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ARTICLES

Gender and Mathematics Achievement in China and the United States

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Abstract This study examines the relationship between gender and mathematics achievement among students in China and the United States, with an emphasis on the gender gap among mathematically talented students. The results show that in neither the US nor China are there gender differences in eighth grade math-achievement test scores. In China, there are no gender differences in mean college entrance examination math scores among high-school seniors, while in America, the mean SAT-Math score among male high-school seniors has been consistently higher than those of their female counterparts. In both the US and China, there are gender differences among the top math performers on college entrance examinations; boys are over-represented. The Chinese national mathematics curriculum, well-trained teachers, beliefs by students and their parents that academic achievement is more a product of effort than of natural ability, a gender-neutral parental expectation for children's education, and generous family spending on the education of girls are suggested as possible factors underlying the comparable performance of the Chinese female and male students. The sorting system at Chinese secondary school level and a cultural stereotype favoring boys in mathematics are suggested as possible contributors to the math-achievement gender gap found among the top Chinese high school seniors.

Keywords Gender · Math scores · Top math students · Stereotype threat · China · The United States

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Introduction

Despite efforts to narrow the gender gap in mathematics test scores, results in the United States have been mixed. Five US national and international surveys of fourth, eighth and twelfth graders from 1990 to 2003 found that boys and girls performed comparably in mathematics [20, 10]. However, during the same period, male eleventh and twelfth graders continued to score at least 30 points higher than their female counterparts on the mathematics section of the Scholastic Aptitude Test (SAT). In 2006, the mean difference was 34 points, not much smaller than the 36-point spread in 1972 [9]. Among SAT top scorers in math, boys have always outnumbered girls. In 2006, even though only 46% of the SAT-Math test takers were boys, among those who scored at 700–749 points, the gender ratio was 1.93:1 favoring boys, and among those who scored at 750–800 points, the gender ratio was 2.6:1 [9].

In mathematically gifted samples, males have consistently outscored females in mathematics. The data collected from 1972 through 1991 in the Study of Mathematically Precocious Youth (SMPY) showed that among the intellectually talented 12 and 13 year-old American youths who scored 700 or more on the mathematics portion of the SAT, there were 13 boys for every girl [17]. Though this gender gap has declined significantly in recent years, the ratio is still 3:1 in favor of boys [7].

Internationally, students in East Asian countries have scored significantly higher in mathematics than have American students. The most recent Trends in International Mathematics and Science Study (TIMSS) found that the eighth graders in Singapore, Taiwan, Hong Kong, South Korea, and Japan scored on average 66–100 points higher than American eighth graders on the TIMSS mathematics test, and that female eighth graders in these Asian countries significantly outperformed American eighth grade *boys* and *girls*. Moreover there were no gender differences in mean math scores in any of these East Asian countries [10, 85–86].

Though a few scholars have suggested genetic causes for gender differences in mathematics,[1] most US researchers have attributed gender differences in mathematics to social and environmental factors, asserting that they are due to differences in social conditioning and societal expectations for boys and girls [23, 27]. Several studies have found that girls tend to see mathematics as a masculine discipline, feel less confidence in their mathematical ability, and like math less than do boys (e.g., [8, 24]). Some researchers have attributed these beliefs and prejudices (against math) to gender-specific expectations of parents and teachers who encourage males more than females to achieve in mathematics, and have found correlations between these beliefs/prejudices and math achievement [23, 14]. Lower self-confidence and lack of interest in mathematics are said to lead females to take fewer mathematics courses than males, which, in turn, result in lower math performance for females [15, 19]. SMPY researchers found that many mathematically talented females "simply choose to develop their abilities in other areas," and that the decisions to

[1] For a summary of biological explanations of the gender-math gap, see [4, 11: pp. 53–58].

not pursue math and sciences are based more on personal preferences than intellectual ability [17: p. 65].

In recent years, several US psychologists have used the concept of *stereotype threat* to explain gender differences in mathematics [3, 26, 5]. According to this view, well-known and widely-shared beliefs in the superiority of one group of individuals over another in mathematics create a threat that directly hampers the performance of individuals in the targeted group. Even for those who do not personally believe in such a stereotype, performance is negatively affected when the stereotype is highlighted during formal math tests [26]. Several US studies have demonstrated the existence of stereotype threat and the negative effects it has on test performance among individuals who had done well in mathematics, scored high on the SAT, and who were sure of their high mathematics ability [2, 26]. In one study, researchers found that while women did perform more poorly than men on difficult math tests, "this gender difference in performance could be eliminated" when the test giver "lowered stereotype threat by describing the test as not producing a gender difference" [26: p. 4]. Stereotype threat may underlie gender differences in advanced math performance among high-math-ability individuals in the stereotype targeted group. However, while stereotype threat seems to be one possible explanation for the math-gender gap among top scorers on the SAT, the stereotype-threat findings are not always replicated [25, 30, 31].[2]

The present paper explores gender and mathematics performance of Chinese students with an emphasis on the gender gap among mathematically talented students at eighth and twelfth grades. The purpose of the present paper is to compare math-gender relations in the US and China.

Research Design

To explore gender differences in the mathematics achievement of students in China, an ideal approach would be to conduct national surveys like the SAT and the TIMSS. Because resources for such an undertaking were not available, I used the math achievement scores I collected from high schools in Wuhan, a large city (population 8 million) in China.

The data collected for this project were 2002 College Entrance Examination scores from 1,078 high-school seniors (633 boys, 445 girls) of three Wuhan academic high schools. To seek a representative sample of urban Chinese high-school seniors, I included one keypoint school and two regular or average schools and included every student in each twelfth grade class. These students are comparable to their American age peers who took the SAT in 2006.[3]

[2] The author thanks one of the reviewers for providing relevant references.

[3] In China, almost all academic high-school seniors take the College Entrance Examination. However, because of the selection and sorting process in the Chinese secondary education system, this sample represented only the top 25% of their age peers. In the US only the top 48% of high-school seniors took the SAT in 2006 [21]. Taking into consideration the 70% drop-out rate among American high school students as well as students who did not attend high school, the SAT test takers represented about 30% of their age cohorts in the United States [21, 22].

The examination scores were provided by the schools. Compared with the SAT-Math test, the mathematics section of the Chinese College Entrance Examination is much more difficult, containing many college-level mathematics questions. One indirect indication of the rigor of this mathematics test is the mathematics competence of Chinese high school graduates. Because the SAT is not available in China, Chinese twelfth graders who apply for American colleges sometimes take the Graduate Record Examination (GRE) and have routinely scored at the 99th percentile on the mathematics section [16].

Additionally, to explore the possible gender differences in mathematics among the top students, I re-examined the math test scores of 1,040 eighth graders (489 boys, 551 girls) in a survey I conducted in 1999.[4] In that survey, I included one highly selective keypoint school and two regular or average schools. Since junior high school education is compulsory in urban China, this sample is representative of their age cohort. The mathematics scores were provided by the schools from a 100-minute standardized eighth grade achievement test, used by all junior high schools in Wuhan as the second semester final examination.

Results

Among the Chinese eighth grade boys and girls in my study, the mean math scores (67.9 for boys, 67.0 for girls) were not statistically different. Nor were there any gender differences for those eighth graders who scored above the 50th percentile. In fact, 10.9% of the girls, 8.4% of the boys scored in the top 10% of the examination distribution (98 points or higher out of a possible 100 points). However, because of the test's ceiling effect, gender ratios beyond the 90th percentile cannot be reliably ascertained.

There was no gender difference in the mean mathematics scores (106.7 for boys and 106.7 for girls) of the Chinese high-school seniors on the College Entrance Examination. However, gender differences did emerge among those who scored above the 50th percentile: boys scored higher than did girls (a mean score of 123.1 for boys and of 120.9 for girls, $F = 9.10$, $p < .01$). Moreover, for the top 5%, the boy–girl ratio was 2.9:1. In the upper 3% of the score distribution there are 24 boys, but only 2 girls. Figure 1 shows the score distributions expressed as percents because of unequal *N*s for boys and girls separately.

Discussion

In the US, male high-school seniors have continuously outperformed their female peers on the mathematics portion of the SAT. In China, there is no gender difference

[4] The survey was originally designed to explore the effects of the one-child-per-family policy on the educational opportunity of girls and the relationship among family income, parenting, and children's academic achievement in Chinese large urban areas. The findings about these issues were published in 2002 and 2005 respectively [33, 32]. For a detailed description of research design and sampling method, see [33].

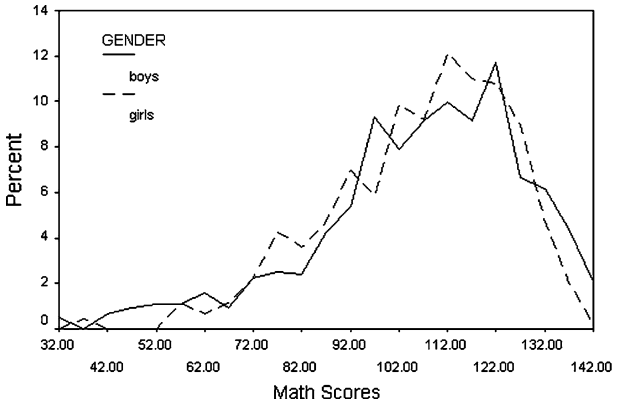

Fig. 1 Percent of boys and girls as a function of math score

in terms of overall mathematics performance among high-school seniors on the College Entrance Examination. However, in both countries, among the top math-test performers on college entrance examinations, there are more boys than girls (see Tables 1 and 2).

Mathematics needs to be taught and proficiency at algebra is impossible without a solid foundation in elementary-school level math. A rigorous curricula and superior instruction of well-trained, competent teachers are important to both male and female students. The lack of gender difference in the mean mathematics scores of Chinese high-school seniors as compared with the persistent gender gap in the SAT math scores for American students may at least be partially explained by differences in the education systems, in the quality of elementary and high-school teachers, and students' own efforts, in the two countries.

In China, a demanding and rigorous national math curriculum,[5] which imposes a universal standard at elementary and secondary-school levels; city-wide, high-school entrance examinations; and a highly competitive national college-entrance examination, help hold individual schools accountable. Because high-quality schools are allowed to charge "a sponsor fee," ranging from 8,000 to 12,000 yuan[6] (equivalent to the total annual income of an average Wuhan family), to admit those students who want to enroll but who scored a few points lower than the required admission scores set by the school, quality teaching also benefits schools and their teachers financially [32].

According to College Board surveys of the SAT test takers, high-SAT-math scorers tend to come from high-quality schools. Compared with other SAT test takers, top math performers had more years of mathematics instruction and had taken demanding math courses [9: pp. 5–6]. Unfortunately most US elementary and high schools are not high quality [9]. Moreover, without a national math curriculum, academic standards vary widely from state to state and from school district to school

[5] There are national curricula at elementary and secondary school levels in all high-math-performing East-Asian countries.

[6] Individual schools retain 50% of these sponsor fees and the other 50% goes to the local government.

Table 1 Gender ratio for top scorers on the college entrance examination among Chinese high-school seniors, 2002

Math score[a]	Boys (%)	Girls (%)	Boy/Girl ratio
140–144	2.0	0.2	10:1[b]
135–139	4.4	2.0	2.2:1
130–134	6.2	4.7	1.3:1

[a] The full score on the math portion of the Chinese College Entrance Examination is 150

[b] There is only one girl

Table 2 Gender ratio for top scorers on the SAT among American high-school seniors, 2006

Math score	Boys (%)	Girls (%)	Boy/Girl ratio
750–800	3.3	1.3	2.6:1
700–749	5.8	3.0	1.9:1
650–699	9.6	6.1	1.6:1

Source: College Board, 2006. 2006 College-Bound Seniors: Total Group Profile Report. The College Board

district [29]. In a national survey, only 34.4% of American eighth graders attended algebra class at least once a week [1], while Chinese eighth graders have mathematics that includes algebra, trigonometry, and geometry every day.

Another reason for the lack of an overall gender difference among Chinese high-school seniors may be the selection and training of math teachers. When applying for admission to a normal school or a teacher's college, applicants in China are required to choose an academic major (in China, education is not a major). Future teachers spend their time learning the content of their major and related subjects and are expected to teach the subject they trained for. In a study of elementary school mathematics teachers in the US and Shanghai, China, Ma [18] found that many Chinese teachers possessed profound understanding of fundamental mathematics, and their mathematical competence enabled them to clearly verbalize concepts and to guide students in the systematic investigation of mathematics. Though Chinese elementary-school teachers received far less formal schooling (11–12 years) than their American counterparts (16–18 years), they far outperformed American teachers in both mathematics calculation and classroom instruction. When given a problem of division with fractions, for example, $1\frac{3}{4} \div \frac{1}{2}$, and asked to make it meaningful to their students, 100% of Chinese teachers solved it correctly and 90% provided a story that was an accurate representation of the division. In contrast, only 43% of American teachers calculated the division correctly and a mere 4% provided an accurate story [18]. Well-trained, experienced teachers and a lot of practice (daily math class and homework) beginning in the first grade, make most Chinese students comfortable with mathematics. Indeed, mathematics and English were tied at the first place as the "most liked subject" by the Chinese students I surveyed.

In the US, many elementary and high school teachers are not academically prepared to teach mathematics. A 1993–1994 national survey of teachers found that

at the elementary school level, only 2% of public-school teachers and 5% of private-school teachers had majored in mathematics or natural sciences as undergraduates. At secondary school level, the percentage was 19.6% for public-school teachers and 23.2% for private-school teachers. The same survey also found that among secondary school teachers whose main teaching field was mathematics, only 64% of public-school teachers and 58% of private-school teachers had either an undergraduate major or minor in mathematics [12].

The lack of an overall gender difference among Chinese students may also be a function of a cultural belief in hard work, rather than innate ability, as the basis for academic achievement. In my eighth grade survey, I found a strong belief in education and in diligence: 50% of respondents strongly agreed with the statement "there is no future without a good education," and 94% chose "hard work" as the most important factor for academic success. In contrast, Stevenson et al. [28] found that American parents and children tended to believe that achievement in mathematics depends on innate ability. Compared to less than 6 h a week on homework for American eighth graders [13], the majority of my respondents spent at least 2 h each week day (after 8 h of school) and 8 h over the weekend on homework. While boys and girls in my survey spent a similar number of hours doing homework on weekdays, Chinese girls spent significantly more time than boys doing homework on weekends [32]. To prepare for the College Entrance Examination, twelfth graders in China attend classes for 10 h a day and 6-and-half-days a week with a total of only four weeks off during their senior year.

Finally, the lack of mean gender difference in mathematics performance among Chinese high school and college students is likely to be related to China's one-child-per-family policy and its resultant gender-neutral *parental* expectations and generous family spending on girls' education. In my research, I found that, unlike previous generations where daughters were valued less than sons, one-child families, at least in large urban areas, have high parental educational expectations for both boys and girls.[7] Because many Chinese parents will depend on their only child for their old-age security and because employment discrimination against women has reappeared in Chinese urban areas in recent decades,[8] the parents of female only-children actually spend more money on education than do the parents of male only-children in order to give their daughters a competitive advantage in the job market. At the same time, without a brother to compete for family resources and parental attention, female only-children have educational aspirations as high as did their male cohorts [33].

Further studies, preferably with national samples, are needed to explain the gender difference among the top math scorers on the college entrance examination

[7] 95% of all families in large Chinese cities have only one child.

[8] Ever since the end of the state-assigned employment system in the 1980s, where some elements of the equal employment for men and women were built into the system and where employers could not choose their workers, many women, including female college graduates, have had difficulty finding good jobs. Worried about costs such as full salaries paid during maternity leave and special accommodations for women in the workplace (required by law), many employers, especially in the private sector, refuse to hire women. Although such practices violate the law, the government has done little to stop them because its priority is to deal with the unemployment situation [34, 35].

in China (and in the US). Based on existing studies, a possible contributor to this gap in China is the fact that many top female students never enroll in academic high schools (the only schools participating in the College Entrance Examination). In Chinese cities schooling at secondary level is highly differentiated and stratified. After a mandatory ninth-grade education, junior-high-school graduates face an institutional sorting process. Depending on their scores on the senior-high-school entrance examination and their stated preferences, students are assigned to academic (college preparatory) high schools, secondary specialized schools, or vocational schools.

Although students with high scores are more likely to choose academic high schools, a significant minority of the best female students prefer normal schools, secondary specialized schools that train kindergarten and elementary school teachers. Analyzing the enrollment patterns of those who scored above the 80th percentile in the senior-high-school entrance examination, Broaded and Liu [6] found that, though their scores qualified them for admission to academic high schools, girls were significantly more likely than boys to enroll in normal schools.

The factors that attract high-achieving girls to normal schools in urban China include job security and relative high pay for teachers. Broaded and Liu [6] found that 20% of girls, but only 3% of boys wished to become teachers. In my eighth grade survey 23% of girls and only 4.6% of boys listed teaching as their first career choice.

With the implementation of the one-child-per-family policy in 1979, teaching has become a high-pay, high-prestige profession in China because of parents' willingness to spend all they can on the education of their only child. The high pay and job security of kindergarten and elementary-school teachers have led to fierce competition in normal school admission: currently, only the best students are accepted by these schools. Although Broaded and Liu did not distinguish between normal schools and other types of secondary specialized schools (nursing or secretarial), they did find that the average required admission scores (on the senior-high-school entrance examination) were higher for secondary specialized schools than for regular academic high schools [6].

Finally *stereotype threat* [26] may explain why males in China are more likely than females to be found among the highest math scorers on the College Entrance Examination. Despite an equally high educational expectation for boys and girls *within* Chinese one-child families in large Chinese cities today, the traditional belief of male superiority over females in math and science still lingers in the larger society, a belief sustained by a continuous dominance of males over females among famous natural scientists and mathematicians in China and the world. Most high school teachers (as well as many high-math-ability female students) I interviewed in China believed that boys tend to do better in math because they have a better visual and spatial ability than girls. Chinese teachers also argue that because boys mature later than girls, the low test scores of intellectually-talented boys before senior high school are caused by their immaturity, characterized by laziness and refusal to use their natural endowment. Once these smart boys realize the importance of education and start to apply themselves, it is believed that they can surpass girls, particularly in math and sciences [33].

Given the authority and influence Chinese teachers have over their students, such beliefs may create a stereotype threat for female twelfth-graders taking the math test of the College Entrance Examination. In my survey of the Chinese eighth graders and college freshmen, I found that although both males and females reject the statement "boys are better than girls at mathematics," girls tend to underestimate their math ability while boys tend to overestimate theirs.[9] Under these circumstances, it is possible that girls, particularly high-math-ability girls who really care about their math performance, would be more anxious when taking the math test of the College Entrance Examination. Such anxiety may affect girls' math performance. Further research testing stereotype-threat theory is needed to better understand the math-gender gap among the best Chinese high school seniors.

Conclusion

Although reasons for the math-gender gap among the very best students remain unclear, the data (no mean gender-math gap among Chinese students on the College Entrance Examination) point to societal conditions (cultural beliefs, parents expectations, rigorous national curriculum, and well-trained teachers) as the cause of the mean gender gap in the SAT-Math scores among American students.

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[9] Unfortunately, no questions regarding the *awareness* of the gender-math stereotype were included in my two surveys. American researchers [2, 26] argue that it is the awareness of, rather than personal beliefs in, the gender-math stereotype that affects the math test performance of female students.

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