Societal inequalities amplify gender gaps in math

Egalitarian countries cultivate high-performing girls

By Thomas Breda, 1,2 Elyès Jouini, 2,3 Clotilde Napp 2,3

While gender gaps in average math performance are now close to zero in developed countries, women are still strongly underrepresented among math high performers (1). This gender gap contributes to the underrepresentation of women in math and science in higher education and to their subsequent worse position in the labor market (2, 3). With the roles of nature and nurture (4–6) on gender performance gaps having been debated for more than a century, research in the 1990s and 2000s (7–9) suggested a cultural origin, relating gender gaps in math to measures of countries’ gender inequality. However, with more recent studies (10–12) having shown that this relation is weak, today we have no clearly identified relationship between countries’ socioeconomic or cultural environment and the gender gap in math. We relate below gender gaps in math to societal inequalities that are not directly related to gender. We find a strong and robust relationship and provide tests suggesting that it is causal: Countries that are generally more egalitarian, or that have institutions more conducive to equality, have a lower gender performance gap in math, suggesting that this gap is partly shaped by more general societal inequalities.

According to the Programme for International Student Assessment (PISA), there are on average only seven girls for ten boys in developed countries, women are still strongly underrepresented among math high performers (1). This gender gap contributes to the underrepresentation of women in math and science in higher education and to their subsequent worse position in the labor market (2, 3). With the roles of nature and nurture (4–6) on gender performance gaps having been debated for more than a century, research in the 1990s and 2000s (7–9) suggested a cultural origin, relating gender gaps in math to measures of countries’ gender inequality. However, with more recent studies (10–12) having shown that this relation is weak, today we have no clearly identified relationship between countries’ socioeconomic or cultural environment and the gender gap in math. We relate below gender gaps in math to societal inequalities that are not directly related to gender. We find a strong and robust relationship and provide tests suggesting that it is causal: Countries that are generally more egalitarian, or that have institutions more conducive to equality, have a lower gender performance gap in math, suggesting that this gap is partly shaped by more general societal inequalities.

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Inequalities and gender gaps among high performers in math

Estimates in column 1 are obtained from separate simple linear country-level regression models on 35 OECD countries in PISA 2015. The dependent variable is the ratio of the numbers of girls and boys among high math performers. Column 2 provides similar estimates based on individual-level regressions with several control variables and adjusted standard errors (see SM). Column 3 is a country fixed-effect version of column 1 based on PISA 2003, 2006, 2009, 2012, and 2015.

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<tbody>
<tr>
<td>Income inequalities (GINI index)</td>
<td>0.067**</td>
<td>-0.094**</td>
<td>-0.094**</td>
</tr>
<tr>
<td>Inequalities in socioeconomic and cultural background</td>
<td>-0.081**</td>
<td>-0.169**</td>
<td>-0.043**</td>
</tr>
<tr>
<td>Socioeconomic inequalities in performance</td>
<td>-0.085**</td>
<td>-0.157**</td>
<td>-0.027**</td>
</tr>
<tr>
<td>Inequalities in learning opportunities</td>
<td>-0.075**</td>
<td>-0.154**</td>
<td>-0.075</td>
</tr>
</tbody>
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** P < 0.01, * P < 0.05. See SM for methodological details, the exact definition of inequality variables, sample sizes, standard errors, and R-squares.

To back up this point, we run “horse races” and also apply three standard machine-learning techniques for model selection to compare the explanatory power of measures of gender inequality and of countries’ development to our measures of non-gender-related inequalities (see SM). For instance, the effect of the Gender Gap Index (GGI) or of the Female Labor Force Participation on the gender gap in math becomes statistically nonsignificant as soon as a measure of (non-gender-related) societal inequalities is introduced as a competing explanatory variable in regression models (table S9).

Societal inequalities are also associated with lower girls-to-boys ratios in science in more unequal countries (see the table, column 2, and table S10). This shows, in particular, that our main results are not driven by differential effects of parents’ education on their daughters’ and sons’ math performance or by differential allocation of household resources across children’s gender.

To explore whether unobserved country characteristics are driving the results, we control for countries’ time-constant unobserved heterogeneity using country fixed-effects models. Variations over time in our main inequality indicators are almost all significantly related to variations over time in the girls-to-boys ratio in math, showing that countries that reduce relatively more girls-to-boys ratios in science still have a lower probability relative to boys to score above the high-performance cutoff (increasing the gender gap, as in math) and higher boys-to-girls ratio in reading (reducing the gender gap) (tables S2, S4, S5, and S8). Consistent with our hypothesis, inequalities are detrimental to the performance of girls relative to boys in the three topics math, reading, and science.

UNDERSTANDING ORIGINS

To suggest causality and better understand the origin of the relationship between non-gender-related inequality measures and gender performance gaps, we offer three different strategies: (i) individual-level regressions, (ii) panel analysis, and (iii) instrumental variables.

We first check that our results are not driven by cross-country differences in observable students’ characteristics. We replicate our analysis using the full PISA student-level data, which contains information on students’ grade repetition, parents’ education, and households’ economic and cultural resources. Conditional on these controls and their interaction with students’ gender, girls still have a lower probability relative to boys to score above the high-performance cutoff (or increase relatively less) socioeconomic inequalities also reduce relatively more the gender performance gap in math (see the table, column 3, table S11, and fig. S2).

To assess further a possible causal link, we exploit institutional differences between countries’ labor markets as instruments for their extent of income inequality. We argue that institutional features such as bargaining coverage, union density, or the value of the minimum wage are not likely to have a direct link with the gender performance gap at school, such that any impact they may have on the math gap would likely be through their impact on social inequalities. To obtain estimates less likely to reflect reverse causality or omitted variables biases, we retrieve variations in the Gini index that are solely explained by those institutional variables. These “instrumented” inequalities, solely driven by institutional factors, affect the gender gap in math to the same extent as noninstrumented inequalities (table S12).

We also study whether institutional features of education systems affect gender performance gaps by considering measures of inequalities in learning opportunities across schools or across students’ socioeconomic background, measures of vertical stratification at school, such as the extent of grade repetition, and measures of the quality of education. All those measures, known to affect socioeconomic inequalities at school (14, 15), directly relate to gender performance gaps across countries (tables S2 and S4 to S7).

It is striking that general indicators of inequalities can explain so well the patterns of gender differences in math, science, and reading performance across countries (whereas other indicators directly related to gender stratification have limited explanatory power). In more egalitarian countries, differences in initial status seem less likely to translate into differences in performance, and girls are more represented among high performers as are, for example, students from a low socioeconomic and cultural background. This suggests that the gender gap in math is a form of social inequality like many others.

This is consistent with our results that gender performance gaps at school are linked to countries’ institutions that more generally reduce social and economic inequalities. As a consequence, gender equality may not only be a matter of gender norms and stereotypes. General policies in favor of more inclusive, less vertically stratified, and more standardized education systems may also have a positive impact on girls’ performance.

REFERENCES


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SUPPLEMENTARY MATERIALS

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