Gender Equity in Mathematics Education

Part I. The Challenge and the Promise

Introduction

In the current (and coming) international high-technology economy, math and science skills are especially valuable for individual careers and for international market competitiveness. Historically, women have been underrepresented in math and science professions. Promoting gender equity in mathematics education and encouraging girls and women in math and science will benefit scientific advancements in these fields and help countries' economies grow (OECD, 2008). If the number of women with math- and science-related careers were in proportion to their representation in the overall labor force, the shortage of professionals in math and science would be dramatically reduced (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). Similarly, the APEC Secretariat states, in the Framework for Integration of Women in APEC (1999), "Women are critical to the achievement of sustainable economic development in the region."

In addition, increased participation in these sections of the workforce would also result in more economic opportunities for women and a greater number of women with high-earning, highly skilled jobs. Psacharopoulos and Patrinos (2004) examined data from 40 countries, including the APEC member economies of Australia, Canada, Chile, China, Japan, Korea, Mexico, Peru, and Thailand, and found that on average, women experienced an 18 percent return on secondary education, versus 14 percent for men, with respect to earnings. Increasing awareness of this effect on earnings can help drive demand for schooling as parents and communities see the benefits of secondary education.

Evidence of the Gender Gap in Education and the Workforce

During the last 50 years, an increasing number of women have made important contributions as mathematicians and scientists; however, there are still consistent gender gaps in women's education in the STEM fields (science, technology, engineering, and mathematics). In the K-12 educational system, mathematics assessments results vary across countries;[1] generally, the more advanced the subject, the lower the female representation (Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007). In the United States, female elementary school students show equal or slightly better mathematics performance compared to male students (Fan, Chen & Matsumoto, 1997), but this advantage gradually declines as they grow older. Researchers have reported a gradual increase in the gender gap, favoring boys, from elementary school to secondary and, within secondary school, from junior high through high school (e.g., Fierros, 1999).

There are positive trends in women's participation in math and science in post-secondary education. For example, a recent study about gender equity in higher education in the United States conducted by the American Council on Education (ACE; King, 2006) shows that in recent years women have made gains in college participation and degree attainment. Although women are still in the minority, the percentage of female students earning advanced

[1] There are no clear patterns of gender differences in math by type of country, such as developed versus developing countries (Mark, 2010). However, the variations in types of education systems or access to education may relate to gender differences on a case-by-case level.

This is publication was supported by the APEC, Human Resources Development Working Group project: HRD 01 2009A

degrees has risen dramatically in the last 50 years. According to the National Science Foundation, 50 years ago, women earned about 8 percent of the science and engineering doctorates. By 2006, this had increased to 40 percent. Additionally, in 1973, only 6 percent of the Ph.D. scientists employed full time in academia, business, or elsewhere were women; by 2006 the number had risen to 27 percent. Over that same time frame, women's share of full professorships in the sciences quadrupled, to about 20 percent.

Despite these gains, there is a need for further progress. In 1999, the ratio of higher education degrees in math, science, and engineering to the 24-year-old population was higher among males than females in most reporting countries, including the APEC member economies of Japan, the Republic of Korea, Canada, United States, and Mexico (National Science Board, 2002). This pattern has persisted: a 2008 report by the Organization for Economic Co-operation and Development (OECD) examined the number of the employed 24 to 35 years old STEM graduates in all related fields and found that the number of male graduates in STEM in 2005 was consistently substantially higher than the number of female graduates in the countries examined, including the APEC member economies of Korea, Australia, New Zealand, Japan, and the United States (OECD, 2008).

In higher education, the proportion of female participation varies from field to field, with women concentrated in social science and men in hard science. Twenty-six percent of full professors in the life sciences are women, but in physics, only 6 percent are women (OECD, 2008). Further, especially for engineering, gender gaps vary across countries, suggesting that national factors such as culture may play a role. In the Republic of Korea, 45 percent of the science and engineering first university degrees earned by women are in engineering. In the United States, 6 percent of science and engineering first university degrees earned by women are in engineering (National Science Foundation, 2010).

The next section presents a brief overview of the literature about attitudes and cultural factors that may impact women's decisions to earn degrees in the STEM fields and to join the workforce in related professions. Understanding these factors can inform policies and systemic efforts for encouraging greater participation of women in the STEM fields.

Attitudes and Cultural Influences that May Contribute to a Gender Gap

Several meta analyses conducted by independent researchers indicate that gender differences in performance in mathematics are generally trivial (e.g., Else-Quest, Hyde, & Linn, 2010; Guiso, Monte, Sapienza, & Zingales, 2008; Hyde et al., 2008). However, the same studies have also found that countries with more gender equity in other areas (e.g., greater economic and political opportunities for women, more positive cultural attitudes towards women) tend to have smaller gender gaps in performance. For example, Else-Quest and colleagues (2010) found a relationship between women's education, political involvement, welfare, and income in each country with test scores from Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). For countries with more women in research-related positions, the girls in that country were more likely to do better in math and feel more confident of those skills. Additionally, Guiso and colleagues (2008) found a relationship between the gender math gap and society-level female socialization as measured by the World Economic Forum's (WEF) gender gap index, which reflects economic and political opportunities, education, and well-being for women Additional studies using international data (e.g., Nosek et al., 2009) have found that nation-level implicit gender stereotypes predicted nation-level gender differences in eighth-grade science and mathematics achievement.

Implicit gender stereotypes may communicate to girls and women that men are naturally more talented in mathematics. Women and girls who believe that these stereotypes are true may experience increased concerns that they will be judged on their gender or be held to a different set of expectations compared to males and, in testing situations, confirm the negative stereotype both in their own eyes and in the eyes of others. This phenomenon, typically referred to as “stereotype threat” (Steele, Spencer, & Aronson, 2002), can cause cognitive load that interferes with performance and decrease motivation to put effort into learning. Female students experiencing stereotype threat may be less interested in mathematics (Schmader, Johns, & Barquissau, 2004; Hyde, 1990), have lower performance expectations (Stangor, Carr, & Kiang, 1998), avoid academic challenges in mathematics (Dweck 1999, 2006), and devalue mathematics as a career choice (Davies, Spencer, Quinn, & Gerhardstein, 2002).

Attitudes towards mathematics and interest in pursuing related fields as a career have a powerful relationship to performance. For example, a study conducted in the Philippines showed that the index of positive attitudes towards mathematics was a positive and statistically significant predictor of mathematics test scores on the TIMSS-1999 (Talisayon, Balbin and De Guzman, 2006). Studies conducted in Australia and New Zealand on students’ attitudes toward mathematics have consistently shown significant gender differences favoring males (Vale, 2009). These studies cover both primary and secondary students and measure a range of affective variables, such as self-confidence, interest, enjoyment, self-efficacy, and self-concept. In addition, female students have had (statistically significant) higher anxiety scores than males. These differences may be linked to observable gaps in math performance. For example, researchers have found statistically significant positive association between self-confidence and mathematics achievement, although it is not clear whether improved math achievement is the cause or effect (Thomson & Fleming, 2004; Thomson, Cresswell, & De Bortolli, 2004).

Differences in attitudes may explain the gender gaps observed in post-secondary education attainment noted above. In her research with Australian students, Watt (2005) found that valuing mathematics and higher self-esteem, rather than academic achievement, was related to gender differences in mathematics course enrollment and career planning. Watt (2006) also found that men were more likely than women to plan to take higher-level mathematics subjects and to plan mathematics careers. Thus, early gender differences in values and self-image play into gender differences in course-taking and ultimately, in learning and career planning.

Conclusion

The research suggests that gender differences in math and science education, achievement, and career choices do not seem to be driven by biological differences. Instead, girls and boys make choices throughout their education and professional careers, and there are systematic differences in these choices. To the extent that these choices are limited by lack of encouragement, misinformation, or stereotypes, it is possible to address the barriers and provide both girls and boys with the information and encouragement to broaden their options. This can be accomplished through setting core standards of performance and setting out the organizational mechanisms that will help bring about gender equity in education and career opportunities (Tembon & Fort, 2008; UNESCO, 2010; UNICEF, 2010). In Part II, we discuss strategies for overcoming these limitations and developing interest and investment in math and science. We first look at how an economy can raise awareness at the national level, then at more focused strategies for piquing students’ initial interest and building long-term interest and investment.