Culture, Gender, and Math

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Culture, Gender, and Math

Analysis of PISA results suggests that the gender gap in math scores disappears in countries with a more gender-equal culture.

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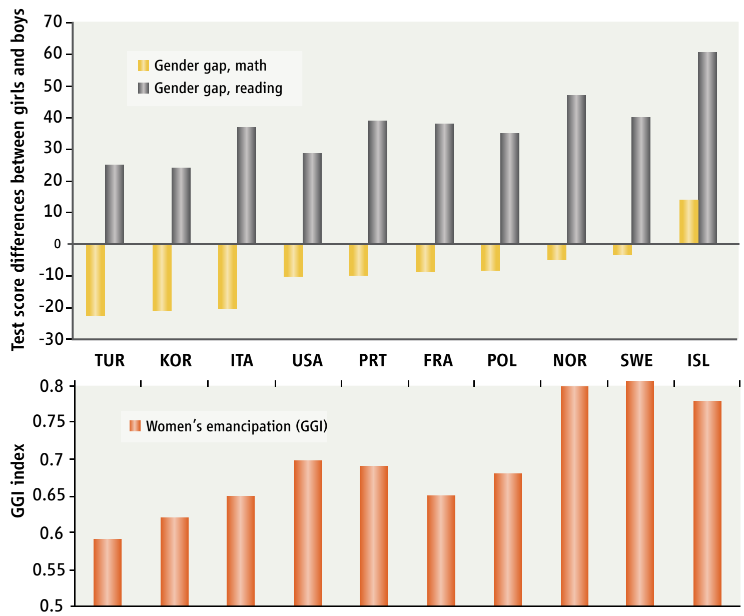
The existence (*1*), degree (*2*), and origin (*3*, *4*) of a gender gap (difference between girls' and boys' scores) in mathematics are highly debated. Biologically based explanations for the gap rely on evidence that men perform better in spatial tests, whereas women do better in verbal recall ones (*1*, *5*, *6*). However, the performance differences are small, and their link with math test performance is tenuous (*7*). By contrast, social conditioning and gender-biased environments can have very large effects on test performance (*8*).

To assess the relative importance of biological and cultural explanations, we studied gender differences in test performance across countries (*9*). Cultural inequalities range widely across countries (*10*), whereas results from cognitive tests do not (*6*). We used data from the 2003 Programme for International Student Assessment (PISA) that reports on 276,165 15-year-old students from 40 countries who took identical tests in mathematics and reading (*11*, *12*). The tests were designed by the Organisation for Economic Co-operation and Development (OECD) to be free of cultural biases. They are sufficiently challenging that only 0.6% of the U.S. students tested perform at the 99th percentile of the world distribution.

Girls' math scores average 10.5 lower than those of boys (2% less than the mean average score for boys), but the results vary by country (see chart, above): in Turkey, –22.6, whereas, in Iceland, 14.5. A similar variation exists in the proportion of girls over boys who score above 95%, or 99% of the country-level distribution (fig. S2A).



Math and reading gender gaps. In more gender-equal cultures, the math gender gap disappears and the reading gender gap becomes larger. **(Top)** Gender gaps in mathematics (yellow) and reading (gray) are calculated as the difference between the average girls' score and the average boys' score. A subset of countries is shown here (see SOM for complete data set and calculations). In many countries, on average, girls perform more poorly than boys in mathematics. In all countries, girls perform better than boys in reading. The gender gap in mathematics and reading correlates with country measures of gender status within the culture, one of which measures is the GGI (**bottom**). Larger values of GGI point to a better average position of women in society. Besides USA, the countries are abbreviated as their first three letters, except for PRT, Portugal, and ISL, Iceland.

The gender gap is reversed in reading. On average, girls have reading scores that are 32.7 higher than those of boys (6.6% higher than the mean average score for boys), in Turkey, 25.1 higher and in Iceland, 61.0 higher (see chart). The effect is even stronger in the right tail of the distribution. In spite of the difference in levels, the gender gap in reading exhibits a variation across countries similar to the gender gap in math. Where girls enjoy the strongest advantage in reading with respect to boys, they exhibit the smallest disadvantage (sometime even an advantage) in math. [The correlation between the average gender gaps in mathematics and reading across countries is 0.59 (fig. S4)].

To explore the cultural inputs to these results, we classified countries according to several measures of gender equality. (i) The World Economic Forum's Gender Gap Index (GGI) (*10*) reflects economic and political opportunities, education, and well-being for women (see chart). (ii) From the World Values Surveys (WVSs) (*13*), we constructed an index of cultural attitudes toward women based on the average level of disagreement to such statements as: "When jobs are scarce, men should have more right to a job than women." (iii) The rate of female economic activity reflects the percentage of women age 15 and older who supply, or are available to supply, labor for the production of goods and services. (iv) The political empowerment index computed by the World Economic Forum (*8*) measures women's political participation, which is less dependent on math skills than labor force participation. These four measures are highly correlated (table S2).

We find a positive correlation between gender equality and gender gap in mathematics (fig. S5). If Turkey, a low gender-equality country (GGI = 0.59), were characterized by the degree of gender equality manifested in Sweden (GGI = 0.81), our statistical model suggests that the mean score performance in mathematics of girls relative to boys would increase by 23 points, which would eliminate the Turkish gender gap in math (see table, p. 1165). In more gender-equal countries, such as Norway and Sweden, the math gender gap disappears. Similar results are obtained when we use the other indicators of women's roles in society. These results are true not only at the mean level, but also in the tail of the distribution (table S3). In Iceland, the ratio of girls to boys who score above the 99th percentile of the country distribution in math scores is 1.17.

There are many unobserved reasons why countries may differ in a way that affects the

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Differences in Test Scores Correlated with Indicators of Gender Equality

	LHS: Gender difference in math				LHS: Gender difference in reading			
Women's emancipation (GGI)	105.49± 26.92**				83.56± 30.43**			
Avg. WVS indicators		13.21± 7.06				16.39± 8.46		
Female economic activity rate			0.45± 0.14**				0.34± 0.15*	
Women's political empowerment				29.10± 10.05**				24.35± 10.86*
Log GDP per capita, 2003	-6.56± 2.40**	1.09± 2.26	-3.12± 1.93	-4.95± 2.52	-2.23± 2.71	0.52± 2.71	-0.56± 2.15	-1.06± 2.73
Constant	-19.62± 20.01	-57.16± 23.27*	-2.75± 17.72	32.43± 23.72	-3.02± 22.62	-16.09± 27.90	21.49± 19.80	39.03± 25.63
Observations (no.)	37	32	39	36	37	32	39	36
R^2	0.32	0.15	0.23	0.21	0.20	0.14	0.12	0.15

Culture affects the gap. More gender-equal cultures are associated with reducing the negative gap in math and further enlarging the positive gap in reading in favor of women. Test scores are positively correlated with indicators of gender equality in society (GGI, WVSs, see text). Economic conditions are accounted for by per capita Gross Domestic Product (GDP). The correlation persists among high achievers on both tests (table S3). See SOM for details of statistical analysis. The constant is where the regression line intercepts the y axis, representing the amount the dependent y (gender gap) will be when all the independent variables are set to 0. LHS, left-hand side variable in the least-squares regression analysis. $*P < 0.05$; $**P < 0.01$.

math gender gap. Without appropriate controls, we run the risk of capturing a spurious correlation between the unobserved factors and our measures of gender equality. We reran our regression at the student level, inserting a dummy variable for each country, to control for unobserved heterogeneity (table S4). The interaction between gender and GGI index remains statistically significant at the 1% confidence level in a two-tailed *t* test, which suggests that the correlation between gender equality and girls' math scores is not driven by unobserved heterogeneity. This interaction between gender gap and GGI remains significant even when we insert an interaction between gender and log of GDP per capita, which suggests that the improvement in math scores is not just related to economic development, but to the improvement of the role of women in society.

To investigate whether the disappearance of the math gender gap in some countries translates into an overall improvement of girls or is simply limited to mathematics scores, we correlated reading performance differences with measures of womens equality (see table, above). In countries where women are more emancipated, girls' comparative advantage in reading widens. Comparing Turkey (GGI = 0.59) and Sweden (GGI = 0.81), we see an increase in the mean score performance of girls relative to boys in reading by 18 points, which almost doubles Turkey's reading gap in favor of girls.

To verify that these results are not driven by biological differences across countries, we analyzed whether they persist in populations that have a similar or identical evolutionary history. To assess history, we used a genetic distance measure (*14–17*) based on the frequency of each allele across DNA polymorphisms.

According to this measure, there are 13 European countries with genetic distance equal to zero and 26 European countries with genetic distance less than 100 (table S5). When we restrict the regression of the table (above) to either one of these two groups, our findings are substantially unchanged (table S6).

These results suggest that the gender gap in math, although it historically favors boys, disappears in more gender-equal societies. The same cannot be said for how boys score in mathematics compared with how boys score in readings. Boys' scores are always higher in mathematics than in reading, and although the difference between boys' math and boys' reading scores varies across countries, it is not correlated with the GGI index or with any of the other three measures of gender equality (table S7A). Hence, in countries with a higher GGI index, girls close the gender gap by becoming better in both math and reading, not by closing the math gap alone. The gender gap in reading, which favors girls and is apparent in all countries, thus expands in more gender-equal societies. Similarly, although the gender gaps in all math subfields decrease in societies with more gender equality, the difference between the gender gap in geometry (where the boys' advantage relative to the girls' is the biggest) and arithmetic (where the boys' advantage relative to the girls' is the smallest) does not (table S7B).

This evidence suggests that intra-gender performance differences in reading versus mathematics and in arithmetic versus geometry are not eliminated in a more gender-equal culture. By contrast, girls' underperformance in math relative to boys is eliminated in more gender-equal cultures. In more gender-equal societies, girls perform as well as boys in mathematics and much better than them in reading. These findings shed some light on recent trends in girls' educational achievements in the United States, where the math gender gap has been closing over time (*2*).

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