Economists find new reason to think that environment, not innate ability, determines how well girls do in math class

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(PhysOrg.com) -- When Glenn Ellison's daughters started middle school in a Boston suburb in 2007, Ellison decided to become a volunteer coach of the school's math team. While his squad was earning a place in the state finals, Ellison noticed something distinctive about his students.

"We would go to math contests, and my team didn't look like other teams," says Ellison, who is MIT's Gregory K. Palm (1970) Professor of Economics. He was coaching an all-girls squad, largely consisting of his oldest daughter and friends she had recruited. But the other schools' teams were composed almost entirely of boys. "It was striking and made me think there was something interesting going on," recalls Ellison.

Ellison made this basic observation the heart of a recently finished paper

showing not only that girls are a small minority of elite high school math students, but also that the prevalence of high-achieving girls in math varies from school to school. Indeed, in research conducted along with Ashley Swanson, a PhD student in the Department of Economics, Ellison found that the best female math students across the United States come from a tiny number of institutions. The majority of the girls who have been chosen to represent the United States in international mathematics competitions come from a set of about 20 high schools with elite math teams.

This extreme concentration of talent strongly indicates the crucial role that environmental factors, not just innate ability, play in shaping the accomplishments of students. “It’s significant that the top girls are coming from a very, very small subset of schools with strong math programs,” says Ellison. “That suggests most of the girls who could be doing well, aren’t doing well. The thousands and thousands of other schools in the United States must have a lot of talent, too, but it’s not coming out.”

As debate over the gender gap in school math rumbles on, Ellison and Swanson suggest a practical reason it matters: “The phenomenon may be related to the underrepresentation of women in scientific fields,” they write in their recent working paper, “The Gender Gap in Secondary School Mathematics at High Achievement Levels.” If highly capable girls are not encouraged to pursue math in school, they may never pursue scientific careers — thus limiting the talent pool of researchers.

The geography of good math students

Ellison and Swanson arrived at their findings by using a novel source of data: the American Mathematics Competitions (AMC), a 60-year-old annual contest involving 125,000 exceptional high-school students. A select group of students who do especially well on the AMC compete in

a series of annual competitions, the U.S. Mathematical Olympiad and the International Mathematical Olympiad. This focus on standout students differs from most studies about math and gender in schools. Those studies have frequently used standardized test scores among all students to draw conclusions. For instance, multiple analyses have identified a narrowing of the gender gap in average test scores since the 1960s, which many researchers attribute to girls increasing the number of math classes they take.

The numbers Ellison and Swanson scrutinized indicate that the gender disparity among star math students widens as performance levels increase. In 2007, about 800,000 girls took the math SAT, compared to about 700,000 boys. Yet at the 99th percentile of the math SATs, boys outnumber girls two to one. In their research, Ellison and Swanson divide that upper tier into even smaller segments, using AMC results. Among students in the 94th percentile of the AMC tests, they found, the top boys outnumbered the top girls four to one; at the 99th AMC percentile, six to one; and at the 99.9th AMC percentile, 12 to one.

Ellison thinks this huge gender disparity is linked to another fact: Among those students scoring so highly on the AMC and participating in the math Olympiads, the range of high schools represented is much greater for boys than for girls. “The top boys in the Olympiads come from all over the United States,” says Ellison. “Some of them are from big powerhouse schools, and some are from schools where they’re the only student who’s really good at math. But it’s these 20 high schools where the majority of the girls are coming from.” Those institutions range from Phillips Exeter Academy, an elite New England prep school, to a fistful of public high schools in Northern California, from Palo Alto to San Jose. By contrast, Ellison and Swanson note, half of the boys in the Olympiads come from about 200 high schools.

Other researchers say that Ellison and Swanson, by identifying this

unusual distribution of top female math students, have opened a new avenue for studying how the gender gap forms in schools. “I think it’s really interesting,” says Mary O’Keeffe, an economist at Union College in New York. “A lot of literature on the subject tries to prove something that’s not really provable — whether there’s an inherent gap between boys and girls. But they’ve drilled into the data in a way that can help us learn about what happens to these girls.”

What makes a school a math powerhouse?

Ellison and Swanson intend to continue their research on the subject by studying why the best female math students appear so frequently at such a small group of high schools. The researchers would like to create a study following the progress of excellent female math students throughout high school, to see what makes them either continue with math or disengage from it.

Provisionally, the researchers think the results underscore the value of learning math as part of a community of students. “It is hard to know, but these high-performing schools could be doing a better job of getting girls involved through clubs and teams,” says Swanson. That does not mean, Ellison notes, that girls need to be on all-girl math teams like his own to thrive. But the legacy of mathematics as a male-dominated subject may still limit the opportunities some girls have to pursue math in a comfortable social setting — apart from the few schools that seem to have broken the mold.

O’Keeffe, who has a daughter who competed in the math Olympiad, is inclined to agree. “Anecdotally, I do think the difference a community makes is enormous,” she says. “If you’re lucky enough to be at a school with a math club, you might be the only girl in it. At Exeter or Stuyvesant [a prominent Manhattan public high school], you might be in a minority, but you won’t be alone.” To be more rigorous, though, Ellison

wants to track many individual students over time.

Ellison and Swanson are already further along on another planned project, using the AMC data to probe the additional differences among schools. “There is a variation across these schools that can’t be explained by income or demographics,” says Ellison. Not all the best math schools are Exeter-style elite institutions; the San Jose high schools, for instance, do not represent economically privileged students. Moreover, only a small fraction of all well-off high schools nationwide are math powerhouses.

Since it appears that money alone does not allow a school to produce elite math students, Ellison would like to investigate whether curriculum differences are a particular key. “Some schools are geared up to get kids a 750 or 800 on the SATs, and that’s it,” says Ellison. “Some schools teach kids in more depth. These top 20 schools are probably the ones where students get that depth without going outside the bounds of the school.” Ellison and Swanson want to analyze a wider range of schools in order to see whether math performance correlates with specific academic practices.

Meanwhile, with the current paper being readied for publication, Ellison hopes the ongoing nature-versus-nurture debate will become more nuanced. “I think most of the debate about natural ability versus social factors is misguided,” he says. “We’re looking for environments where girls are doing better and worse, and using that variation to try to understand what’s causing it and what can improve the situation.”

More information: econ-www.mit.edu/files/4298

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