail the life that they wanted. Some reasons given were that it was too competitive, it required them to sacrifice other important aspects of their lives outside of mathematics, or it was too isolated. The lack of socialization was prominent in these women's responses, but was also present in the responses from Piatek-Jimenez's (2008) interviewees in that they saw mathematicians as isolated or disconnected from other aspects of life.

Women in the aforementioned studies developed perceptions of what is required to be a mathematician and decided that it did not fit their personal goals. Even though these women were successful in mathematics and enjoyed mathematics, it was still not enough to keep them in the field (granted, they ultimately were interested in mathematics-related careers). In addition, even though these studies were conducted roughly 12 years apart, there are still stereotypes present in these women's responses, indicating that we have still not progressed past these influences. So what influences some women decide to become a mathematician?

Anderson (2001) interviewed six females (mostly white, middle-class) who were either mathematicians or graduate students in a Ph.D. program in mathematics to determine what they perceived as influencing their decisions to become mathematicians. Every woman mentioned their love for mathematics and the influence of their parents in regards to encouraging them to go

into whatever they desired, not setting limitations or low-expectations for them. They all also seemed to be driven and have strong identities. "Throughout their stories, the voices of the women sounded resolute, convincing, and powerful; one could even say they sounded Herculean" (Anderson, 2001, p.17). Despite strong identities, several women perceived themselves as having lower-confidence in situations outside of mathematics, when they may not have in the past. Relationships with family and friends were still very important in their lives, indicating that they were not living in isolation opposing the stereotype. Not all the women perceived their own gender as having an effect on their choices. Anderson (2001) characterized the women's responses about their perceived effect of being a female in mathematics as having 'positive', 'neutral', or 'negative' effects and viewed them as dynamic in different situations. Some thought being female helped them (with regards to affirmative action, requesting time off, and funding), while others felt they had to work harder because of it. Still others did not even acknowledge gender, claiming that they are just mathematicians who are also female.

Having reviewed some of the literature on successful female mathematicians and observed varying perceived contributions to interest and success in mathematics, one may inquire if they are present for successful males in mathematics, or those even for students and mathematicians with different ethnic backgrounds. Thus, I conclude this section with a study investigating the perceptions of successful African American males.

Cluster (2012) brings some balance into the literature by considering the perceived influences of eleven mathematically successful African American males with either STEM (Science, Technology, Engineering, Mathematics) careers or STEM majors. Cluster (2012) collected data through interviews and online discussion boards. There are similarities between his results and Anderson's (2001). Every participant in this study also articulated the importance

of the influence and support of one of more parents, and either peers or siblings. In addition, the support from a teachers and high teacher expectations were important for every participant. Thus, having a support group seems to be an important factor for those pursing mathematics, or STEM careers. The persistence to overcome a challenge was also key for these participants. All of them mentioned at least one challenge (e.g. failing a class or test, difficult mathematical content, and/or lack of preparation) they had to overcome to be successful. Support groups and perseverance were what helped them be successful, even in the face of a challenge. There were some influences not mentioned by Anderson's (2001) participants. For example, several participants in Cluster's (2012) study attributed participation in programs such as the Alliance for Minority Participation (AMP) where they were exposed to summer research projects as factors in their success. Also, participating in mentoring and tutoring programs were perceived as influential. These similarities may be indicative of what we, as teachers, can do to support students in pursing mathematics or mathematics-related careers or goals.

Conclusions

I have provided selected samples of literature that have investigated perceived factors contributing to students' interest and success in mathematics from high school through graduate school and beyond. The participants included representations from three of different countries (U.S., Australia, and U.K), of both male and females perspectives, and at least two different ethnicities (some reports did not include the ethnic backgrounds of participants). It is important to note that population of participants in these studies is not necessarily diverse. Many of the participants were Caucasian, middle-class students, which is a potential bias in the research, and thus the data collected.

Perceptions of mathematics are formed even younger than high school, but seem to persist for many students. These perceptions of mathematics potentially influence high school students' decisions to continue with mathematics or choose a subject that aligns more closely with their self-perceptions. Some students see the perceived difficulty of mathematics as a challenge to overcome, while others see it as too difficult to pursue. Some students see mathematics as lacking creativity or useless and thus pursue other, more desirable, options. When a mathematics-related career is desirable for students, it is usually not because of the mathematics itself. Thus it is clear (and somewhat obvious) that a strong interest in mathematics based on one's perception of mathematics is required in order for one to choose this as a focus in their studies or career.

Because of societal influences, gender also plays a role. Some of the above research indicates that it may be more difficult for women to pursue mathematics than men because they have certain pressures or desires that pull them in sometimes opposing directions. Women in mathematics sometimes feel they have to balance the masculinity of mathematics with their feminine societal roles or desires. These conflicting influences may cause more challenges because they may feel they have to make more sacrifices. It is likely that they may not even be aware of the societal influences. For example, females in our society are encouraged to be nurturing and caretakers. This influences their career decisions in a direction where they may not be allowed to be 'selfish,' like that of mathematics.

Most importantly, from these studies, we can see what people attribute to their success in mathematics. One of those is support from teachers and parents or mentor. The other is perseverance. As teachers, we have some control over both of these, at least in our classroom. We can be mentors and we can teach in ways that allow students to see the creativity and

usefulness of mathematics. Boaler and Staples (2008) have described the case of Railside high school, where they have had success in helping students see the usefulness of mathematics, multiple solution paths, and most importantly, mathematics were all students contribute and are valued. In this atmosphere, there were not 'smart' and 'dumb' students, there are just who did or did not do their work. The perception of mathematics as being isolated and individual is also changed because in this reform-oriented approach, where students work together as teams to solve problems. As a bonus, student achievement also increased.

Through these studies, I argue that we can use instruction of mathematics to benefit more students, specifically those currently underrepresented in STEM careers. In addition, as teachers, we can act as role-models and mentors for students who show interest in mathematics and help them overcome the inevitable challenges they will face. These efforts might just change the outlook on the field of mathematics and STEM careers.

Implications and Cautions

For students who show lack of interest or have narrow or stereotypical perceptions of mathematics and mathematicians, exposing them to a different view of mathematics by changing instruction might influence them to enjoy, or even just appreciate mathematics. For those students who already enjoy mathematics, being a role model or a mentor could make a world of difference for them. Future studies should investigate how interventions and awareness of equity in mathematics could influence student perceptions of mathematics and mathematics-related careers. In addition, more work needs to be done to see if how mathematics is taught might influence students' perceptions of mathematics. There is some evidence that by allowing mathematics to be more creative, we may see interest from more students. It is also important to realize that we may decrease interest for some students who enjoy mathematics based on their

current perceptions. For example, if a student enjoys that “mathematics problems always have one way to do it” and “there is always one right answer” may not enjoy an inquiry or problem-based approach and thus may lose interest. Research would need to be done to investigate this hypothetical phenomenon.

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